Japan International Cooperation Agency
Vietnam Administration of Forestry
Ministry of Agriculture and Rural Development,
The Socialist Republic of Vietnam

Final Report

The Study on Potential Forests and Land Related to "Climate Change and Forests" in The Socialist Republic of Vietnam

March 2012

Japan Overseas Forestry Consultants Association

Japan Forest Technology Association

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Abbreviations

AD: Activity Data
AGB: Above Ground Biomass
A/R CDM: Afforestation and Rehabilitation Clean Development Mechanism
BAU: Business As Usual
BCEF: Biomass Conversion and Expansion Factor
BDS: Benefit Distribution System
BEF: Biomass Expansion Factor
BGB: Below Ground Biomass
C: Carbon
CAPD: Center of Agro-forestry Planning and Designing
CC: Climate Change
CBFP: Community- Based Forest Protection
CER: Certified Emission Reduction
CFM: Community Forest Management
COP17: The 17th Conference of the Parties
CPC: Commune People's Committee
DARD: Department of Agriculture and Rural Development
DBH: Diameter at Breath Height
DPC: District People's Committee
EF: Emission Factor
FAO: Food and Agriculture Organization
FCCM: Forest Change Matrix Method
FIPI: Forest Inventory and Planning Institute
5MHRP: Five Million Hectare Reforestation Program
FRD: Forest Ranger Department, FPD
FRS: Forest Ranger Station, FPD
FPD: Provincial Forest Protection Department, DARD
FSIV: Forest Science Institute of Vietnam
GHG: Green House Gas
GIZ: German Company for International Cooperation
HHs: Households
ICRAF: World Agroforestry Centre
IPCC: Intergovernmental Panel on Climate Change
JICA: Japan International Cooperation Agency
KP: Kyoto Protocol
MARD: Ministry of Agriculture and Rural Development
MODIS: Moderate Resolution Imaging Sectroradiameter
NFA: National Forest Assessment
NFI: National Forest Inventory
NPV: Net Present Value
NR: Natural Reserve
NRMB: Nature Reserve Management Board
NRP: National REDD + Program
MRV: Measurement, Reporting, Verification
NTFP: Non-Timber Forest Products

PaMs: Policy and Measures
PPC: Provincial People's Committee
PFMB: Protection Forest Management Board
QA/QC: Quality Assessment/ Quality Control
RCFEE: Research Centre for Forest Ecology and Environment, FSIV
REDD: Reducing Emissions from Deforestation and Forest Degradation
REDD+: Reducing Emissions from Deforestation and Forest Degradation; and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon StocksREL: Reference Emission Level
RIL: Reduced Impact Logging
RL: Reference Level
RS: Root Shoot ratio
SCM: Stock Change Method
SFE: State Forest Enterprise
Stdev: Standard Deviation
Sub-DARD: District Agriculture and Rural Development, DARD
Sub-DoF: Sub-Department of Forestry, DARD
Sub-FPD: District Forest Protection Department, DARD
SBSTA: Subsidiary Body for Scientific and Technological Advice
SWOT: Analysis based on Strengths, Weaknesses, Opportunities, and Threats
TW: Total Weight
UNESCO: United Nations Educational, Scientific and Cultural Organization
UNFCCC: United Nations Framework Convention on Climate Change
VFU: Vietnam Forest University
VND: Vietnam Dong
VNFOREST: General Administration of Forestry, MARD
WD: Wood Density
Ws: Weight of Stem
Wb: Weight of Branch
Wl: Weight of Leave
Wr: Weight of Root

Introduction

The Draft Final Report (hereinafter referred to as the "the Report") presents the final results pertaining to the "Study on Potential Forests and Land Related to 'Climate Change and Forests' in the Socialist Republic of Viet nam" (hereinafter referred to as "the Study") implemented from September 2009 to March 2012. The Study is implemented on the basis of Scope of Work agreed upon by the Ministry of Agriculture and Rural Development (hereinafter referred to as "MARD") and the preliminary study mission dispatched by Japan International Cooperation Agency (hereinafter referred to as "JICA") in June 2009, and Memorandum of Understanding for the Extension of the Study agreed upon between JICA and Vietnam Administration of Forestry (hereinafter referred to as "VNFOREST"). The contents of the Study and its implementation plan described in the Inception Report were presented at the substantial steering committee on September 30, 2009 and the Progress Report was presented on November 30, 2009. In addition, the first and second interim reports were presented on September 20, 2010 and April 26, 2011, respectively.

Executive Summary

1. Framework of the Study

1.1 Objectives of the Study

The Study contributes to facilitation of international efforts for mitigation of global climate change under UNFCCC through identifying the potential areas for A/R CDM projects and reducing emissions from deforestation and forest degradation in developing countries (REDD+) and examining possibilities of non-UNFCCC approaches in Vietnam.

1.2 The Scope of the Study Activities

Main activities of the Study are summarized in the following seven components.

a. **Development of digital maps:** Forest status maps in five time series of 1990, 1995, 2000, 2005, and 2010 are developed and distribution of the lands potentially suitable for REDD+ and afforestation/reforestation projects (e.g. A/R CDM) in the entire country is displayed on the GIS map through processes of classifying the lands on the basis of satellite data analysis and data on volumes of forests, etc.

b. **Development of emission factor and verification of data in the National Forestry Inventory (NFI):** The emission factor was developed based on the cycle data of NFI and other relevant information. In addition, the verification of Cycle 4 data in the NFI is implemented incorporating idea of QA/QC through conducting the field survey in around 400 sub-plots.

c. **Setting interim RELs/RLss for REDD+ and estimating cost and beneficial effects associated with A/R-CDM and REDD+:** The RELs/RLs for REDD+ is estimated on the basis of historical trends on decrease of forest biomass. Costs and benefits associated with the projects are estimated separately for A/R-CDM projects and REDD+ implementation.

b. **Model land survey:** Potential of several project types for climate change mitigation of the forest sector (e.g. A/R CDM and REDD+) is studied in the model land; costs associated with projects assumed to be implemented on the model land and beneficial effects of carbon sequestration or REDD+ are estimated as case studies.

e. **Preparation of “the Basic Plan for REDD+ Development in Dien Bien Province”:** The basic plan is prepared to contribute to the development of the mechanism on REDD+ and other measures in the Province, and to clarify the process of developing the REDD+ pilot activities toward realization of their implementation. The plan is set for the readiness stage to contribute to establishment of Provincial REDD+ Program in Dien Bien Province to be developed in the future.

f. **Development of method on estimating forest carbon stock:** “Biomass Conversion and Expansion Factor (BCEF)” for the natural evergreen broad-leaved forest in Dien Bien Province is developed based on the biomass survey.

g. **Provision of information to potential investors:** A questionnaire survey is implemented for potential investors in projects for the carbon sequestration and REDD+, and information to promote investment to such projects is provided to private firms.

2. Development of Forest Distribution Maps as Activity Data

Figure 2.1 shows the output of nationwide forest distribution maps focusing on the years 2010 and 2005 out of five points in time in order to understand the forest dynamics. Based on those maps, the aggregated area of each forest types No. 1 to No. 12 are obtained as shown in Figure 2.2.

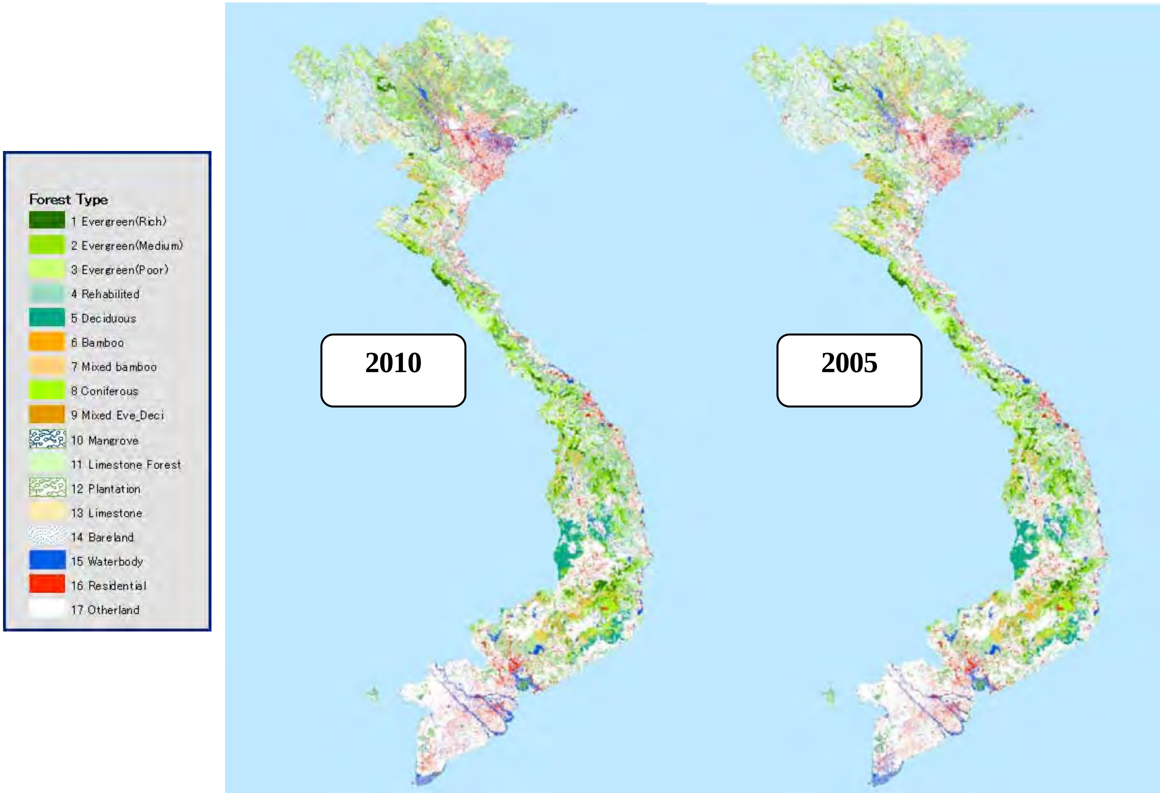

Figure 2.1 Forest Distributon Map of year 2010 and 2005

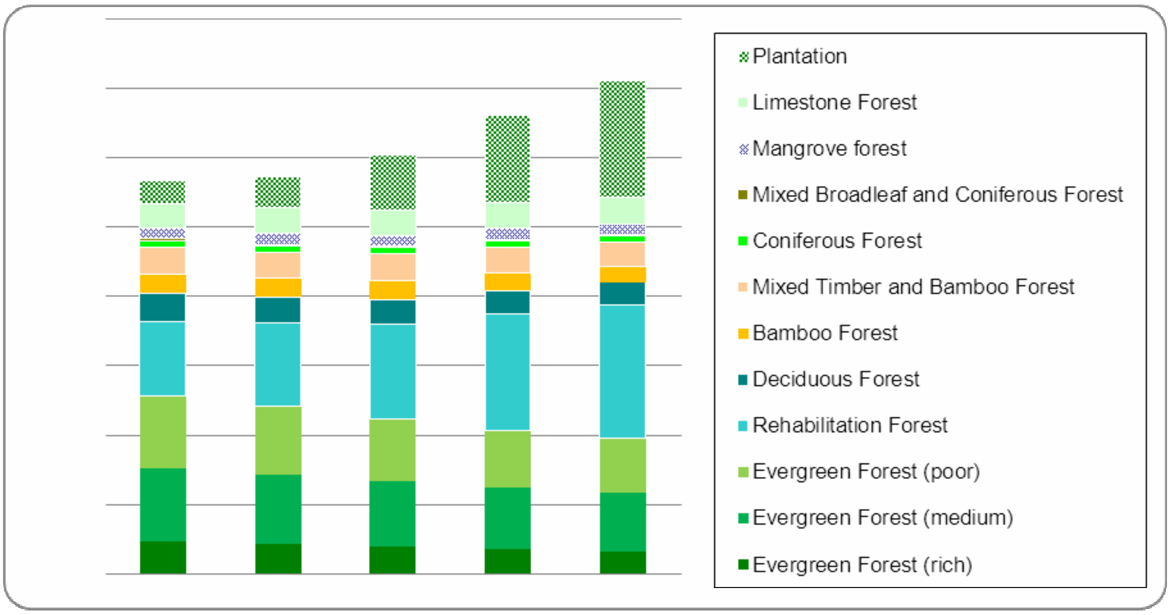

Figure 2.2 Dynamics of the Area of Land for Each Forest Type since 1990
(National Aggregation, Unit: 1,000ha)

3. Development of Forest Volume and Biomass Data as Emission Factor

EF is estimated for each forest type based on the data set of each of Cycles 1, 2, 3, and 4 using stratification of Bio-Eco regions. Figures 3.1 through 3.4 are the results of the EF for each forest type by Bio-Eco regions estimated by BCEF of FAO and Tie-1 of IPCC.

Table 3.1 EF for Each Forest Type by Bio-Eco region in Cycle-1 (CO_2t^3/ha)

※1 ※2	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	646	283	157	110	228		297					
3												
4	959											
5	606	283	143	140			329					121
6	560	272	124	98		106	191	5			209	78
7	471	258	141	107			193	83				77
8			113	97								
9	518	261	117	74		25	173	96				77
10	477	283	127	148	224	189	240					121
11	546	276	154	121	185	119	205	203	200			123
12	529	279	131	135	219		316	298				120
14												

Table 3.2 EF for Each Forest Type by Bio-Eco region in Cycle-2 (CO_2t/ha)

※1※2	1	2	3	4	5	6	7	8	9	10	11	12
1			149	142						64		
2	489	274	107	144	241		258					
3										68		
4	660	295	187				330					
5	561	274	139	93		87	256					77
6	587	271	115	83		119	151				116	86
7	457	268	147	99			195	98				90
8												
9		260	104	65		96	99	90				88
10	446	276	124	141	237	126	181		94			87
11	459	278	142	141	255	85	172	127	233			84
12	465	277	129	126	183		184	223	363		20	64
14												

Table 3.3 EF for Each Forest Type by Bio-Eco region in Cycle-3 (CO_2t/ha)

※1 ※2	1	2	3	4	5	6	7	8	9	10	11	12
1		319	163	157						99		
2	434	271	112	148	214		236					
3										99		
4	472	300	130				249					
5	519	268	142	101		83	181	82				116
6	505	270	119	75		283	114	29			116	83
7	428	285	153	109		107	151	87				60
8												
9		250	118	68		75	95	86				77
10	435	280	143	146	226	121	202	340				88
11	448	280	143	134	257	75	154	166	268		150	195
12	449	277	134	140	180		190	96	169		78	201
14										89		124

Table 3.4 EF for Each Forest Type by Bio-Eco region in Cycle-4 (CO_2t/ha)

※1 ※2	1	2	3	4	5	6	7	8	9	10	11	12
1			181	157								75
2	604	282	144	157	178		279					
3										115		104
4	798	299										
5	508	275	158	131		78	219	92				67
6	516	272	135	94		66	118				165	103
7	417	272	171	116		82	181	146				70
8												
9		271	110	115		86	122		105	4		85
10	465	282	158	148	196	138	249					94
11	502	291	162	135	153	91	199	253	292			163
12	511	280	120	128	189	104	240		271			106
14												102

※ 1 (Bio-Eco regions);1=Cardamom Mountains rain forests, 2=Central Indochina dry forests, 3=Indochina mangroves, 4=Luang Prabang mountain rain forests, 5=Northern Annamites rain forests, 6=Northern Indochina subtropical forests, 7=Northern Vietnam lowland rain forests, 8=Red River freshwater swamp forests, 9=South China-Vietnam subtropical evergreen forests, 10=Southeastern Indochina dry evergreen forests, 11=Southern Annamites mountain rain forests, 12=Southern Vietnam lowland dry forests, 14=Tonle Sap-Mekong peat swamp forests

※2 (Forest types) ; 1=Evergreen broadleaf forest(rich forest), 2=Evergreen broadleaf forest(medium forest), 3=Evergreen broadleaf forest(poor forest), 4=Evergreen broadleaf forest(rehabilitation forest), 5=Deciduous forest, 6=Bamboo forest, 7=Mixed timber and bamboo forest, 8=Coniferous forest, 9=Mixed broadleaf and coniferous forest, 10=Mangrove forest, 11=Limestone forest, 12=Plantation

4. Setting Interim RELs/RLs for REDD+ at the National Level of Vietnam

The definition and clear methodology for how to develop RELs/RLs have not been provided. On the other hand, the importance of understanding historical trends and the effectiveness of understanding forest dynamics by combining satellite data and ground-based surveys are widely recognized. It is important to reduce uncertainty as much as possible, and methods with robustness and transparency should be used when submitting reports to UNFCCC.

Technical options for developing RELs/RLs can be selected by taking into consideration these basic principles, and the options are shown below. For the stratification classification for developing EF, it was concluded that Bio-Eco regions should be used in order to reduce uncertainty in Chapter 3. The following explains the results of considering each technical option.

Note that in the Study, RELs and RLs are defined as follows.
RELs: the change of emission levels of CO_2 resulting from the deforestation and forest degradation.
RLs: the change of removal levels of CO_2 resulting from forest enhancement, rehabilitation, and reforestation.

Considering the consistency between the factors of increase and decrease of forest, the method to calculate RELs/RLs is appropriate, in order to apply separate RELs and RLs in order to explain historical trends. However, it should be noted that no method using separated RELs/RLs has been approved by IPCC. In addition, stratification classification is effective for observing regional characteristics of forest increase/decrease, which is required for calculating RELs/RLs in accordance with geographical unit. This causes fluctuation in robustness when observing the model of future projection.

Regarding the number of sets of past satellite data to be used, when simple increase is shown in the trend, the options do not show differences, while the data derived from three points in time may result in different output from the data derived from five points in time. Moreover, Bio-Eco region has less uncertainty for stratification classification in order to develop EF.

Regarding the model for future projection, applying a higher polynomial regression model requires careful consideration, since it sometimes estimates extreme level because of fluctuation caused by the latest trend. The influence of future projection by each model would be different depending on whether the historical trends of carbon emissions/removal are positive or negative.
Table 4.1 shows the summary of the result discussed in relation to the options above.

Table.4.1 Characteristics of the options to develop RELs/RLs

Item to be considered	Option 1	Option 2
Method of Calculating Interim RELs/RLs	Integrating RELs/RLs • The historical trends of emissions/removal are unknown. • The method is approved by IPCC	Separating RELs と RLs • The historical trends of emissions/removals are known. • The trends of emissions/removals are clearly defined by the influence from the policies and deforestation. • The method is unique and not approved by IPCC.
Unit for developing Interim RELs/RLs	The projection are made at the national scale • It is suitable to grasp the macro change. • It does not indicate regional character of forest change and policies.	The projections are made at Sub-national scale and aggregated to obtain national results • It is suitable to grasp the trends of forest change as well as the factors of forest increase/decrease. • The results are indicating regional uniqueness of the policies.
Number of sets of past satellite data to be used	Three points in time • If forest change has the certain trends, the model ensures low uncertainty. • Cost performance is low.	Five points in time • The model ensures robustness rather than the one used three points in time. • Cost performance is high.
Stratification classification for developing EF	Agro-ecological zones • Uncertainty may be high if Agro-Eco regions are applied to calculate EF.	Bio-ecological zones • Low uncertainty may be ensured if Bio-Eco regions are applied to calculate EF.
The model to be used to make the projections	Calculation of the average • If the removal has a simple increase trend, the future projection would be at low level. • If the removal has a simple decrease, the future projection would be at high level. • If the emissions have a simple increase trend, the future projection would be at low level. • If the emissions have a simple decrease trend, the future projection would be at high level.	Regression Model • If the removal has a simple increase trend, the future projection would be at high level. • If the removal has a simple decrease, the future projection would be at low level. • If the emissions have a simple increase trend, the future projection would be at high level. • If the emissions have a simple decrease trend, the future projection would be at low level.

5. Development of Thematic Maps in the National Level

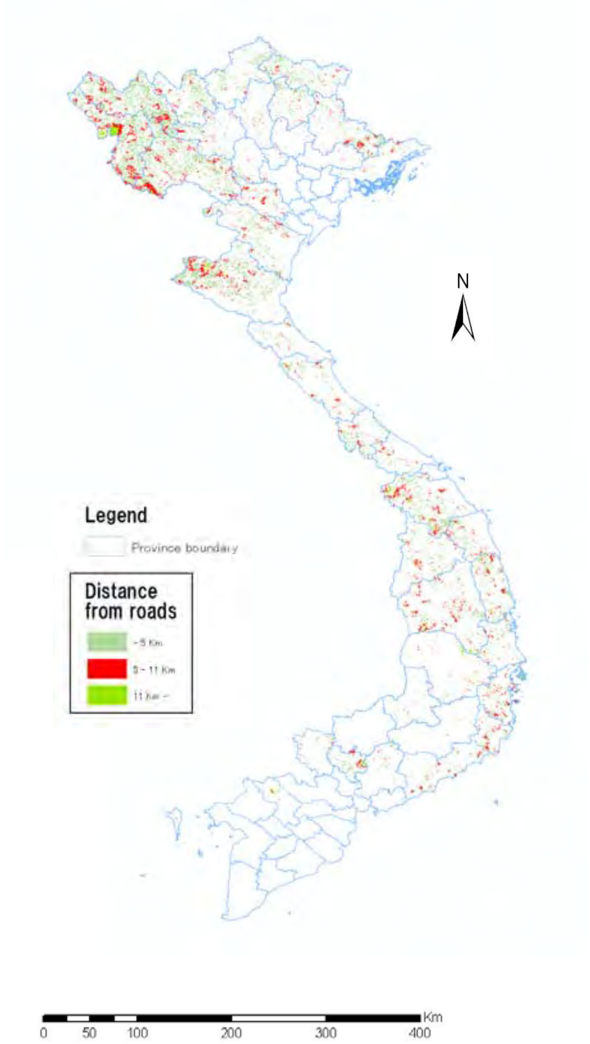

Figure 5.1 Map of potential areas to implement A/R CDM project activities

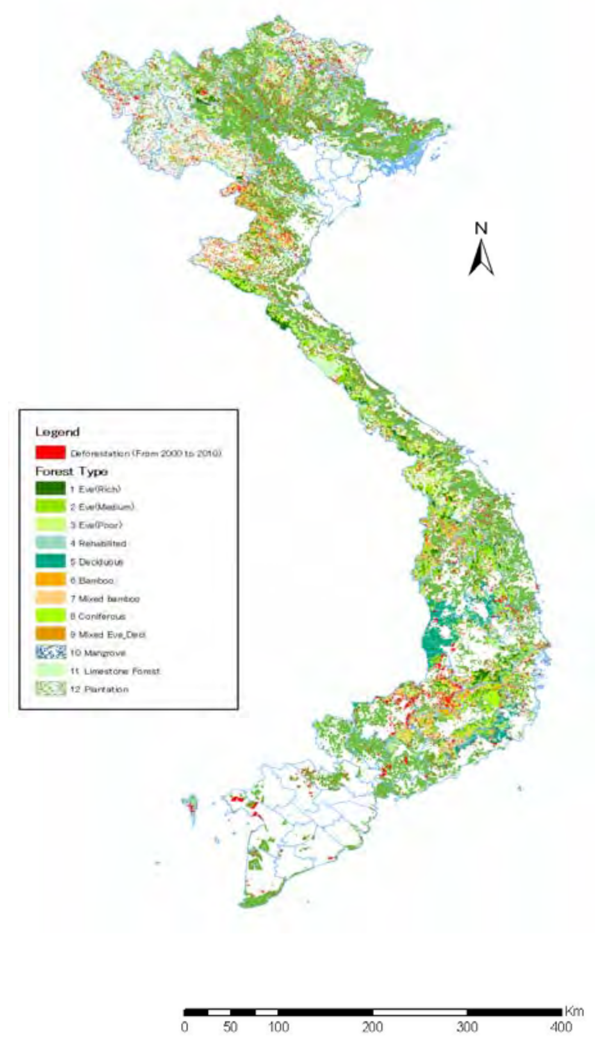

Figure 5.2 Map of Forest Change

This map shows Potential areas to implement A/R CDM project activities. Red color features show the potential areas on the map.

(How to develop the map)

A composite forest distribution map of 1990 and 2010 was created first using the GIS overlay function. Then eligible land was extracted with the following query conditions, "Ftype1990 code 13 – 17 non-Forested land, And Ftype2010 code 14 Bareland". The potential areas were highlighted with overlaying road buffers lying between 5km and 11km from road center on the map.

This map shows Forest change in Vietnam from year 2000 to 2010. Red color features show deforestation areas on the map.

(How to develop the map)

A composite forest distribution map of 2000 and 2010 was created first using the GIS overlay function. Then specific features were extracted with the following query conditions to show deforestation areas, "Ftype2000 code 1 - 12: Forested land, And Ftype 2010 code: 13 – 17: non-Forested land".

6. Analyzing Cost and Benefit for A/R CDM and REDD+

6.1 Analyzing Cost and Benefit for A/R CDM

The Study tried to estimate costs and benefits on the national scale that can be incurred or earned through implementation of the A/R CDM and REDD+ activities, using the data developed by the Study as well as the existing data.

In order to analyze costs and benefits of A/R CDM implementation, all costs and benefits pertaining to implementation of A/R CDM project activities were estimated, assuming that all the potential lands to implement A/R CDM projects in Vietnam are afforested or reforested under CDM. Benefits of implementing A/R CDM projects are estimated from 1) profit of selling timber products and 2) value of the carbon credits (CER). Meanwhile, costs of implementing A/R CDM projects are estimated from 1) cost of afforestation/reforestation activities and 2) cost of process to earn the credit approved in the CDM framework.

In order to exercise the investment analysis to justify the additionality, this trial only considered the distance between road and plantation and associated cost of transportation of logs from the harvesting sites to the main road as a parameter to examine the additionality. As a result of this analysis, it was found that afforestation or reforestation project activities would be additional to the BAU and economically feasible if they were implemented on lands between 5 km and 11 km away from roads.

According to the section 6.1, the total area of the potential lands to implement A/R CDM project activities in Vietnam would be 804,411 ha. Assuming that the price of tCER is 5 US Dollars/tCO_2 and all the potential lands for implementation of A/R CDM projects in the country are afforested or reforested, the total gross benefit from the selling the tCER in the 30-year project period would be:
US$ 112,569,275 in the fifth and twentieth years
US$ 577,462,525 in the tenth and twenty-fifth years
US$ 823,724,908 in the fifteenth and thirtieth years

Assuming a discount rate of 10%, the net present value of the net benefit of the A/R CDM project implementation for 30 years in the country would be 243,909,997 US dollars.

6.2 Analyzing Cost and Benefit for REDD+

Regarding the benefit calculation, the value of the benchmark of the RELs at the national level in 2015 is 331 MCO_2 tons based on the method by average of historical trends, which was prepared by the Study Team. Trial calculation is conducted based on the premise that the emission of CO_2 tons becomes zero.

If 5.5 US$/$CO_2$ ton, which is an average price for offsets across the primary forest carbon markets in 2010 according to “State of Forest Carbon Markets 2011”, is multiplied by this 331 MCO_2 tons, it becomes US$1,820,500,000.

The total cost is shown in the following table.

Items	Amount
Forest protection activity cost	541,600,000 US$
Monitoring cost	2,236,000 US$
Transaction cost	54,383,600 US$
Total	598,219,600 US$

Comparing US$1,820,500,000 of REDD+ benefit and US$598,219,600 of REDD+ cost, surplus of US$1,222,280,400 can be generated. However, it should be noted that the surplus is a figure based on the assumptions of the trial calculation. In reality, 1) since it is impossible for the reduction of forest to be zero, the figure of surplus has to be smaller than the surplus based on this trial calculation, 2) the method by average of historical trends for extrapolation in the future was taken for this trial calculation, but at present there is no assurance that the method will be approved by the UNFCCC; therefore, if other extrapolation methods such as polynomial model are adopted, the benchmark value will be smaller than 331 MCO_2t which is used for this trial calculation. Taking into account the considerations mentioned above, the surplus of US$1,222,280,400 would inevitably be smaller.

7. Preparation of the Basic Plan for REDD+ Development in Dien Bien Province

The objective of preparation of "the Basic Plan for REDD+ Development in Dien Bien Province" is to contribute to the development of the mechanism of REDD+ and other measures while improving the livelihoods of the rural population and maintaining biodiversity in the Province, and to clarify the process of developing the REDD+ pilot activities toward realization of their implementation.

For the developing REDD+ pilot activities, it is important to strengthen forest governance to maintain/enlarge areas of forest plantations, forest protection, and restoration by providing the stakeholders with incentives towards those activities, considering the livelihood improvement of ethnic minorities and biodiversity conservation. For the strengthening, it is indispensable that the capacity of provincial/local organizations with regard to REDD+ be developed through the implementation of REDD+ pilot potentially eligible for the credit payment. Since preparation of the basic plan is in the process of implementation, the preparation could play a role of capacity development.

In addition, regarding the plan's standing, the Vietnamese Government is now preparing a National REDD+ Program (NRP) and also intends to prepare a REDD+ Program for every province according to the NRP. Therefore, the plan is set for the readiness stage to contribute to establishment of a Provincial REDD+ Program in Dien Bien Province to be developed in the future.

The components of the basic plan are as follows,

(1) Objectives of Basic Plan for REDD+ Development in Dien Bien Province
(2) Natural and Socio-economic Conditions Regarding REDD +in Dien Bien Province
(3) Conditions for REDD + Implementation
(4) Forestry Policy/Program and Institutional Framework in Dien Bien Province
(5) Draft Potential REDD + Activities in Dien Bien Province
(6) Prioritized Area for Each Potential REDD + Activity

(7) Classification of the Districts for the Implementation of the Potential REDD + Activity
(8) Legal intervention in REDD+ Activity
(9) Proposal of Option for Setting Interim REL/RL in Dien Bien Province
(10) Implementation arrangement (MRV, Forest Monitoring System for BDS, BDS, Framework of the Implementation of REDD + Activities in the Pilot Areas)
(11) Safeguards
(12) Issues and Recommendation on Implementation for REDD + Activities

Since the basic plan was printed in a separate volume as the Annex I of the Report, please refer to the volume for details of the basic plan.

8. Development of Method to Estimate Forest Carbon Stocks in Dien Bien Province

This Chapter describes the development of allometric equations of tree biomass and biomass expansion factors of single tree level by biomass measuring survey of dominant tree species. First, there is described estimation of forest biomass and carbon stocks based on using allometric equations, biomass expansion factors, and every tree census data of the 90 survey plots in the Muong Nhe Nature Reserve. Furthermore, the development of conversion factors for estimation of forest biomass per unit area from growing stock per unit area of the forest is explained.

Section 1 explains the allometric equations, the biomass expansion factor, and the R-S ratio. In this explanation, the Study describes the details of the biomass measuring survey of 30 trees of the dominant species and the tree census of 90 survey plots to obtain data on Muong Nhe Nature Reserve to calculate these formulas and factors. The biomass expansion factors of each of 3 dominant tree species which the Study obtained were those for *Schima* 1.12-1.62, *Castanopsis* 1.25-1.59, and *Engelhardtia* 1.17-1.39. The R/S ratios which are obtained in the Study were for *Schima* 0.18-0.21, *Castanopsis* 0.17-0.21, and *Engelhardtia* 0.17-0.31. In all equations, biomass of stem, aboveground biomass, and total biomass of trees indicate close correlation with DBH of trees ($r = 0.95-0.99$).

Section 2 examines the advantages and disadvantages of the biomass expansion factors and the allometric equations obtained in Section 1. Based on the results, the Study calculates the aboveground and belowground biomass of each tree in the 90 plots using allometric equations for aboveground biomass and R/S ratio. Then data are tabulated for each plot, and converted to aboveground and belowground biomass per hectare. Then, the carbon stock per hectare for each plot is estimated. Calculated mean aboveground and belowground biomass of each forest type were; 92 t/ha and 18 t/ha for poor forest, 164 t/ha and 33 t/ha for medium forest, and 205 t/ha and 40 t/ha for rich forest. Mean carbon stock of aboveground and belowground organs, which were estimated by multiplying biomass by carbon function 0.47, 43 t/ha and 9 t/ha for poor forest, 77 t/ha and15 t/ha for medium forest, and 96 t/ha and19 t/ha for rich forest.

In Section 3, the Study develops biomass conversion expansion factors and R-S ratio which can estimate aboveground and belowground biomass per hectare directly from growing stock per hectare and aboveground biomass per ha, using growing stock, aboveground biomass, and belowground biomass of the 90 plots. The biomass conversion expansion factors (BCEF) which the Study calculated ranged from 0.7 for a growing stock level of about 300 m^3/ha to 1.6 for a growing stock level of about 50 m^3/ha. The regression formula of the biomass conversion expansion factor which can be used to determine this factor was *BCEF=4.4757*(Growing* *stock* m^3*/ha)*$^{-0.3}$. Also, obtained R/S ratio for estimating belowground biomass per hectare was about 0.96 for every level of aboveground biomass. These conversion factors and R/S ratio aimed at establishing a simple method to easily estimate forest biomass for local technicians.

Section 4 summarizes the issues toward higher accuracy of the allometric equations and biomass expansion factors which were developed in this development study. To increase the accuracy of biomass estimation going forward, it seems desirable to prepare biomass allometric equations for five or six other tree species besides the three dominant ones for which the biomass measuring survey was performed. Moreover, additional sample plot survey data for stands with growing stock of less than 50 m^3/ha and around the 300 m^3/ha level seem essential for increasing the precision of BCEF. Also, in this development study, re-growth forest and bamboo forest are not subject to survey, although coefficients and biomass allometric equations that apply to those re-growth and bamboo forests will need to be developed individually going forward to estimate forest biomass at high accuracy.

In conclusion, utilization of the research results and next steps are summarized. In order to evaluate the forest carbon stock, it is necessary to collect two sets of data: the data of the biomass per unit area, which corresponds to the forest distribution maps, and the maps themselves. When those two factors are improved in accuracy estimation, the result of calculating forest carbon stock would have lower uncertainty. It could be said that REDD+ measures based on the robust methodology are achieved as a result. Therefore, estimating the amount of biomass per unit area very accurately is the essential factor, and because of this, the BCEF in the Northwest region could be obtained.

The next step could be to verify the possibility of BCEF for the evergreen forest in the central region and the southern region in order to develop higher Tier at the national scale. The result may be able to be used for the pilot activities of participatory forest carbon monitoring in Dien Bien Province, which is considered to be started sooner or later. Moreover, wide use of BCEF for various forest types may be developed if additional survey, explained in 10.4.1, is conducted with a consideration of the trends of the forest changes in Dien Bien Province, such as increasing re-growth forest.

9. Contents of the Website

The Study developed a website to introduce the activities of the Study as one of the final outputs of the component “Provision of information to potential investors” of the Study. Contents of the website are based on the results of the questionnaire survey, which are described in section 10.1 of this report. Information to be provided on the website was analyzed, taking into consideration what information can break the barrier for potential investors to initiate investment. Meanwhile, other information collected through implementation of the Study was also analyzed by the Team on its applicability to promote implementation of REDD+ by potential investors.

There are six sub-sites provided beneath the homepage of the website. Site 1 introduces overall achievements of the JICA Study. Site 2 through site 4 provide basic information that can be taken into consideration during the design of REDD+. Site 5 provides information on how to contact NGOs and consultants that can support implementation of the field level activities. Site 6 introduces publications on REDD+. The website can be accessed at http://www.jpn-vn-redd.org.

1. Framework of the Study

1.1 Objectives of the Study

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1.2 The Scope of the Study Activities

Main activities of the Study are summarized in the following seven components.

a. **Development of digital maps:** Forest status maps in five time series, 1990, 1995, 2000, 2005, and 2010, are developed, and distribution of lands potentially suitable for REDD+ and afforestation/reforestation projects (e.g. A/R CDM) throughout the entire country is displayed on the GIS map through the processes of classifying the lands on the basis of satellite data analysis, data on volumes of forests, etc.

b. **Development of emission factor and verification of data in the National Forestry Inventory (NFI):** The emission factor was developed based on the cycle data of NFI and other relevant information. In addition, the verification of Cycle 4 data in the NFI is implemented incorporating idea of QA/QC through conducting the field survey in around 400 sub-plots.

c. **Setting interim RELs/RLs for REDD+ and estimating costs and benefis associated with A/R-CDM and REDD+:** The RELs/RLs for REDD+ are estimated on the basis of historical trends on decrease of forest biomass. Costs and benefits associated with the projects are estimated separately for A/R-CDM projects and REDD+ implementation.

b. **Model land survey:** Potential of several project types for climate change mitigation of the forest sector (e.g. A/R CDM and REDD+) is studied in the model land; costs associated with projects assumed to be implemented on the model land and beneficial effects of carbon sequestration or REDD+ are estimated as case studies.

e. **Preparation of “the Basic Plan for REDD+ Development in Dien Bien Province”:** The basic plan is prepared to contribute to the development of the mechanism on REDD+ and other measures in the Province, and to clarify the process of developing REDD+ pilot activities toward realization of their implementation. The plan is set for the readiness stage to contribute to establishment of a Provincial REDD+ Program in Dien Bien Province to be developed in the future.

f. **Development of method on estimating forest carbon stock:** “Biomass Conversion and Expansion Factor (BCEF)” for the natural evergreen broad-leaved forest in Dien Bien Province is developed based on the biomass survey.

g. **Provision of information to potential investors:** A questionnaire survey is implemented for potential investors of projects for the carbon sequestration and REDD+, and information to promote investment in such projects is provided to private firms.

1.3 Concept of RELs/RLs

Developing countries which join the REDD+ mechanisms will gain the benefit from the monitoring results of the estimated forestry related GHG emission/removals in the future based on RELs/RLs in each country. In other words, it is essential to develop RELs/RLs for the REDD+ mechanism. Meanwhile, depending on how to set the RELs/RLs, the amount of the GHG emission/removals can be derived easily. Therefore, RELs/RLs must be set to provide estimates that are transparent, consistent, as accurate as possible, and that reduce uncertainty.

1.3.1 Definition of RELs/RLs

The definition of RELs/RLs was discussed by SBSTA (Subsidiary Body for Scientific and Technological Advice) during November 11 to 15, 2011 in Bonn, Germany. However, UNFCCC could not stipulate the definition, because various understandings of RELs/RLs are expressed. In addition, the following principles were indicated at COP17 in Durban, South Africa.

Box 1.3.1 Principles of RELs/RLs indicated at COP17

(a) Information that was used by Parties in constructing a forest reference emission level and/or forest reference level, including historical data, in a comprehensive and transparent way;
(b) Transparent, complete, consistent and accurate information, including methodological information, used at the time of construction of forest reference emission levels and/or forest reference levels, including, inter alia, as appropriate, a description of data sets, approaches, methods, models, if applicable and assumptions used, descriptions of relevant policies and plans, and description of changes from previously submitted information;
(c) Pools and gases, and activities listed in decision 1/CP.16, paragraph 70, which have been included in forest reference emission levels and/or forest reference levels and the reasons for omitting a pool and/or activity from the construction of forest reference emission levels and/or forest reference levels, noting that significant pools and/or activities should not be excluded;
(d) The definition of forest used in the construction of forest reference emission levels and/or forest reference levels and, if appropriate, in case there is a difference with the definition of forest used in the national greenhouse gas inventory or in reporting to other international organizations, an explanation of why and how the definition used in the construction of forest reference emission levels and/or forest reference levels was chosen.

Based on the above situation, the Study decided to define RELs/RLs as follows.

- RELs/RLs are future extrapolations taking into account the historical carbon stock trends in order to project the future situation. In other words, the Study defines RELs/RLs as the future projection based on BAU (Business as usual). On the contrary, although international discussion are being held about national circumstance to develop RELs/RLs, the Study came to a conclusion not to consider development of a model combined with socioeconomic and policy factors which are required for estimation in general, because it may become difficult to develop and may result in increasing uncertainty.

- The historical carbon stock trend is obtained by the combination of the land area by forest type (Activity Data) and the carbon stock level per unit area for each forest type (Emission Factor). Activity Data (AD) are obtained from the existing forest distribution maps and satellite imagery. Emission Factor (EF) is obtained by the ground-based survey which was implemented before. This method considers the decision 4/CP.15[1] which indicates that a combination of remote sensing data and ground-based inventory approaches is appropriate for estimating forest-related GHG emissions.

1.3.2 Methodology of Developing Interim RELs/RLs

The Study proposes the most appropriate methodology of developing interim RELs/RLs based on the conclusions drawn from the examination of not only one methodology but also several technical options related to its development. The main options examined in this report for developing interim RELs/RLs are shown in the table below.

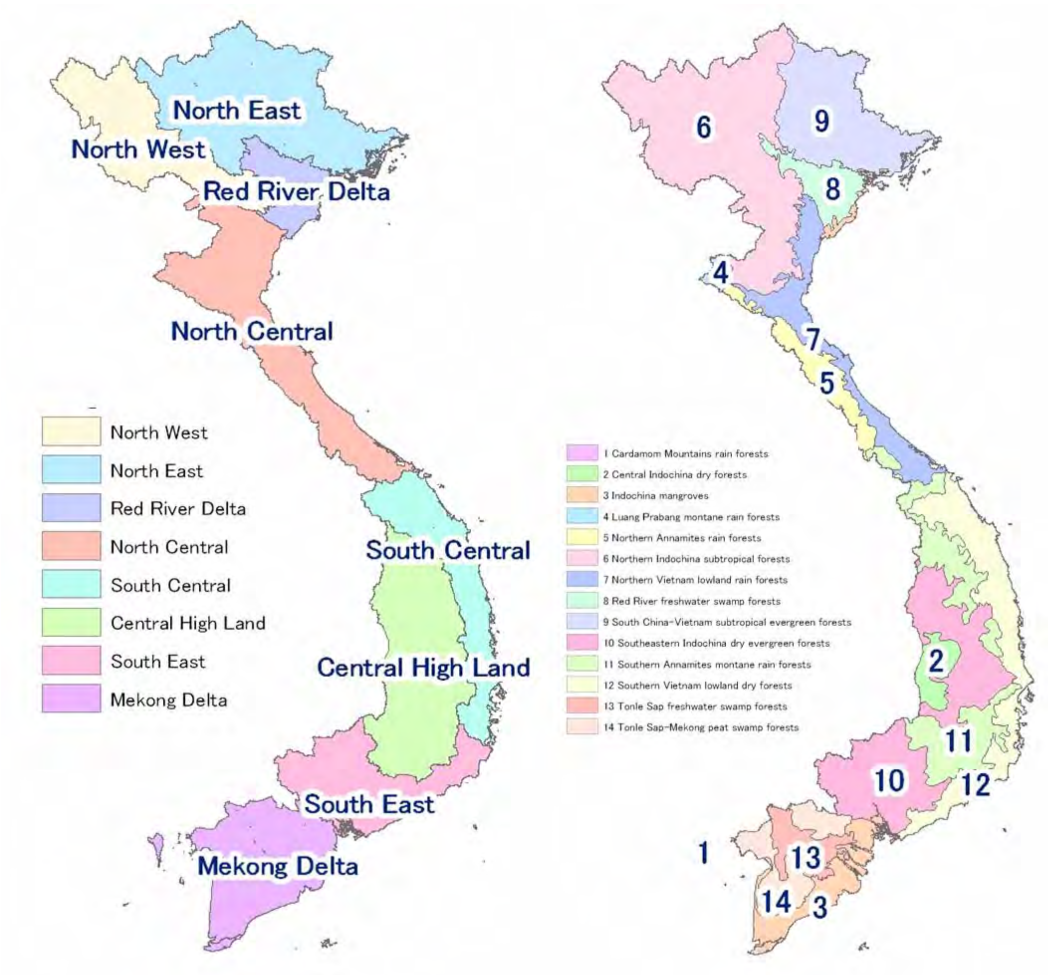
Table 1.3.1 Option for Developing Interim RELs/RLs

Examination items	Option 1	Option 2
Method for calculating interim RELs/RLs	Integrating RELs and RLs	Separating RELs and RLs
Unit for developing interim RELs/RLs	The projections are made at the national level.	The projections are made at each sub-national scale and the results are aggregated to obtain national results.
Number of sets of past satellite data to be used	Three points in time	Five points in time
Stratification classification for developing EF	Agro-ecological zones	Bio-ecological zones
The models to be used to make the projections	Calculation of the average	Regression model

Since every item in the above table is an essential factor for developing RELs/RLs, the merits and demerits of every option are examined based on the results of trial calculation in the Study.

In the model to be used to make the projections of RELs/RLs for afforestation or reforestation purpose, Vietnam is generally divided into eight agro-ecological zones on the basis of geographic location. Agro-ecological zones can be described as administrative boundaries that are equivalent to the boundaries of provinces. However, the parameters of EF that fluctuate because of ecological factors may increase uncertainty if EF is calculated and integrated on the basis of the administrative boundaries (agro-ecological zones). Therefore, stratification based on agro-ecological zones must be compared and examined. Based on the examination of the stratification classification in terms of the versatility in other countries as well, the Study decided to adopt Bio-Eco regions which are introduced by international organizations, such as IUCN.

[1](i) Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;



Agro-ecoregions Bio-ecoregions

Figure 1.3.1 Two eco-regions for stratification

2. Development of Forest Distribution Map as Activity Data

In order to develop interim RELs (Reference Emission Levels)/RLs (Reference Levels), it is important to understand the historical changes in the land area by forest type and to understand the carbon stock level per unit area for each forest type. The former data is called "Activity Data (AD)." This chapter explains the collection of past forest distribution maps for obtaining AD in Vietnam, including how they were made and also explains conclusions drawn from the collected data.

2.1 Necessary Conditions for Forest Distribution Map Preparation for REDD+

This section discusses the conditions required for creating forest distribution maps which are currently being discussed regarding the REDD+ mechanism. Since UNFCCC has not defined RELs/RLs., it is not possible to conclude what requirements must be met. Currently, various efforts are being made including demonstration activities by SBSTA and by various countries as well as proposals made by international organizations. The following explains the main discussion points.

2.1.1 Status of International Discussion on UNFCCC

Based on advice from IPCC, UNFCC stipulated five basic principles for reporting the amount of greenhouse gases (GHG) removed and emitted, including transparency, completeness, consistency, comparability and accuracy. The 2003 IPCC Good Practice Guidance (GPG) stipulates the following regarding the GHG emission/removal estimation: deforestation is the conversion of forested land to non-forested land; forest degradation and/or the increase in the forest carbon stock level are occurring on forested land; and the conversion of non-forested land to forested land results in an increase in the carbon stock level. Therefore, these three types of changes in land cover are included in the REDD+ activities. In addition, the GPG says that the data needed for GHG emission/removal inventory includes Activity Data (AD) and Emission Factor (EF). AD is data on the area of land where the above-mentioned activities took place. The unit used for this data is ha/year. The EF is the amount of GHG removed/emitted per unit area. The unit used for this data is CO_2/ha.

Based on the COP resolutions, etc., the following clarifies the conditions needed for AD. When looking at the discussions at UNFCCC on carbon monitoring, the following resolution was adopted at COP15: "Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (4/CP.15)". The provisions in Paragraph 1 (d) are particularly important as shown below.

Box.2.1.1 Paragraph 1(d) 4/CP.15

(d) To establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems and, if appropriate, sub-national systems as part of national monitoring systems that:

(i) Use a **combination of remote sensing and ground-based forest carbon inventory approaches** for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;

(ii) Provide estimates that are **transparent**, **consistent**, **as far as possible accurate**, and that **reduce uncertainties**, **taking into account national capabilities and capacities**;

(iii) Are transparent and their results are available and suitable for review as agreed by the Conference of the Parties;

The provisions say the following: for GHG estimations, it is appropriate to use the method which combines remote sensing data and ground-based carbon inventory; estimations should be transparent, consistent, as far as possibly accurate, and that reduce uncertainties, while taking into account national capabilities and capacities. Therefore, in the preparation of AD, the following needs to be taken into account when developing methodology: consistency with existing forest maps when creating categories; efforts to reduce uncertainties regarding the forest maps; consistency in the satellite data used for making maps; and setting categories for classification by taking into account the analysis capabilities that Vietnam has.

The requirements suggested by various international organizations are reviewed next. Major reference is the "REDD source book" which are prepared by GOFC-GOLD. This textbook was introduced and its importance was emphasized at SBSTA. The REDD source book recommends that resolution of time and space and availability of historical data be considered in order to estimate carbon stock using satellite imagery. Landsat TM (Thematic Mapper) data contains a full historical data which includes data going back to the 1990s. In order to identify forest degradation, the Landsat TM (with the ground resolution of 30 m) may not be enough; moreover, it needs high level of skills to interpret the data on the forest degradation. Employing the MODIS satellite data to estimate deforestation may bring argument because the methodology may neglect small scale of deforestation. However, the REDD source book mentions that multi-temporal data can detect historical trend of forest change easily. These discussions realize that each kind of the satellite data has advantages and disadvantages on generating RELs/RLs.

2.1.2 Existing Data for Grasping Forest Changing Trends in Vietnam

As mentioned above, it is important to collect data by taking into account the local circumstances including the possibilities of using existing data, the survey systems and the analysis capabilities of each country. In Vietnam, FIPI of MARD and MONRE create forest related maps. Forest distribution maps are mandated to FIPI and have been created through the National Forest Inventory (NFI) every five years since 1991 based on the law. These existing forest distribution maps have been approved by the national government and used for various statistics and policies.

Table 2.1.1 Existing Forest Distribution Map

Project Title	Survey periods	Data Sources
National Forest Resources Inventory program	1989－1992	Field inventory
National forest resource changes inventory and assessment	1991 – 1995	Landsat MSS and Ladsat TM
National forest resource changes inventory and assessment	1996 – 2000	Landsat ETM+ and SPOT4
National forest resource changes inventory and assessment	2001 – 2005	Landsat ETM+
National forest resource changes inventory and assessment	2006 – 2010	SPOT4 and SPOT5

Although the first forest distribution maps made in about 1990 use some of the Landsat TM data, many maps have been created through ground-based surveys and kept in the form of hard copy. Therefore, digitalization of the maps and the improvement of accuracy using satellite data are important tasks.

Satellites with different resolutions are being used such as Landsat TM with spatial resolution of 30 m, digital Landsat7-ETM+ with resolution of 15 m, SPOT4 image with resolution of 20 m and SPOT5 images with resolution of 2.5 m. SPOT5 satellite imagery with a resolution of 2.5 m (higher resolution than the satellite imagery used in the past) were used to create the fourth NFI maps. It is effective in terms of improving accuracy, but this change needs to be handled with care in terms of ensuring consistency of methods.

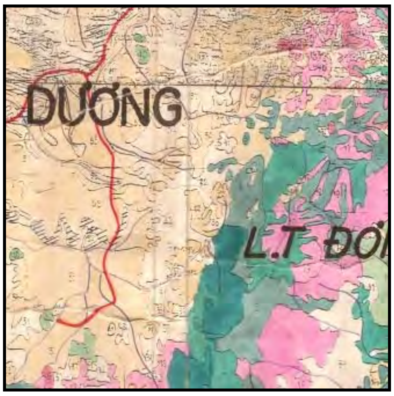


Figure 2.1.1 Existing Forest Distribution Map from 1990 (Hard Copy)

Figure 2.1.2 Landsat TM Image from 1990

2.2 Methodology of Preparation of Forest Distribution Maps

It was decided that the existing maps shown in Table 2.1.1 would be digitalized, their accuracy would be improved as part of efforts to obtain AD and to prepare the basic data needed for the development of RELs/RLs, based on the international requirements reviewed in 2.1 above. The following basic policies were followed when preparing the data.

- 1990 was a turning point after which deforestation was controlled and forestation was promoted through the implementation of the circular 661 policy. Therefore, in order to develop RELs/RLs which accurately reflect the situation in Vietnam, it is essential to include data on changes in forests dating back to 1990.

- Existing forest distribution maps are utilized and maps for the missing parts are created. In order to ensure time consistency, the forest distribution maps from 2010 are used as the benchmark maps based on which past classification results are corrected.

- As Table 2.1.1 shows, each set of forest distribution maps are not created within one year, but they are created over several years. Therefore, it is necessary to determine the year for each set of forest distribution maps. In the project, the years of forest distribution maps were defined as follows.
  1989-1992: Forest distribution maps for 1990
  1991-1995: Forest distribution maps for 1995
  1996-2000: Forest distribution maps for 2000
  2001-2005: Forest distribution maps for 2005
  2006-2010: Forest distribution maps for 2010

- Visual interpretation of the Landsat TM, ASTER, ALOS and SPOT satellite data are used to supplement the missing parts of the maps. The visually interpreted items are based on Decree number 01/2008/NĐ-CP dated 03/01/2008.

The diagram below shows the procedures for preparing AD based on the basic policies above.

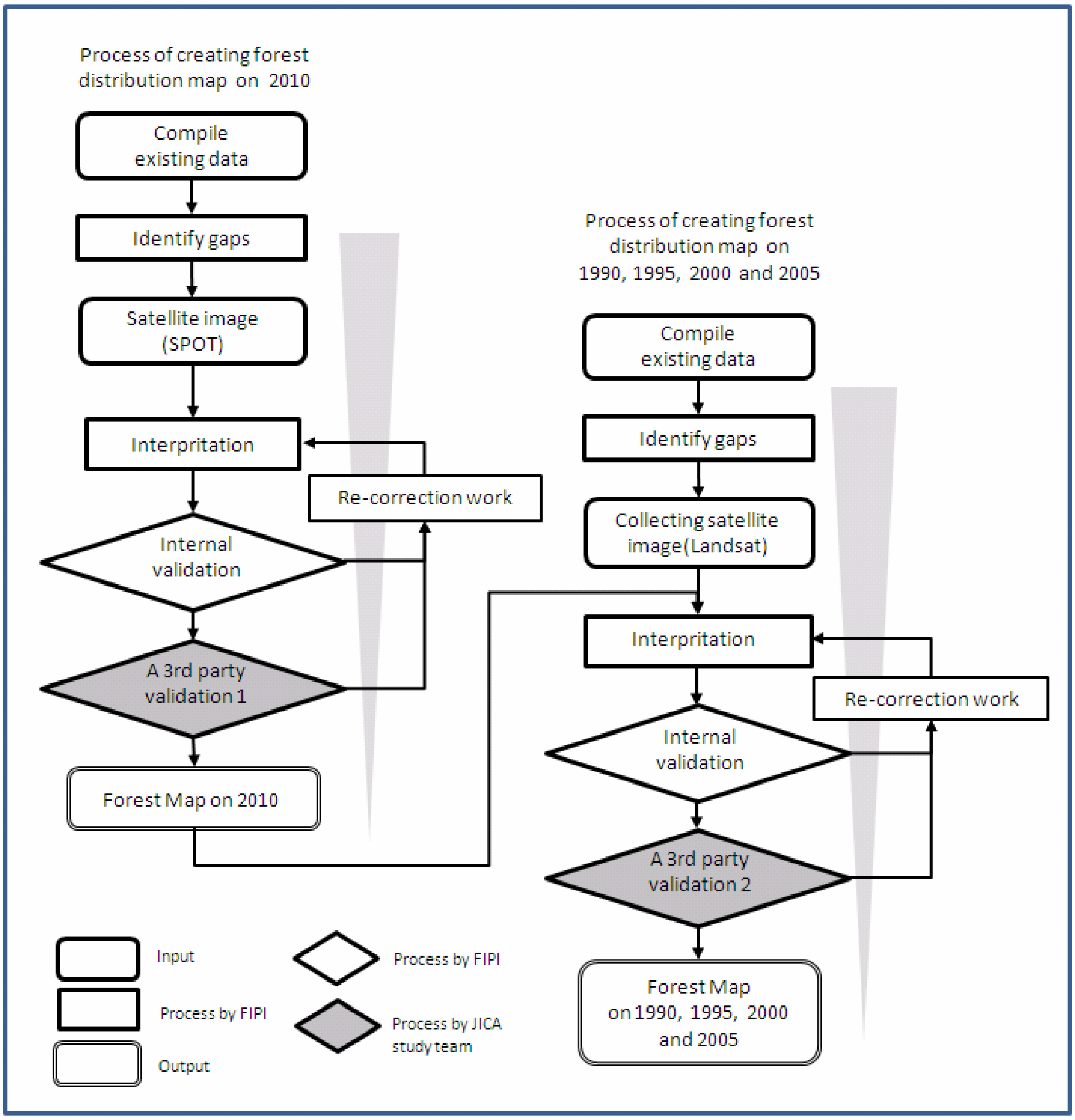


Figure 2.2.1 Flow Chart for the Preparation of Activity Data

2.2.1 Compilation of Existing Data

It is necessary to compile existing data in a database after resolving differences in categories for classification and differences in the projective methods used. Much of the data before year 2000 uses the UTM (Universal Transverse Mercator) coordinate system and much of the data after year 2000 uses the Vietnamese VN2000 coordinate system. Therefore, the UTM coordinate data was converted to the VN2000 coordinate data.

The definition of forest in Vietnam and 17 classifications of the forest distribution maps are examined as follows. Generally, forest definition in Vietnam changed towards making the definition more details and specific, particularly the definition of forest is in line with the international definition. There are mainly three effective forest definitions and classifications, decision 84, circular 34 which is nearly equal to the forest protection and development law, and DNA. DNA is only used for CDM.

Table 2.2.1 Forest definition regulated in legal documents in Vietnam

Legal document	Description of forest definition
Regulation No. QPN6-84	● Forested land is the area consisting of wood trees, bamboo and non-timber forest product growing with the canopy cover of 0.3 or more
Forest Protection and Development Law 2004	● Forest means an ecological system consisting of the populations of forest fauna and flora, forest microorganisms, forestland and other environmental factors, of which timber trees and bamboo of all kinds or typical flora constitute the major components with the forest canopy cover of 0.1 or more. Forests include planted forests and natural forests on production, protective and special-use forestland. ● Forest canopy cover means the degree of coverage of forest canopy over forestland, which is indicated by the decimal fraction of the forestland covered by the forest canopy to the forestland acreage.
Designated National Authority (DNA)	Forest has to meet the following criteria: ● has a minimum tree crown cover of 30%; ● has a minimum tree height of 3 meter; and ● has a minimum area of 0.5 hectare;
Circular Number 34/2009/TT-BNNPTNT	An object is considered a forest if it meets all 3 following criteria: ● is an ecological system which mainly consists of long term wood trees, coco species with the height of 5.0 m or more (excluding new plantation forest and mangrove forest), bamboo species, where can provide timber, non-timber forest product and direct or indirect value such as biodiversity conservation, landscape conservation. Newly planted forests with woody trees or new regeneration forest after harvesting plantation forest with average height of trees more than 1.5 m for slow growing species and more than 3.0 m for fast growing species and with the density of 1,000 trees per hectare or more is considered a forest. ● Canopy cover of the main tree species of the forest is 0.1 or more. ● Has a minimum block area of 0.5 ha. In case of trees strip, a minimum width of strip is 20 m and there are at least 3 rows of trees in a strip.

Reference: NORDECO (2010), Report on Existing National Forest Resources Data Assessment

In addition to those regulated in legal documents, there is one more forest classification system, Cycle-4, particularly developed for Forest Inventory by FIPI in 2008. Thus, the forest distribution maps from 1990 to 2010 in Vietnam are made based on three kinds of forest classification systems, Decision 84 approved in 1984, Cycle-4 developed by FIPI in 2008, and Circular 34 approved in 2009 (see below chart). Because forest classification systems are mainly designed for management regime in the context of Vietnam, it is changed over time based on the requirement of management. When those are revised, the maps follow most recent forest classification systems.

(1) Since different indicators are used among Decision 84, Cycle-4 and Circular 34 in each time series, the accuracy of the maps were not consistent. To meet the new requirement for designing for carbon related project, 17 land classification system was developed in 2010 to harmonize them to create land distribution maps with time consistency among three time series (1990, 2000 and 2010) with a cooperation of NORDECO project and FIPI. JICA Study Team follows this 17 land classification system to establish REL of five time series (1990, 1995, 2000, 2005 and 2010) in Vietnam.

(2) To harmonize the classification systems among decision 84, Cycle-4 and Circular 34, following chart is made to harmonize three classification systems.

(3) Modification of the maps from 1990 to 2005 in this year 2011 follows the newest indicator of Cycle-4 based on circular 34. Thus, definition of 17 categories follows circular 34.

Table 2.2.2 Forest distribution maps (1990 to 2010) and forest classification systems

Decision 84
✓ Decision 84 defines the indicators of forest stratification such as basal area, diameter, height of trees and forest structure. ✓ Those were used for making the original maps of 90, 95, 00, and 05 until circular 34 approved in 2009. ✓ See Appendix 16 for more detailed contents.
Cycle-4 of the FIPI system since 2008
✓ The classification between Cycle-4 and Circular 34 are almost equal except bamboo forest, alum forest land, plantation, and bare land in forest area. ✓ The newly indicators are defined in Circular 34, the original (the original vegetation) of the forest and volumes of the trees etc. ✓ Thus, making a map of 2010 follows the indicator of the circular and revising the maps of 90, 95, 00, and 05 after the year 2009 as well. ✓ See Appendix 16 for more detail about circular 34 and its relationship between Cycle-4.

Reference: Hearing from FIPI

2.2.2 Identification of Gaps

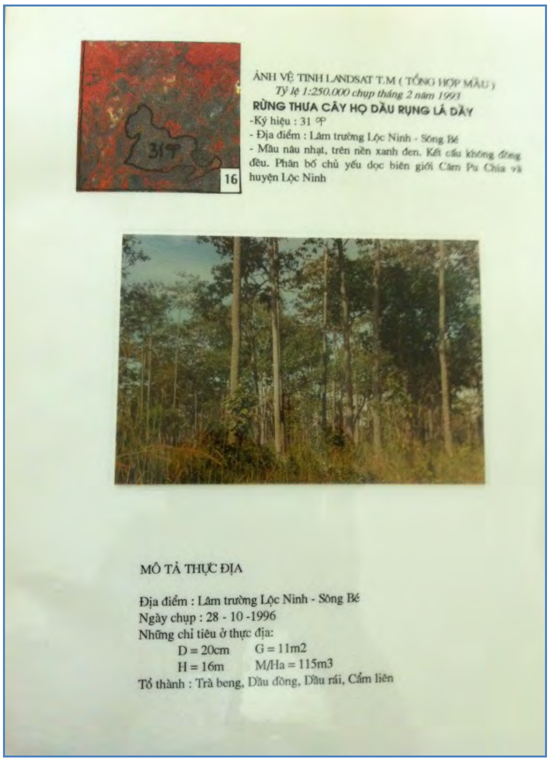
The 1990 forest distribution maps need to be digitalized since they are kept in the form of hard copy. In addition, the 1990 forest distribution maps were created based on ground-based surveys without using satellite data. In this situation, the Study team decided to carry out re-interpretation of the forest distribution maps by overlaying them on the Landsat satellite data.

In order to re-correct classification results for the forest distribution maps of year 1995 and the forest distribution maps of year 2000, Landsat satellite data was collected. For the forest distribution maps of year 2005, Landsat satellite data was collected for re-interpretation as well as collecting the ASTER satellite data in order to complement the missing data for the Mekong river basin and the Red river basin.

SPOT satellite data was available for year 2010 in MONRE, but there were missing data for some provinces. Therefore, ASTER satellite imagery was collected to supplement the missing data for the Mekong river basin and the Red river basin. (see Appendix 17 for a list of the satellite data collected).

2.2.3 Visual Interpretation for Filling Gaps

Interpretation of the satellite data is carried out by FIPI because FIPI has enough experience in the visual interpretation of satellite data and is expected to continue playing an important role in creating forest distribution maps. In this regard, it was considered that FIPI is considered as an appropriate institution to conduct the data development work. However, it is necessary to pay attention to the fact that, although FIPI has much experience in visual interpretation, the accuracy of forest distribution maps depends on the skill levels of the experts who conduct the interpretation. Therefore, an interpretation manual was developed and the utilization of interpretation data cards (see Figure2.2.2) was mandated in order to standardize accuracy of interpretation. The most difficult interpretation is to categorize evergreen forests into “Rich,” “Medium” and “Poor” in accordance with stem volumes. This is an essential item to interpret because without this interpretation, it will be impossible to identify forest degradation in AD. This suggests that there are many uncertainties in the interpretation results for forest degradation.



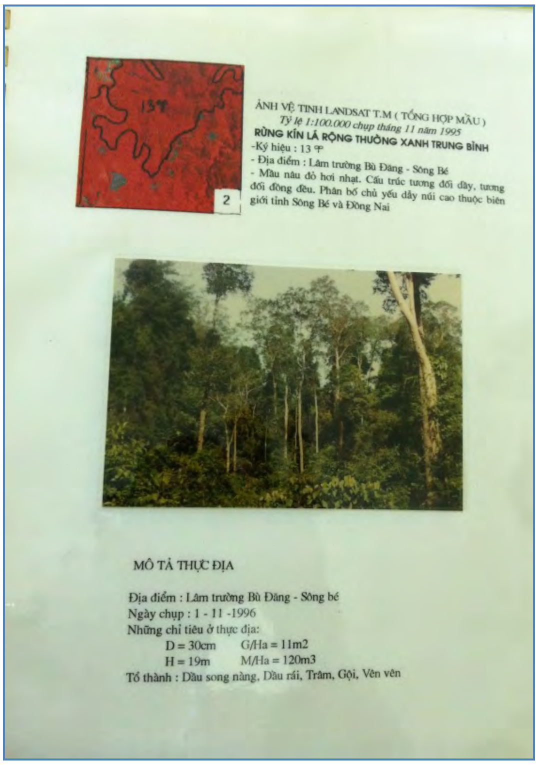


Figure 2.2.2 Example of Textbook about Interpretation Key

2.2.4 Securing Classification Consistency

The forest distribution maps of year 2010 are produced on the basis of satellite data of SPOT as a main and ALOS as a part. Due to its high resolution images (2.5 m), the maps are highly accurate. On the other hand, the forest distribution maps before year 2010 were mainly produced using the Landsat satellite and are less accurate due to the 30 m resolution. It is necessary to take measures to ensure consistency of integrating data when two sets of satellite data which have different resolutions are used as time-series data.

Therefore, after the creation of the forest distribution maps of year 2010, the data and the forest distribution maps of year 2005 were compared and the consistency between the classification results was checked. Similarly, the forest distribution maps of year 2005 and the forest distribution maps of year 2000 were compared and the continuity of the interpretation results was checked. For example, if a certain area that was an evergreen forest in 2000 had changed to non-forested land in 2005 and then changed back to evergreen forest in 2010, it can be considered that there was an interpretation error because such dynamics are unlikely to happen within the parameters of normal forest change. In order to avoid these types of errors, maps were corrected by taking into consideration the continuity of analysis results, using the forest distribution maps of year 2010 as the benchmark maps. The draft forest distribution maps were created through the process explained above.

2.2.5 Verification by a Third Party

On the way producing the forest distribution maps, a third party check is carried out as Quality Control (QC) in order to improve the accuracy and precision of making the maps. A third party check consists of two steps:

(1) Outline check at small scales between 1/500,000 and 1/700,000; and

(2) Detail Check at large scales between 1/100,000 and 1/200,000.

When any errors and problems of the data are found through a third party check, the Study team asked FIPI to re-correct them respectively. This process was repeated several times in order to improve the quality.

A third party check focused on the time-series consistency of classification results conducted through visual interpretation. The scale to be used was decided on based on the results of the following discussions, by taking into account the limited imaging abilities of the Landsat satellite data. According to GOFC-GOLD (Global Observation of Forest and Land Cover Dynamics), satellites with the Landsat TM resolution level are suitable for understanding forest dynamics at the national scale. The appropriate scale of the forest distribution maps are decided by the resolution of satellite imagery which are used to make the maps. In other words, the satellite imagery should not be used to make more detailed maps than the appropriate scale. When looking at the Vietnamese forest distribution maps, it is appropriate to use the maps as national scale or Agro-Eco region scale maps. The resolution level of the Landsat satellite data may not be detailed enough to be used for provincial scale or more detailed maps.

Based on the above discussion, abstract of Outline check at small scale and Detail check at medium scale conducted in the Study are explained below (see more detail in 2.4).

(1) Third Party Verification (Outline)

Outline check was conducted to compare the forest distribution maps of five time series of data in each province at small scales between 1/500,000 and 1/700,000, in order to detect obvious errors focusing on the misidentification of forest types and time consistency.

(2) Third Party Verification (Detail Check)

A detailed check was conducted for the draft forest distribution maps which passed the general check. Further detailed checks were conducted at small scales between 1/100,000 and 1/200,000. The detected errors were compiled in an error report and fed back to the interpreters for confirmation.

2.3 Result of Development of Activity Data

Forest distribution maps were created for five points in time starting with the forest distribution maps of year 1990. Figure2.3.1 and 2.3.2 show those in national scale. The forest distribution maps for each province as the outputs of the Study are stored in the DVDs, which were separately submitted.

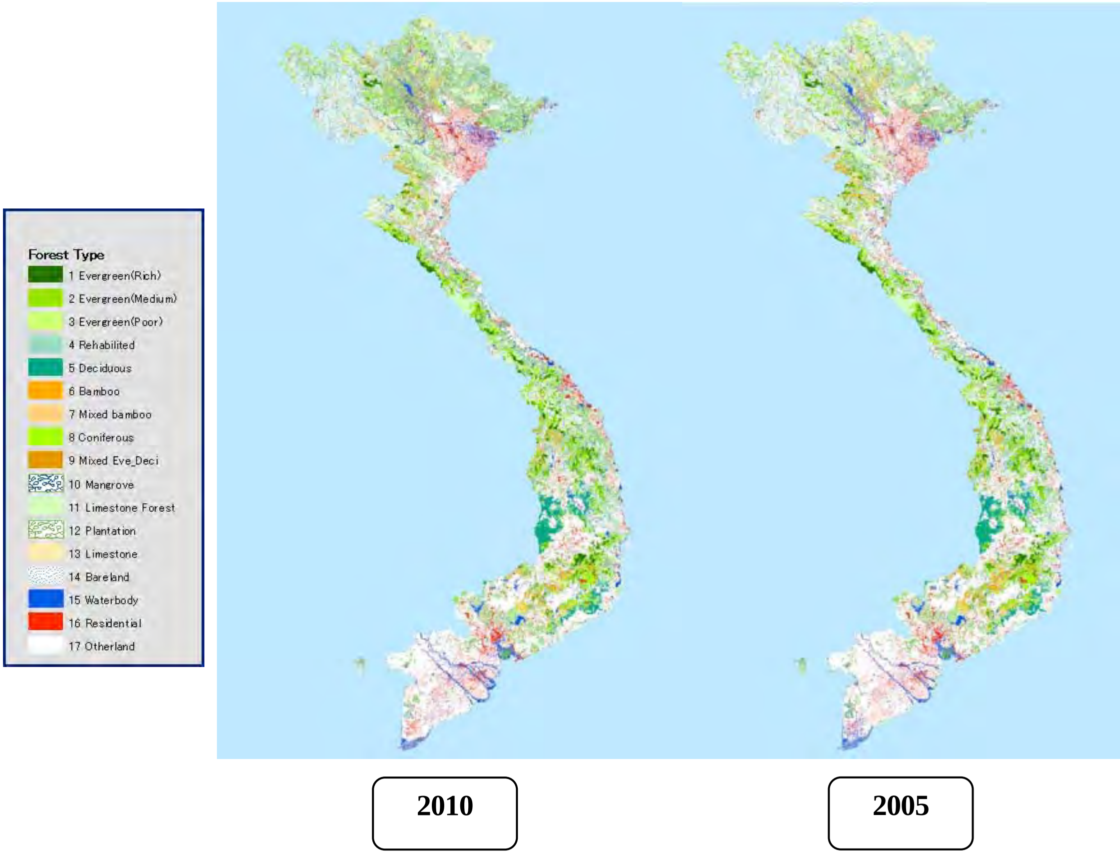


Figure 2.3.1 Forest Distribution Map of year 2010 and 2005

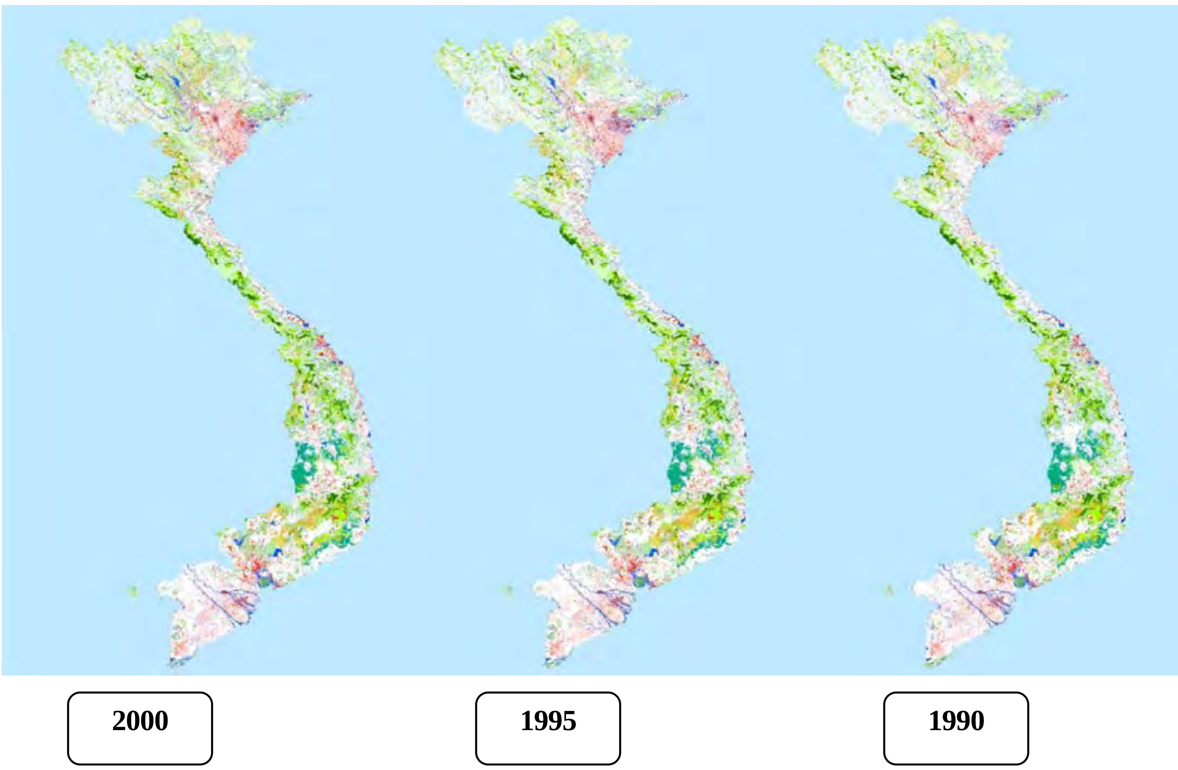


Figure 2.3.2 Forest Distribution Map of year 2000, 1995 and 1990

Figure 2.3.3 and Table 2.3.1 show the aggregation results for forest type 1 to 14 in terms of forest change out of above forest distribution maps.

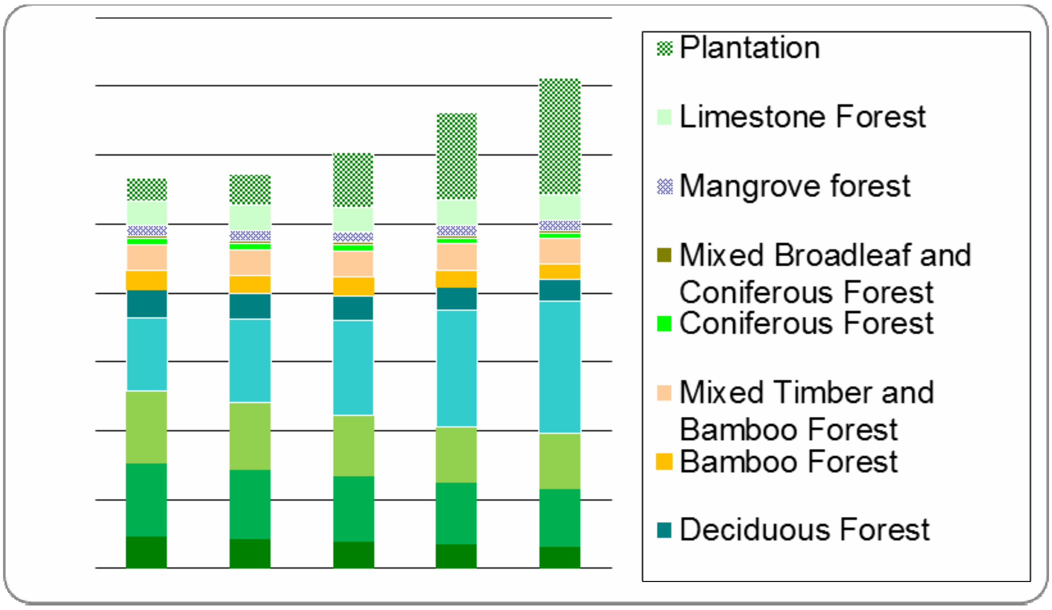


Figure 2.3.3 Dynamics of the Area of Land for Each Forest Type since 1990

(National Aggregation, Unit: 1,000ha)

Table 2.3.1 Forest Area of each forest type since 1990

Forest type / Year	1990	1995	2000	2005	2010
Evergreen Forest (rich)	928	777	777	691	636
Evergreen Forest (medium)	2,107	1,879	1,879	1,778	1,678
Evergreen Forest (poor)	2,096	1,790	1,787	1,635	1,590
Rehabilitation Forest	2,139	2,740	2,740	3,384	3,849
Deciduous Forest	812	720	720	667	642
Bamboo Forest	552	547	553	502	454
Mixed Timber and Bamboo Forest	761	760	765	754	717
Coniferous Forest	193	176	176	172	172
Mixed Broadleaf and Coniferous Forest	70	56	56	54	53
Mangrove forest	284	295	296	304	296
Limestone Forest	712	727	727	757	762
Plantation	675	1,590	1,591	2,520	3,368
Total	11,329	12,058	12,067	13,218	14,217

Figure 2.3.3 indicates that the total forested land area has generally increased since 1990, while the areas for all

the subcategories of Evergreen Forest and Deciduous Forest are decreasing. On the other hand, the area of Rehabilitation Forest keeps growing and has increased by 1.8 times when compared to the value in 1990. The area of Plantation has increased by five times. It is important to pay attention to changes in some areas from one forest category to another at different points in time. For example, Rehabilitation Forest (which is expanding) contains a mixture of degraded evergreen forests and shrubs developed on non-forested land. It is also worth noting that some areas on forest distribution maps remain Rehabilitation Forest five years later while others have changed into non-forested land due to slash-and-burn agriculture, etc. Even if the area of land has increased when comparing figures for two points in time, it is necessary to note that there may have been complex changes in land cover from one category to another.

The following summarizes the forest dynamics for each Agro-Eco region（Figure 2.3.4 ～ Figure 2.3.11).
When looking at total forested land in the aggregation results, forested land is generally increasing in the northern part of Vietnam and remains the same or slightly decreased in the southern part of Vietnam. The increase in the forest area in the north mainly comes from the increase in the area of Rehabilitation Forest and Plantation. The area of Evergreen Forest is generally decreasing. Therefore, forest increases and decreases are happening at the same time.

Evergreen Forest (Poor) is the main forest type which is in decline in the high land area which has the largest area of forested land in the southern part of Vietnam. There is no change in the total area of Evergreen Forest (Rich/Medium). However, it is necessary to note that this does not mean that the Evergreen Forest (Rich/Medium) is well preserved. This is because these figures include changes from Evergreen Forest (Rich) to Evergreen Forest (Medium) and vice versa, some of which has been offset with each other. This suggests that it is necessary to analyze local forest dynamics using GIS (geographic information systems) in order to understand the increase/decrease of the area of land covered by each type of forest.

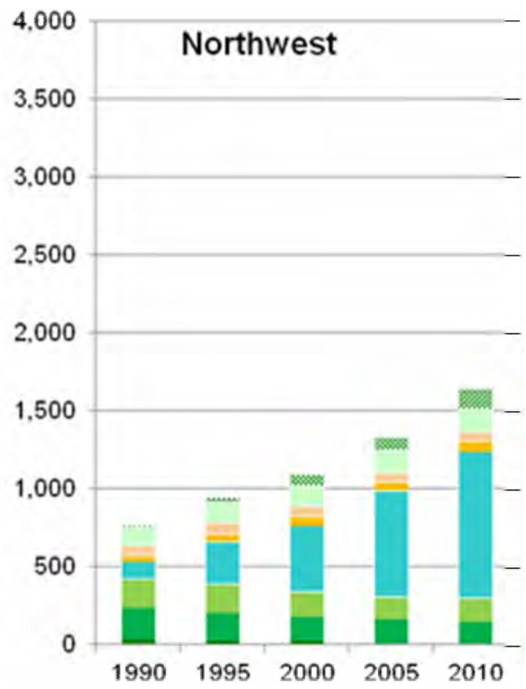


Figure 2.3.4 Forest Dynamics (North West)

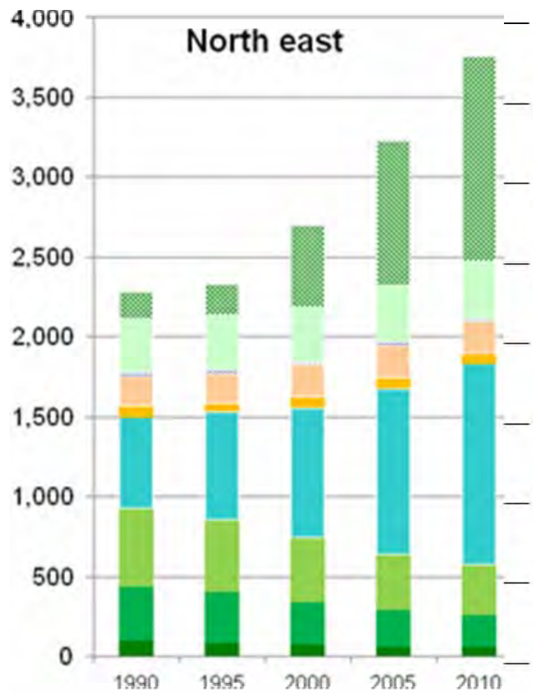


Figure 2.3.5 Forest Dynamics (North East)

Figure 2.3.6 Forest Dynamics (Red River Delta)

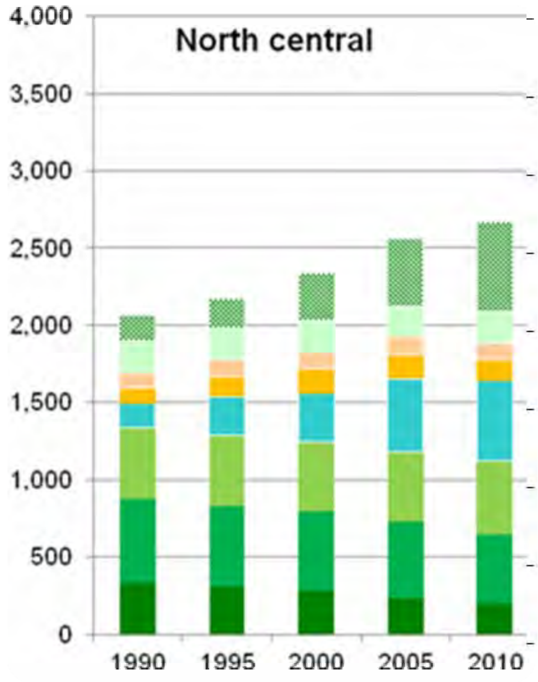


Figure 2.3.7 Forest Dynamics (North Central)

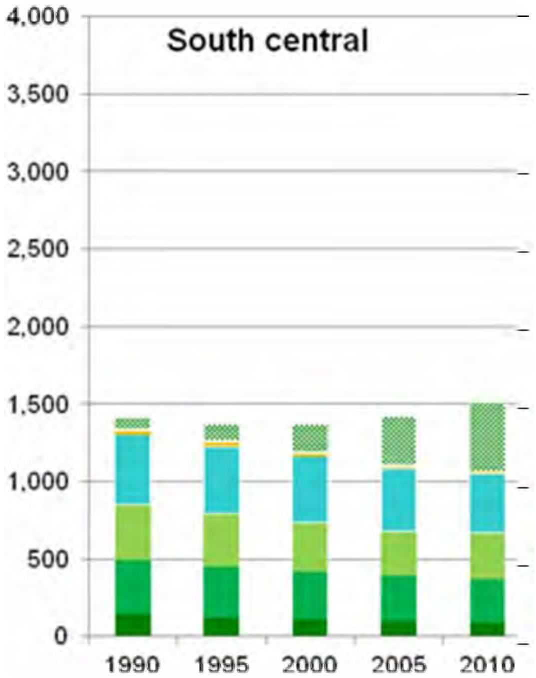


Figure 2.3.8 Forest Dynamics (South Central)

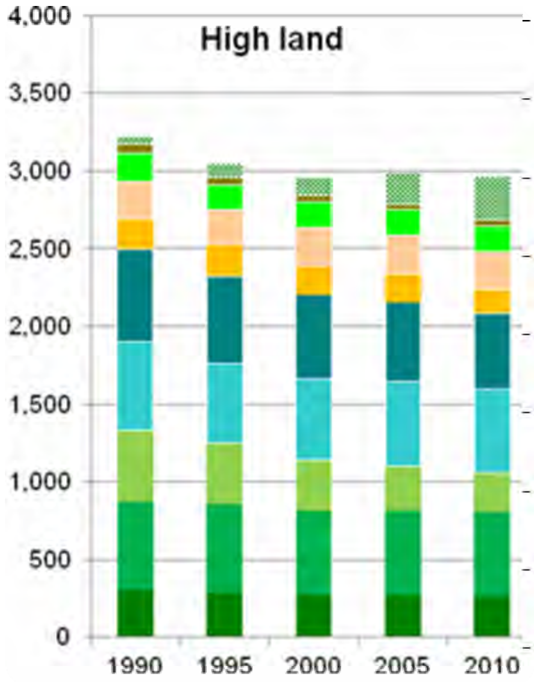
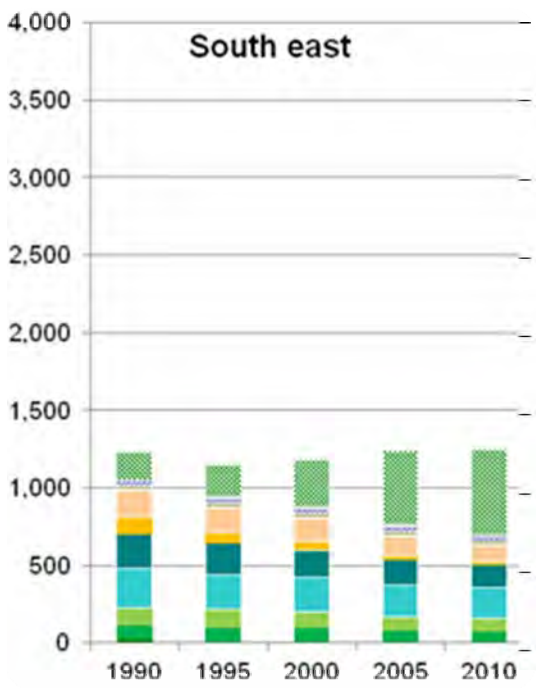


Figure 2.3.9 Forest Dynamics (High Land)



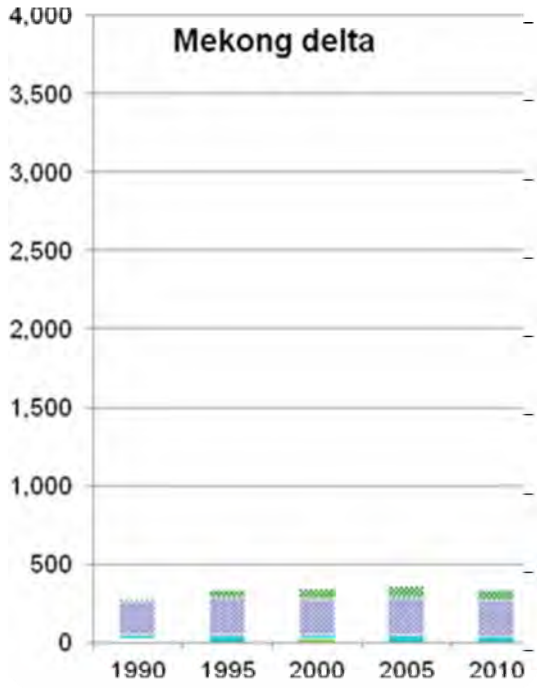


Figure 2.3.10 Forest Dynamics (South East)

Figure 2.3.11 Forest Dynamics (Mekong Delta)

2.4 Verification of Forest Distribution Map (Activity Data)

The guidelines for submission of RELs/RLs which were resolved at SBSTA 35 stipulate that transparency and accuracy of information must be ensured. In order to ensure transparency, it is necessary to go through the verification process and evaluate the uncertainties. This section reports on the verification results for the AD used to create RELs/RLs.

2.4.1 Detailed Methodology

The accuracy of the maps can be verified from various standpoints. In the Study, the accuracy of thematic maps was verified.

The verification of thematic map accuracy is a process for checking whether the classification results for each forest type are correct. There are three verification processes as part of the development of Activity Data, verification processes 1, 2, and 3:
(1) Verification process 1 is mainly for the purpose of QC and partially for the purpose of final check of the forest distribution maps of year 2010 using SPOT satellite data as a benchmark;
(2) Verification process 2 is for the purpose of QC of the forest distribution maps at five points in time using Landsat satellite data; and
(3) Verification process 3 is for the purpose of final check of the forest distribution maps at five points in time.

In order to carry out the QC in the verification process, QC is separated into two verification methods due to the lack of Ground truth. The Ground truth in 2010 can be used for verification of the satellite data taken in 2010 but not for the other old satellite data. Figure 2.4.1 and Figure 2.4.2 show the verification processes 1 to 3. Each process is described next.

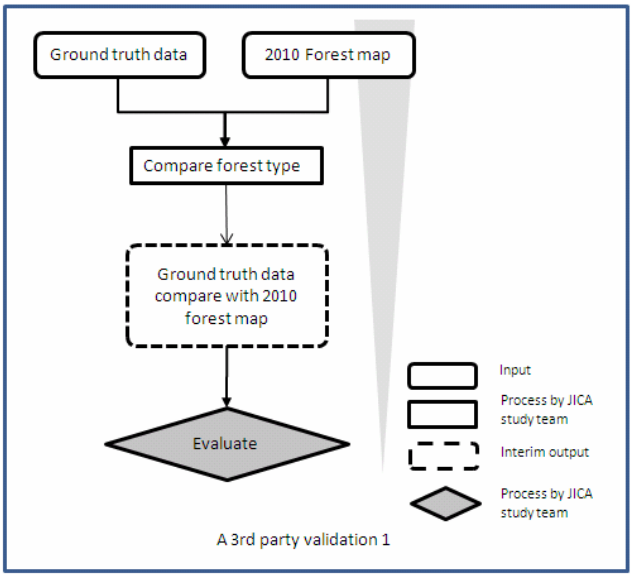


Figure 2.4.1 Process of the Verification 1

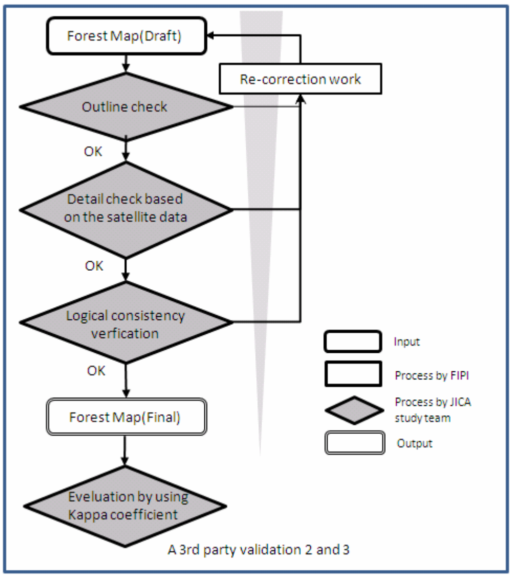


Figure 2.4.2 Process of the Verification 2

(1) Verification 1 for the QC purpose and final check purpose for forest distribution maps of year 2010

The verification 1 process includes not only the QC process but also the final check of verification 3. However, the former is the main purpose. For verification using the Ground Truth data in Verification 1, the basic method employed was to conduct the ground-based survey in order to obtain Ground Truth. It is important to implement it before time had passed after the images had been taken in order to evaluate the accuracy of the satellite classification data and to compare the ground-based survey results and the classification results for the relevant sites using positional information obtained from GPS (Global Positioning System). However, it is very difficult to obtain Ground Truth data for many points in order to cover all national land. Therefore sampling method is selected for the verification in the area where major forest types are existed.

(2) Verification 2 for the QC purpose for the forest distribution maps at five points in time

In verification 2, the outline check and the detail check were conducted. The guidelines on the submission of RELs/RLs (one of the resolutions at COP 17) stipulate that “consistency” needs to be ensured, but the interpretation of what “consistency” means varies. For example, consistency could mean consistency between RELs/RLs submitted in the past and newly submitted RELs/RLs, or consistency in the methods used. In Verification 2, the time-series consistency of thematic maps was verified. In this process, the consistency of the analysis results for the forest distribution maps at five points is conducted as explained in 2.2.5.

In this process, forest distribution maps were overlaid with satellite imagery using the GIS software and visual inspections were conducted to check whether the data was interpreted appropriately. The criteria for judgment were: 1) the appropriate borders are drawn to classify forested and non-forested land in accordance with the satellite imagery; and 2) the appropriate land cover categories were allocated for each area. The verification work was conducted on each forest distribution map and the map was considered to have passed the test if most of the area was consistent with the satellite imagery (about 80% of the total area of land) (Figure 2.4.3).

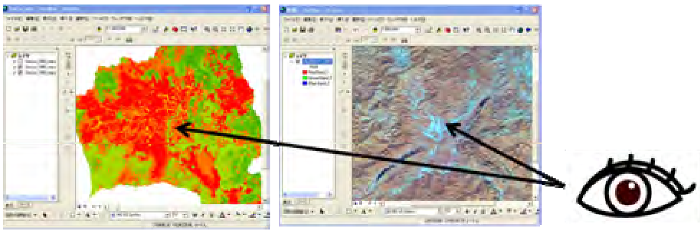


Figure 2.4.3 Evaluation Work

(3) Verification 3 for the final check purpose for the forest distribution maps at five points in time

In Verification 3, an equally spaced grid was placed on the created map, the third party interpreted whether or not the lattice points are on forested land or non-forested land, and the percentage of consistency with the final output of the forest distribution map was calculated. A typical way of verifying accuracy is to check the interpretation accuracy from the standpoint of the map producers ("Producer's Accuracy") and the accuracy from the standpoint of the third party ("User's Accuracy"), and to compare both results. However, Japanese experts are not necessarily familiar with forest types in Vietnam. Therefore, it is uncertain whether they could determine the forest types. Therefore, it was decided that they would only check and verify whether it was forested land or non-forested land.

2.4.2 Results of Verification

(1) Verification of the Forest Distribution Maps of year 2010 through Ground-Based Verification (Results of Verification 1)

Ground-based surveys were conducted from Oct 14th to Nov 16th in 2009 in order to evaluate the accuracy of the forest distribution maps. In the survey areas, evaluation of forest types and qualitative evaluation were conducted for a specific area of land. If survey areas are selected using random sampling, each survey point may contain multiple forest types and types of land cover. In order to avoid this, areas which have a homogeneous forest type was selected through visual interpretation and evaluation was conducted. Through this method, the evaluation eliminated bias derived from the levels of geometric correction accuracy and the levels of complexity of evaluation sites. The table below shows the survey results.

Table 2.4.1 Verification Results for the Accuracy of Interpretation of Forested/Non-Forested

Province	Incorrect	Correct	Sub-total
DakLak		3	3
Dien Bien		11	11
Gia Lai	2	4	6
Ha Tinh		5	5
Kon Tum	1	6	7
Lai Chau		13	13
Lao Cai		9	9

Nghe An		14	14
Quang Tri		6	6
Quang Nam	2	2	4
Thanh Hoa		5	5
Yen Bai		8	8
Sub-total	5	86	91

According to the table, 86 out of 91 points were correctly interpreted (the accuracy rate was 94.5%). The remaining five points were interpreted as forest, but they were non-forested land according to the Ground Truth results. Therefore, it is estimated that the error rate is 5%.

Out of the survey points which were correctly interpreted as forest, the survey points whose forest types were correctly interpreted accounted for 80%. Out of the survey points which were interpreted as Evergreen Forest, the survey points whose evergreen forest quality was correctly evaluated (Rich, Medium or Poor) accounted for 74%.

(2) Verification of the Forest Distribution Maps for before year 2010

FIPI provided the Study team with satellite imagery which they used for interpretation. At the technical meeting on the working report, the Study team explained the outline of the findings to FIPI and showed examples of sites which were found questionable using GIS. The participants discussed and agreed on whether or not the findings for each example were correct. The Study team then asked FIPI to check again and make corrections to each map. Forest distribution maps were created for each province and submitted as GIS data (the shape format and the projective method: UTM, Datum: VN2000 or WGS84. Maps were created for five points in time, 1990, 1995, 2000, 2005 and 2010. Evaluation was conducted for two points in time which were selected randomly out of the five points in time, for each province. The scales used for the work was decided to be between 1/100,000 and 1/200,000 as a result of discussions with FIPI.

Table 2.4.2 shows the main findings (points where incorrect interpretation may have occurred) for each map

Table 2.4.2 Main Findings of Possible Misinterpretation of the Forest Distribution Maps

No	Findings
A	Projection of forest maps is different from the satellite imagery.
B	Study Team cannot understand the reason of the interpretation of some polygon.
C	Unsuitable classification of the forest type
D	Several different forest types are included in one polygon.
E	Several different forest types are included in one texture and color of the satellite imagery.
F	Several re-corrections indicated by the JICA Study team in May 2011 have not done by FIPI.
G	Others

The most common problems found by the Study team were finding B and C. Finding B indicates that the polygon being placed on a forest distribution map is unclear (Figure 2.4.4). Finding C indicates that the land cover category allocated to a map does not match the land cover type assumed from the color on a satellite image.

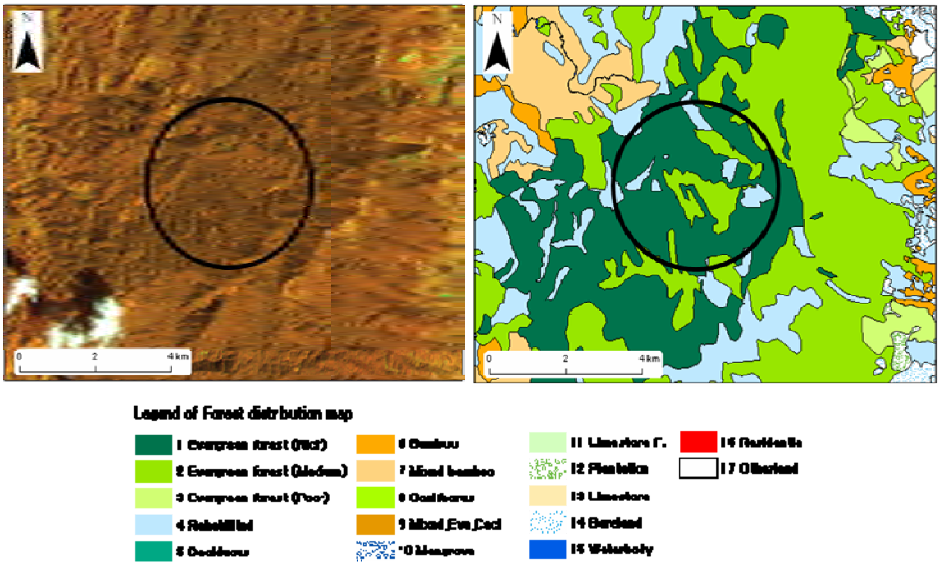


Figure 2.4.4 Examples of Findings

(Finding B: Unclear Reason for Interpretation of Some Polygons)

There were also other cases where an area which has the same color (land cover) on satellite imagery was classified into multiple different land cover types. In addition, there were cases where a forest distribution map for a certain year was simply copied to make a forest distribution map for another year, as well as cases where numerous small polygons were created on a map (about 110,000 polygons out of about 140,000 polygons were less than 25 ha). The following summarizes these findings.

- Corrections were made for several to 10% of the relevant land area.
- For some of the corrected sites, it was not clear why such changes were made.
- There are still many sites where the interpretation does not match the satellite imagery and the reason for the interpretation is unclear.

Due to this situation, it was determined that it is necessary to ask for re-correction for some of the provincial maps which were re-submitted, and the classification results were revised.

(3) Verification of the Forest Distribution Maps Based on the Percentage of Consistency between Two Parties' Interpretations (Results of the Verification 3)

Forest distribution maps are created mainly using the Landsat satellite imagery and the SPOT satellite imagery. They are created for several points in time. Therefore, verification was conducted by focusing on these factors. The method employed was to calculate the percentage of consistency between the results of interpretation by FIPI and the results of interpretation by the third party. A 4 km interval grid (lattice points) was placed on the forest distribution map of the area subject to the test and the percentage of consistency for the interpretation on the lattice points was calculated.

The areas subject to the test and the verification results are shown below (Table 2.4.3, Figure 2.4.5 ~2.4.8).

Table 2.4.3 Results of the Percentage of Consistency of the Forest Distribution Maps

Year	Satellite	Region	Province	Number of points verified	Percentage of consistency (%)
1990	Landsat	North East	Yen Bai / Phu Tho	655	88.9
2000	Landsat	Central High Land	Dac Lak	821	80.4[2]
2010	SPOT	North West	Lai Chau / Dien Bien	1,150	96.7
2010	SPOT	South Central	Quang Nam	656	94.4

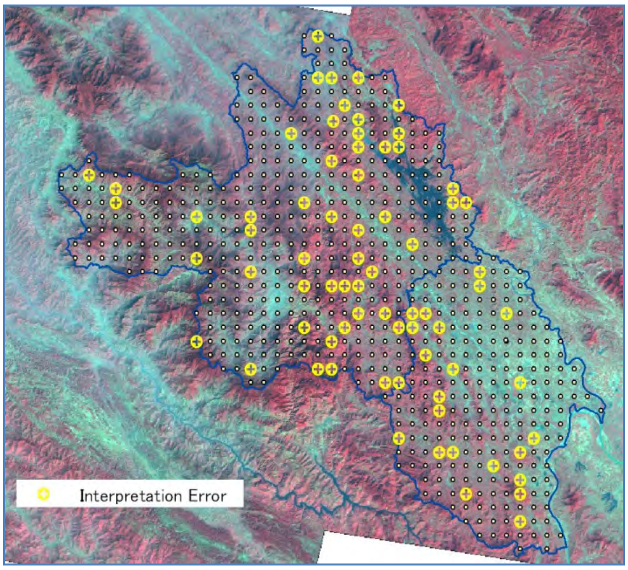


Figure 2.4.5 Verification of the Forest Distribution Map of year 1990 (Yen Bai Province and Phu Tho Province)

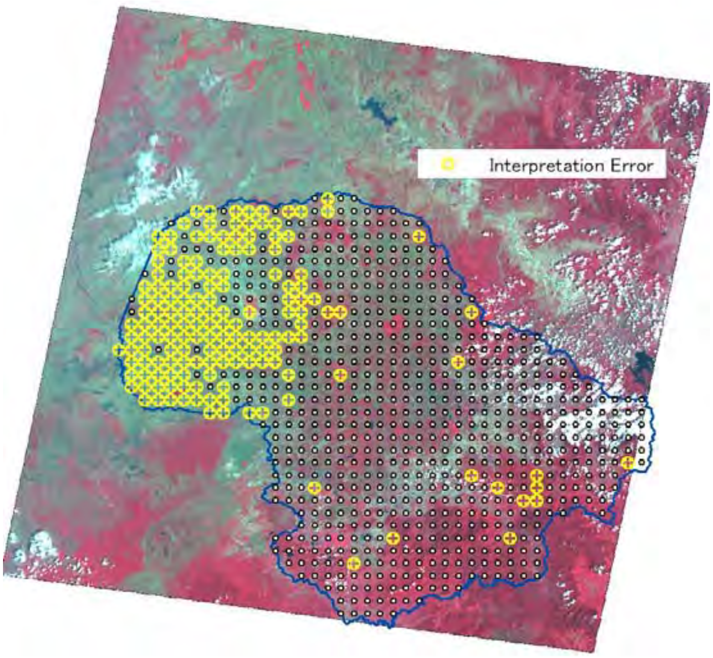


Figure 2.4.6 Verification of the Forest Distribution Map of year 2000 (Dac Lak Province)

[2] The percentage of consistency was 89% when corrections were made using ground-based surveys and past materials as supplementary data.

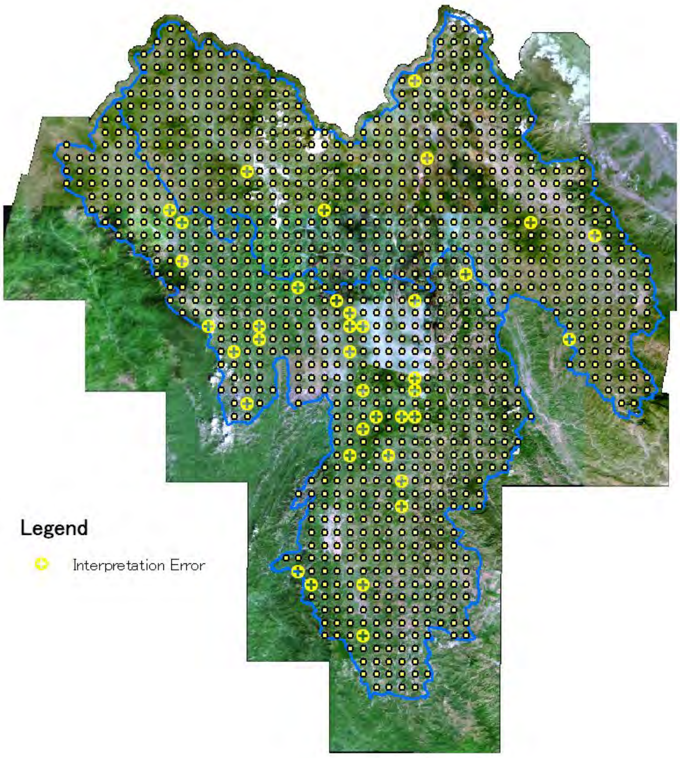


Figure 2.4.7 Verification of the Forest Distribution Map of year 2010 (Lai Chau Province and Dien Bien Province)

Figure 2.4.8 Verification of the Forest Distribution Map of year 2010 (Quang Ninh Province)

Verification for the forest distribution maps of year 2000 was conducted for Dac Lak Province. As a result, the interpretation results did not match for most of the border area in the western part of the country. This is because the areas which were interpreted as forested land by FIPI were interpreted as non-forested land by the third party. As a result of checking the satellite data taken in different seasons and interviewing engineers who are familiar with the forests in the relevant areas, it was discovered that the areas are mainly covered with deciduous forest. The Landsat satellite imagery used to create the forest distribution maps were taken during the defoliation period, and the deciduous forest areas were interpreted as non-forested land. However, there were also cases where some areas were correctly interpreted as deciduous forests by referring to supplemental information. After taking into consideration this fact, the percentage of consistency was corrected from the original about 80% to 90%. In addition to using satellite data, FIPI also added corrections to their interpretation results using additional information such as information obtained on the ground. This means that the percentage of consistency calculated based on the results of interpretation by the third party may not be always correct. This highlights that there are problems to be solved in third party verification.

As a result of verification, the accuracy of the interpretation for forested/non-forested land using the Landsat satellite data was estimated to be around 90%. It is thought that errors are almost evenly distributed to all areas rather than being localized. On the other hand, the accuracy of interpretation for forest/non-forested land using the SPOT satellite data was estimated to be around 95%. The accuracy of interpretation for forested/non-forested land through verification 3 was also estimated to be around 95% when verification 1 was conducted using ground-based surveys. Therefore, it was confirmed that it is possible to create forest distribution maps with a 95% accuracy rate if SPOT satellite imagery are used. It can be concluded that the higher accuracy was achieved because the resolution of the SPOT satellite is 2.5 m although the resolution of the Landsat satellite is 30 m.

The fact that the accuracy of classifying land into forested land and non-forested land is 95% means that it is possible to estimate the AD for deforestation with the same level of accuracy. On the other hand, in order to work out the accuracy for evaluating forest degradation, it is necessary to quantify the accuracy of the classification of Evergreen Forest (Rich) and Evergreen Forest (Medium). Ground-based survey results (verification 1) show that the classification accuracy is about 75%. In the present study, the estimation of the percentage of consistency for forest degradation based on the third party interpretation could not be conducted because such third party verification requires higher levels of interpretation skill which takes into consideration supplementary information such as on-the-ground information.

2.5 Recommendation

As is emphasized in the REDD+ mechanism, estimates to be submitted need to be consistent, transparent, certain and complete method. The following gives recommendations for improving the current methods to create AD from these standpoints.

First, change analysis technology which ensures consistency can be introduced. Past forest distribution maps were made at each point in time without referring to the previous forest distribution maps. In the Study, analysis results for past forest distribution maps were tried to be corrected based on the forest distribution maps of year 2010 considering as a benchmark in order to ensure consistency. However, correction work has its limits.

When creating new forest distribution maps, it is desirable to follow the procedures for identifying non-changed areas and changed areas by referring to the polygons on previous forest distribution maps and then identifying land cover types and forest types for the changed areas. The main reason why this method is recommended used is because the relationship difference between the accuracy of the method used to estimate changes and the actual amount of change may become more appropriate and feasible. For example, if the actual amount of change is small, the accuracy of identifying changes needs to be high enough to fully detect the small change. Otherwise, there is a chance that fluctuations created due to uncertainties which are derived from the low level of accuracy may exceed the actual amounts of changes. In order to use this method, object-oriented forest classification is expected to be useful.

Second, the introduction of change analysis technology which takes into account the level of certainty is recommended. FIPI has been relying on visual interpretation for classification analysis. In the verification process for developing AD, it was discovered that many forest distribution maps for specific regions needed classification revision, but this trend was not found for forest distribution maps made in specific years. This suggests that the development of forest distribution map accuracy may depend on the level of experience of those who conduct the interpretation. This means that this visual interpretation method causes the bias among operators of interpretation and increases the level of uncertainty concerning forest distribution maps nationwide and the AD cannot be considered to be created using a method which ensures certainty.

Some efforts are effective in standardizing analysis accuracy or increasing accuracy. For example, it would be very useful to conduct standardized and constant interpretation training for analysis technicians as well as taking the technicians on ground-based verification surveys. These capacity building activities as well as the improvement of analysis technology and software are recommended.

The above-mentioned object-oriented image analysis software does not rely on the skill of users. It can create the same interpretation results by inputting specific parameters. It is expected that the use of such software will improve the situation where the above difficulties of creating forest distribution maps through different technicians.

As a conclusion, it is recommended that the QA/QC (quality assurance/quality control) process should be clarified and its results should be fed back into the analysis work. There was no verification procedure for the accuracy of the existed created forest distribution maps nor was there a procedure to feed back the verification results to the technicians engaged in the creation of maps. Therefore, it is surmised that efforts to improve the techniques of these technicians were not made or were limited. In order to reduce uncertainties, it is important to improve the accuracy of the systematic interpretation techniques by creating a continuous system for the QA/QC system as well as conducting regular training for the above-mentioned analysis.

3. Development of Forest Volume and Biomass Data as Emission Factor

In order to develop interim RELs/RLs, it is important to understand the historical changes in the size of each forest type and to understand the carbon stock level per unit area for each type of forest. The former is referred to as Activity Data (AD) and the latter is Emission Factor (EF). This chapter explains the process of developing EF in Vietnam, the method used and results obtained from the development of EF through the collection of past National Forest Inventory data.

3.1 Existing Data for Calculating Emission Factor in Vietnam

The AD is multiplied by EF to produce emissions estimates. It is necessary to develop an Emission Factor for each forest type which is defined for the AD. To what extent carbon pools and GHGs are included will be decided on based on the existing data situation and the amount of work needed to prepare new data.

The ground-based survey systematically conducted in the whole of Vietnam is called the National Forest Inventory, Monitoring and Assessment (hereinafter referred to as "NFI"). This is the only ground-based data that has been obtained in an integrated manner nationwide. Therefore, data collected in the NFI is useful for calculating EF.

The NFI has been conducted four times since 1991. The systematic sampling survey design (which uses around 8 km lattice points) has been adopted although the number of survey points was changed each time due to changes in the design because of revisions to the estimation accuracy.

Table 3.1.1 List of Existing Maps

Project Title	Survey periods	Number of Plots
NATIONAL FOREST INVENTORY, MONITORING AND ASSESSMENT, Cycle-1	1991 – 1995	3,000
NATIONAL FOREST INVENTORY, MONITORING AND ASSESSMENT, Cycle-2	1996 – 2000	3,800
NATIONAL FOREST INVENTORY, MONITORING AND ASSESSMENT, Cycle-3	2001 – 2005	4,200
NATIONAL FOREST INVENTORY, MONITORING AND ASSESSMENT, Cycle-4	2006 – 2010	2,100

Each 8 km interval plot is an L-shaped transects. It is made up of 20 sub-plots extending north and 20 sub-plots extending east. Each sub-plot is a 25 m × 20 m rectangle survey plot. Tree measurement is conducted on each sub-plot. In the case of natural forests, all trees with at least a 6 cm diameter at breast height (DBH) of 1.3 m become subject to the recording of the DBH and the species. Regarding the tree height, three trees are selected from areas close to the central part of each sub-plot and the trees are measured from the base on the ground to the top.

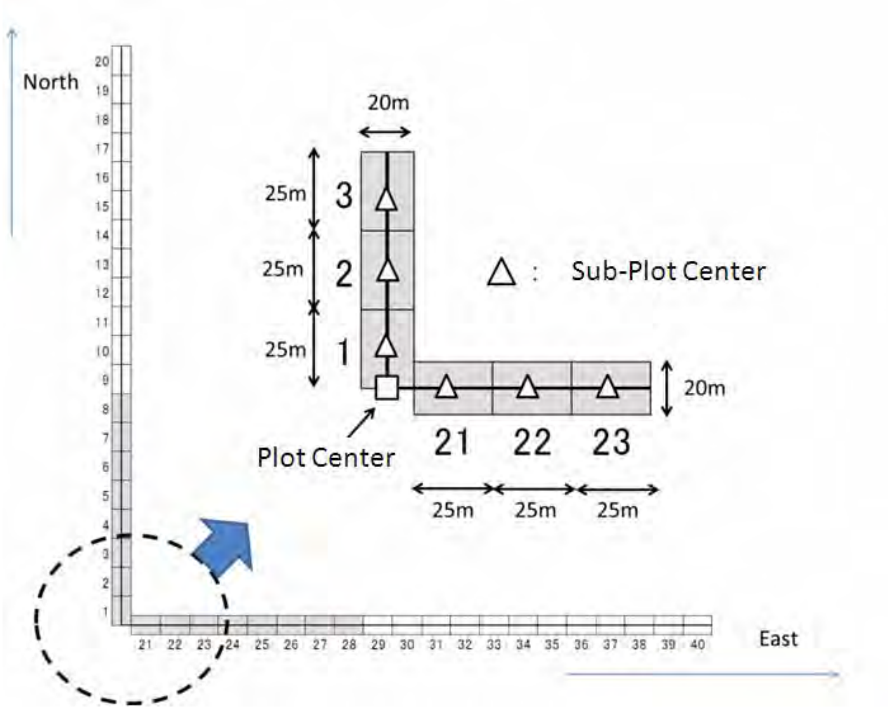


Figure 3.1.1 Layout Design of Sub-Plot

Table 3.1.2 Sample of Field Note

No	species	D1.3	quality	quality of tree following section (wood)				Height		note
				Đ1	Đ2	Đ3	Đ4			
				for bamboo				Total height	Bole height	
				Clump's bamboo	young	Medium	Old			
1	2	3	4	5	6	7	8	9	10	11

3.2 Methodology for Preparation of Emission Factor

Based on the international requirements reviewed in 2.1, data obtained through past NFI was compiled. The above-ground standing volume was calculated for each of the 13 categories related to forests shown in AD and for each stratification category. The basic policy for the calculation is as shown below.

- Calculate the mean timber volume for each point in time using data from the four NFI conducted in the past.
- Re-calculate the mean timber volume for 40 sub-plots contained in each plot in order to obtain more homogeneous data.
- After calculating the mean timber volume, plots with the following standing volume are excluded from

each type of forest: exclude plots with a mean timber volume of less than 200 m^3 from Evergreen Forest (Rich); exclude plots with a mean timber volume of 200 m^3 or more and plots with a mean timber volume of less than 100 m^3 from Evergreen Forest (Medium); and exclude plots with a mean timber volume of 100 m^3 or more from Evergreen Forest (Poor).

- For branches/leaves (part of the biomass above ground) and the biomass below ground, use the parameters provided by the FAO.
- The following carbon pools are subject to the measurement in the study.

Table 3.1.3 Carbon Pool Subject to the Measurement

Carbon pool	Data Source
Above ground	NFI and FAO Parameter
Dead wood/Litter	Not accounted
Below ground	FAO Parameter
Soil organic matter	Not accounted

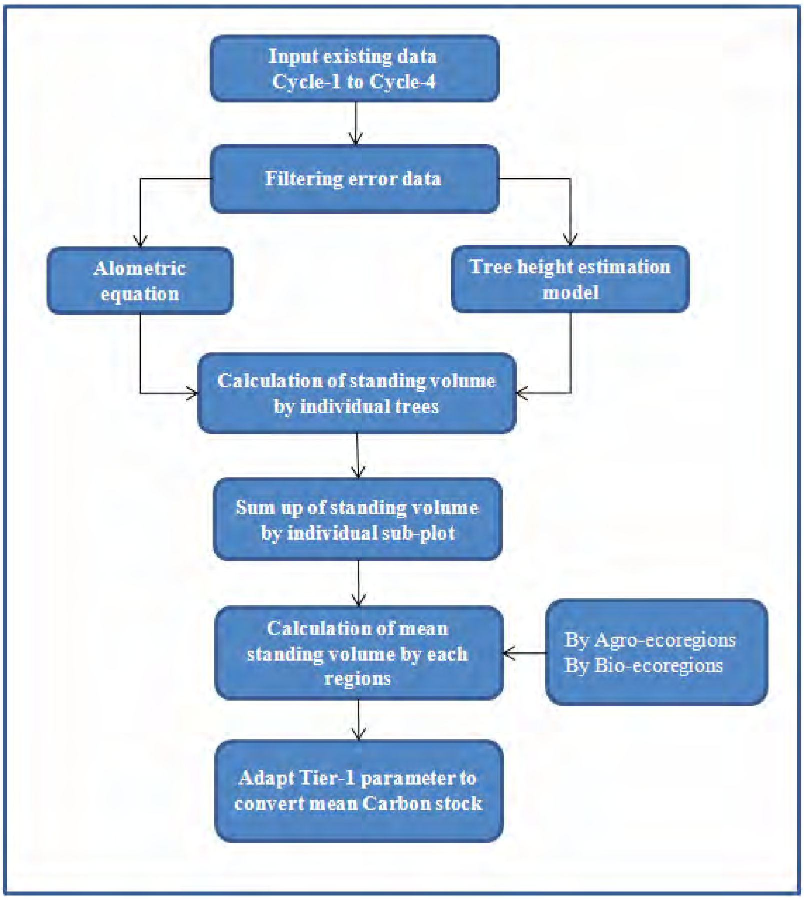


Figure 3.1.2 Flow of Calculating EF

3.2.1 Filtering Error Data

In order to filter the error data, screening of the data has done by deleting the incorrectly written data and incomplete data from whole data of Cycle-1, 2, 3 and 4 that were entered in the PC at the first step of calculating

EF. The results are shown in the table below.

Table 3.1.4 Number of plots/sub-plots before and after screening

	Number of plots for which data was entered	Number of plots after screening	Number of sub-plots after screening
Cycle-1	1,167	1,148	34,234
Cycle-2	3,598	2,409	66,644
Cycle-3	3,971	2,629	72,196
Cycle-4	2,090	1,793	49,632

The table below shows the breakdown of the above data of sub-plots after screening for each forest type.
Note: The data for Mangrove Forest is missing from the Cycle-1 data.

Table 3.1.5 Number of sub-plots after screening for each forest type

	1	2	3	4	5	6	7	8	9	10	11	12
Cycle-1	7,042	5,517	4,280	6,991	4,320	383	3,343	1,022	42		5	1,290
Cycle-2	12,942	12,880	7,962	11,341	8,914	442	8,138	1,968	614	232	97	1,113
Cycle-3	11,744	12,898	8,282	12,968	7,625	487	11,033	2,271	466	524	213	3,685
Cycle-4	10,041	6,032	4,457	8,862	4,392	1,005	8,188	748	219	197	25	5,466

1=Evergreen broadleaf forest (rich forest), 2=Evergreen broadleaf forest (medium forest), 3=Evergreen broadleaf forest (poor forest), 4=Evergreen broadleaf forest (rehabilitation forest), 5=Deciduous forest, 6=Bamboo forest, 7=Mixed timber and bamboo forest, 8=Coniferous forest, 9=Mixed broadleaf and coniferous forest, 10=Mangrove forest, 11=Limestone forest, 12=Plantation

3.2.2 Calculation of Mean Timber Volume by Eco-Regions

In order to calculate the mean timber volume for each forest type, the methodologies for calculation were considered from a time-series point of view and each Cycle point of view.

From a time-series point of view, two methods can be considered: totaling the data through Cycle-1 to Cycle-4 and calculating the mean value; and calculating the mean value for each cycle. The following graph shows the changes in the mean timber volume for three types of Evergreen Forest from Cycle-1 to Cycle-4.

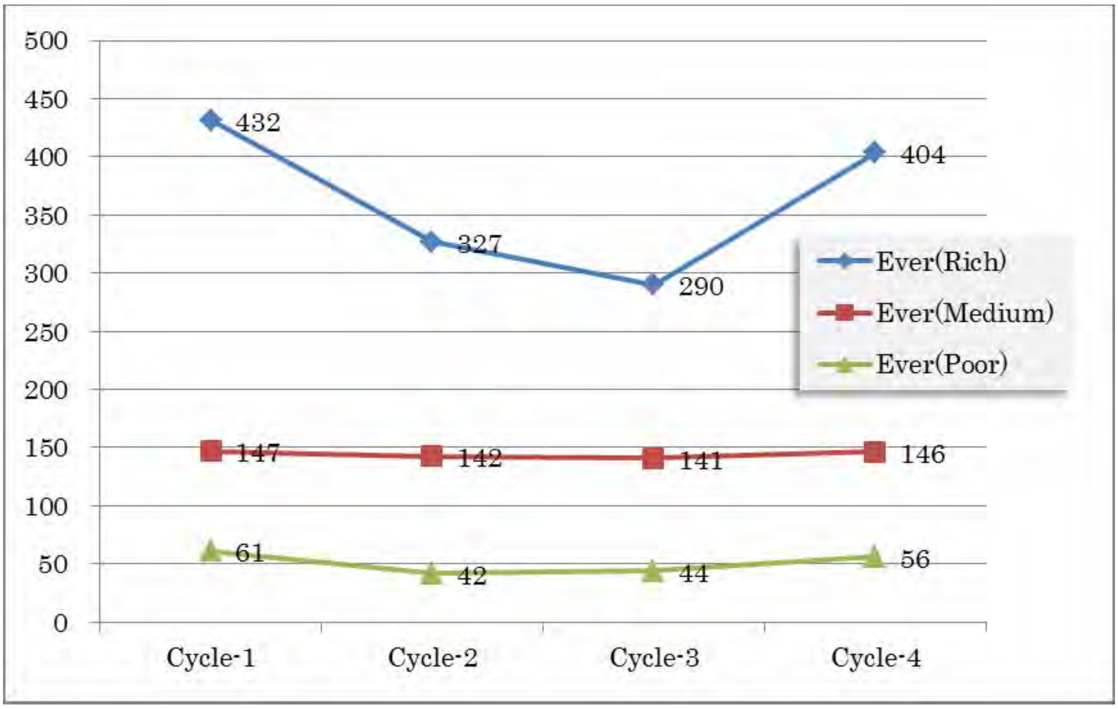


Figure 3.1.3 Changes in the Mean Timber Volume for Three Types of Evergreen Forest through Cycle-1 to Cycle-4 **(m^3/ha)**

There is no significant fluctuation in the standing volume of Evergreen Forest (Medium) and Evergreen Forest (Poor) during the four cycles. For Evergreen Forest (Rich), the mean timber volume decreased during Cycle-1, 2, and 3 and increased in Cycle-4. This indicates that forest degradation took place in Evergreen Forest (Rich) and the mean timber volume decreased as a result, whereas increasing in standing volume in Cycle-4 indicates that the growth in volume is included in the fluctuations of the mean timber volume.

Therefore, if data through Cycle-1 to Cycle-4 is aggregated in order to calculate the mean timber volume, important information such as forest degradation and growth in volume may be lost. Therefore, it was determined that the calculation of the mean timber volume for each cycle would be appropriate.

Regarding the geographical standpoint for calculating the mean timber volume for each forest type, stratification is necessary as a way to reduce uncertainty. For example, it is natural to expect from the ecological point of view that there will be a difference between the mean timber volume in Evergreen Forest (Rich) in the northern part of Vietnam and in Evergreen Forest (Rich) in the central highland area of Vietnam. If these geographical differences are ignored when calculating the mean value, variance in the statistical population increases and therefore uncertainty about the mean value increases. Therefore, it is necessary to use stratification to calculate the mean value in order to reduce the variance.

As mentioned in “1.3 Concept of RELs/RLs,” Agro-Eco regions and Bio-Eco regions are possible stratification classifications which can be considered in Vietnam. In order to reduce uncertainty, the standard deviations for the mean timber volume can be compared and the stratification classification which has the smaller standard deviation can be employed. There is a great deal of complexity involved in comparing all the cycles and geographical classifications, therefore only the main calculation results are shown below.

Table 3.1.6 Result of Stratification Compared between Bio-Eco regions and Agro-Eco regions (North East Region)

Eco-region type	Eco-regions	1	2	3	4	5	6	7	8	9	10	11	12
Bio-Eco regions	Northern Indochina subtropical forests	144	71	41	39		22	52				51	25
Agro-Eco regions	Northwest	191	59	47	38		5	54					25
Bio-Eco regions	South China-Vietnam subtropical evergreen forests	48	57	33	42		17	45		29	0	0	44
Agro-Eco regions	Northeast	65	63	33	39		14	43		29	0	20	35

1=Evergreen broadleaf forest (rich forest), 2=Evergreen broadleaf forest (medium forest), 3=Evergreen broadleaf forest (poor forest), 4=Evergreen broadleaf forest (rehabilitation forest), 5=Deciduous forest, 6=Bamboo forest, 7=Mixed timber and bamboo forest, 8=Coniferous forest, 9=Mixed broadleaf and coniferous forest, 10=Mangrove forest, 11=Limestone forest, 12=Plantation

The standard deviations for the mean timber volume were compared between selected two similar regions. For example, when comparing standard deviations for Evergreen Forest (Rich), the standard deviation for Northern Indochina subtropical forests (of Bio-Eco region) was 144 and the standard deviation for the Northwest region (of Agro-Eco region) was 191. Therefore, the Bio-Eco region had a smaller standard deviation. The same results were obtained for Evergreen Forest (Medium) and Evergreen Forest (Poor). A similar trend was seen in the results of comparisons between another set of northern regions (South China-Vietnam subtropical evergreen forests and the Northeast region). On the other hand, Bio-Eco regions showed higher standard deviations for Bamboo Forest and Mixed Timber & Bamboo Forest.

As can be seen from the above table, Bio-Eco regions provide more accurate mean timber volumes for Evergreen Forest, but Agro-Eco regions provide more accurate mean standard volumes for other forest types. Agro-Eco regions (which are based on administrative divisions) showed similar standard deviations as Bio-Eco regions. It can be surmised that this is because Agro-Eco regions were developed as guidelines for selecting appropriate areas for forestry species and therefore they were developed by taking ecological factors into consideration. In fact, Bio-Eco regions and Agro-Eco regions have geographically similar stratification designs.

In light of the results shown above, in order to reduce uncertainty throughout the data, Evergreen Forest which greatly affects the evaluation of biomass is effective. Therefore, it was determined that using Bio-Eco regions as the stratification classification is appropriate.

The following tables show the mean timber volumes by Bio-Eco region, forest type and cycle.

Table 3.1.7 Standing Volume for Each Forest Type by Bio-Eco region in Cycle-1

(m^3/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	432	147	61	43	107		154					
3												
4	641											
5	405	147	56	55			171					40
6	374	141	48	33		20	90	1			98	26
7	315	134	55	42			90	39				26
8			38	32								
9	347	136	46	25		3	68	64				14
10	319	147	50	58	105	74	113					47
11	365	144	60	47	86	46	96	158	94			48
12	354	145	51	53	103		164	233				47
14												

Table 3.1.8 Standing Volume for Each Forest Type by Bio-Eco region in Cycle-2

(m^3/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1			58	55						8		
2	327	142	42	56	113		121					
3										23		
4	442	153	73				172					
5	375	142	54	31		10	120					14
6	392	141	45	28		40	59				39	29
7	305	139	57	33			76	65				17
8												
9		135	35	22		18	33	53				29
10	298	143	48	55	111	49	85		31			29
11	307	145	55	55	119	16	67	99	109			28
12	311	144	50	49	86		86	174	242		2	21
14												

Table 3.1.9 Standing Volume for Each Forest Type by Bio-Eco region in Cycle-3

(m^3/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1		166	64	61						33		
2	290	141	44	58	100		123					
3										33		
4	316	156	51				129					
5	347	139	55	34		28	85	38				39
6	337	140	46	25		147	44	4			45	28
7	286	148	60	37		20	59	51				11
8												
9		130	39	23		25	32	40				26
10	291	145	56	57	106	47	95	265				30
11	299	146	56	52	120	25	60	129	140		59	91
12	300	144	52	55	84		74	64	66		15	78
14										30		48

Table 3.1.10 Standing Volume for Each Forest Type by Bio-Eco region in Cycle-4

(m^3/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1			71	61								25
2	404	146	56	61	83		145					
3										45		19
4	534	155										
5	340	143	62	51		15	102	54				22
6	345	142	53	31		12	46				64	19
7	279	142	67	45		10	85	114				24
8												
9		141	43	38		10	47		41	0		28
10	311	146	62	58	92	54	129					31
11	335	151	63	52	60	11	93	197	152			64
12	341	146	47	50	89	19	112		141			41
14												34

※1 (Bio-Eco regions);1=Cardamom Mountains rain forests, 2=Central Indochina dry forests, 3=Indochina mangroves, 4=Luang Prabang mountain rain forests, 5=Northern Annamites rain forests, 6=Northern Indochina subtropical forests, 7=Northern Vietnam lowland rain forests, 8=Red River freshwater swamp forests, 9=South China-Vietnam subtropical evergreen forests, 10=Southeastern Indochina dry evergreen forests, 11=Southern Annamites mountain rain forests, 12=Southern Vietnam lowland dry forests, 14=Tonle Sap-Mekong peat swamp forests

※2（Forest types）; 1=Evergreen broadleaf forest(rich forest), 2=Evergreen broadleaf forest(medium forest), 3=Evergreen broadleaf forest(poor forest), 4=Evergreen broadleaf forest(rehabilitation forest), 5=Deciduous forest, 6=Bamboo forest, 7=Mixed timber and bamboo forest, 8=Coniferous forest, 9=Mixed broadleaf and coniferous forest, 10=Mangrove forest, 11=Limestone forest, 12=Plantation

3.2.3 Adaptation of Tier-1 Parameter to Convert Volume data to Mean Carbon Stock

The Emission Factor which integrates above-ground biomass and below-ground biomass can be calculated as follows.

Emission Factor (CO_2t/ha) = (AGB+BGB)*CF*44/12
AGB = GS × BCEF (1a)
BGB = AGB × R (2)
Where:
AGB = Above-ground biomass (tons)
BGB = Below-ground biomass (tons)
GS = Growing stock (Volume, m^3 over bark)
BCEF = Biomass conversion and expansion factor (Above ground biomass /growing stock, (tons/m^3))
R = Root-shoot ratio (Below-ground biomass / Above-ground biomass)
CF = Carbon Fraction (0.47)

The parameters provided by FAO are used as the BCEFs. BCEFs for humid tropical areas are shown in the table below.

Table 3.1.11 Parameter Provided by FAO for BCEF

TABLE 5.4 [4] DEFAULT BIOMASS CONVERSION AND EXPANSION FACTORS (BCEF), TONNES BIOMASS (M^3 OF WOOD VOLUME)$^{-1}$ BCEF for expansion of merchantable growing stock volume to above-ground biomass (BCEFs)										
Climatic zone	Forest type	BCEF	Growing stock level (m^3/hectare)							
			<10	11-20	21-40	41-60	61-80	80-120	120-200	>200
Humid tropical	conifers	BCEFs	4.0 (3.0-6.0)	1.75 (1.4-2.4)	1.25 (1.0-1.5)	1.0 (0.8-1.2)	0.8 (0.7-1.2)	0.76 (0.6-1.0)	0.7 (0.6-0.9)	0.7 (0.6-0.9)
	natural forests	BCEFs	9.0 (4.0-12.0)	4.0 (2.5-4.5)	2.8 (1.4-3.4)	2.05 (1.2-2.5)	1.7 (1.2-2.2)	1.5 (1.0-1.8)	1.3 (0.9-1.6)	0.95 (0.7-1.1)

The BCEFs in table 3.1.11 is given as a mean default value and, within parenthesis, a range. Within this range, lower values apply if Growing stock definition includes branches, stem tops and cull trees; upper values apply if branches and tops are not part of Growing stock, minimum top diameters in the definition of Growing stock are large, inventories volume falls near the lower category limit or basic wood densities are relatively high.

Since the NFI uses stem volume as the parameter, while FAO uses usable timber volume, the lower values were used among growing stock level in above table. For the other values, Tier-1 provided by IPCC[3] was used. More specifically, the Carbon Fraction of 0.47 and the Ratio of Below-Ground Biomass to Above-Ground Biomass of 0.24 were used.

3.3 Results of the Development of Emission Factor

As a result of the above-explained considerations, EF was developed as shown in the tables below. Please note that these parameters do not include dead wood, litter or soil organic matter.

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3 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4; Forest Land

Table 3.1.12 Emission Factor for Each Forest Type by Bio-Eco region for Cycle-1

(CO_2t/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	646	283	157	110	228		297					
3												
4	959											
5	606	283	143	140			329					121
6	560	272	124	98		106	191	5			209	78
7	471	258	141	107			193	83				77
8			113	97								
9	518	261	117	74		25	173	96				77
10	477	283	127	148	224	189	240					121
11	546	276	154	121	185	119	205	203	200			123
12	529	279	131	135	219		316	298				120
14												

Table 3.1.13 Emission Factor for Each Forest Type by Bio-Eco region for Cycle-2

(CO_2t/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1			149	142						64		
2	489	274	107	144	241		258					
3										68		
4	660	295	187				330					
5	561	274	139	93		87	256					77
6	587	271	115	83		119	151				116	86
7	457	268	147	99			195	98				90
8												
9		260	104	65		96	99	90				88
10	446	276	124	141	237	126	181		94			87
11	459	278	142	141	255	85	172	127	233			84
12	465	277	129	126	183		184	223	363		20	64
14												

Table 3.1.14 Emission Factor for Each Forest Type by Bio-Eco region for Cycle-3

(CO_2t/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1		319	163	157						99		
2	434	271	112	148	214		236					
3										99		
4	472	300	130				249					
5	519	268	142	101		83	181	82				116
6	505	270	119	75		283	114	29			116	83
7	428	285	153	109		107	151	87				60
8												
9		250	118	68		75	95	86				77
10	435	280	143	146	226	121	202	340				88
11	448	280	143	134	257	75	154	166	268		150	195
12	449	277	134	140	180		190	96	169		78	201
14										89		124

Table 3.1.15 Emission Factor for Each Forest Type by Bio-Eco region for Cycle-4

(CO_2t/ha)

*1 \ *2	1	2	3	4	5	6	7	8	9	10	11	12
1			181	157								75
2	604	282	144	157	178		279					
3										115		104
4	798	299										
5	508	275	158	131		78	219	92				67
6	516	272	135	94		66	118				165	103
7	417	272	171	116		82	181	146				70
8												
9		271	110	115		86	122		105	4		85
10	465	282	158	148	196	138	249					94
11	502	291	162	135	153	91	199	253	292			163
12	511	280	120	128	189	104	240		271			106
14												102

※1 (Bio-Eco regions);1=Cardamom Mountains rain forests, 2=Central Indochina dry forests, 3=Indochina mangroves, 4=Luang Prabang mountain rain forests, 5=Northern Annamites rain forests, 6=Northern Indochina subtropical forests, 7=Northern Vietnam lowland rain forests, 8=Red River freshwater swamp forests, 9=South China-Vietnam subtropical evergreen forests, 10=Southeastern Indochina dry evergreen forests, 11=Southern Annamites mountain rain forests, 12=Southern Vietnam lowland dry forests, 14=Tonle Sap-Mekong peat swamp forests

※2（Forest types）； 1=Evergreen broadleaf forest(rich forest), 2=Evergreen broadleaf forest(medium forest), 3=Evergreen broadleaf forest(poor forest), 4=Evergreen broadleaf forest(rehabilitation forest), 5=Deciduous forest, 6=Bamboo forest, 7=Mixed timber and bamboo forest, 8=Coniferous forest, 9=Mixed broadleaf and coniferous forest, 10=Mangrove forest, 11=Limestone forest, 12=Plantation