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Acronyms and Abbreviations

AD	Activity data
AE	Allometric Equation
AF	Afforestation
AGB	Above Ground Biomass
BCEF	Biomass Conversion and Expansion Factors
BEF	Biomass Expansion Factor
BGB	Below Ground Biomass
BUR	Biannual Updated Report
CF	Carbon Fraction
DARD	Dept. of Agriculture and Rural Development (at the Province)
DBH	Diameter at Breast Height
DF	Deforestation
EBF-M	Evergreen Broadleaf Forests, Medium
EBF-P	Evergreen Broadleaf Forests, Poor
EBF-R	Evergreen Broadleaf Forests, Rich
EF	Emission Factor
ER_PIN	Emission Reduction Program Idea Note
ER-P	Emission Reduction Program (area)

ERPA	Emission Reduction Payment Agreement
FAO	Food and Agriculture Organization
FCM	Forest cover map
FD	Forest degradation
FE	Forest enhancement
FIPI	Forest Inventory and Planning Institute
FORMIS	Forest Resource Monitoring System
FPCF	Forest Carbon Fund Facility
FPD	Forest Protection Department
FREC	Forest Resources and Environment Centre
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GHG	Green house gases
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LULUCF	Land use, Land Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
Mha	Millions hectare
MONRE	Ministry of Natural Resources and Environment
Mt CO_2e	Million tonnes carbon dioxide equivalent
NCC	North Central Coast
NDVI	Normalized difference vegetation index
NFI	National Forest Inventory
NFIMAP	National Forest Inventory, Monitoring and Assessment Program
NFIS	National Forest Inventory and Statistics
PPMU	Provincial Program Management Unit
PSU	Primary Sample Unit
QA/QC	Quality Assurance/Quality Control
REDD+	Reducing Emission from Deforestation, forest Degradation, forest carbon conservation and enhancement and sustainable management of forests
RF	Removal Factors
R/S	Root to shoot ratio
SCC	South Central Coastal
SD	Standard deviation
SF	Stable forest
SNF	Stable non forest
SSP	Secondary sample plot
STDEV	Standard deviation
tC	Tonne of carbon
TTHue	Thua Thien Hue (province in the NCC))
UNFCCC	United Nations Framework Convention on Climate Change
VAFS	Vietnam Academy of Forest Sciences

VFU	Vietnam Forest University
VNFOREST	Vietnam Forest Administration
VRO	Vietnam REDD+ Office
WD	Wood Density

Contents

1 Activity Data Report

1.1 Objectives task and methodology

1.1.1 Objectives and tasks

The objectives of this work are to: 1) review and upgrade the historical forest cover maps for 2000, 2005 and 2010; and 2) generate forest and land use change maps and matrices to serve the development of a forest reference level for the North Central Coastal (NCC) region of Vietnam.

To achieve the mentioned objectives, the following tasks were undertaken: 1) Review and update historical forest cover maps for 2000, 2005 and 2010 for each province, aggregate them to regional maps for the NCC; 2) Develop the forest and land use change maps and matrices for the periods 2000-2005 and 2005-2010; and 3) Assess the accuracy of the forest cover map.

1.2 Methodology

Historical forest cover maps have been reviewed and improved through a number of technical and financial assistance projects funded by international development partners including Finland, Japan, and UNREDD, and also through a follow up project under MARD. Limitations of the existing maps included that 1) they have not been standardized due to the difference of applied methods; 2) the classification system and coordinate system is different with different formats (hardcopy and softcopies); and 3) they have differences in forest definition, in terms of canopy cover (30% canopy cover was applied before 2004 and 10% after the 2004, this change was according to Forest Protection and Development Law 2004). The process of improving original historical forest cover maps is presented below:

The following maps were used:

- The map in 2000: the hard copy map of the second National forest inventory and statistic (NFIS) program for the period 1998-2000 and digital map of National forest inventory, monitoring and assessment program (NFIMAP) cycle 2 for the period of 1996 – 2000;
- The map in 2005: a digital map of National forest inventory, monitoring and assessment program (NFIMAP) cycle 3 for the period 2001 – 2005; and
- The map in 2010: a digital map of National forest inventory, monitoring and assessment program cycle 4 for the period 2006 – 2010.

Nordeco Project[1]

The main activities of this project was the digitization of the hard copy maps of the NFIS for the period of 1998-2000 and standardizing of digital output map and the mapping of NFIMAP cycles 3 and 4; including: classification system, coordination, and structure of attributes. However, there were some limitations such as the satellite images of 2000, 2005, and 2010, which were less used to supplement and update the maps accordingly. The content that

[1] Project “Technical Assistance in the Development of the National REDD Programme of Vietnam” funded by Finland

needed to be updated included: polygon boundaries, names of forest type and logical forest change over time..

JICA project[2]

This study was aimed at the enhancement of the quality of the maps produced by the Nordeco project, including: Landsat images covering the periods 2000, 2005 and 2010 were used for enhancing the quality of the maps by applying visual interpretation methods, including: polygon boundaries, names of forest type and misclassification of forest changes over time. The main limitation of this mapping was that the results were subjective and depended on the knowledge and experience of the interpreters, hence the quality of the enhanced map is uneven.

National FREL/FRL establishment:

Under the work for the establishment of the national FREL/ FRL continued efforts focused on enhancement of the quality of maps produced by JICA project has continued, including: the result of an “Object based” classification method applied for Landsat images to upgrade the quality of maps produced by the JICA project, including: polygon boundaries, names of forest type and correcting of large areas having misclassification of forest changes over time. Sample plots implemented more or less the same year as the maps have also been used for correcting the name of the forest type of the polygon containing that plot, if the forest type is different. The limitation is that only regional forest maps were produced and no consultation was conducted to produce forest cover maps for each province in North Central Coast (NCC) region.

1.2.1 Time interval

The time period to calculate the activity data (AD) serving for emission/removal estimation for the NCC region is determined to be 5 years (2000, 2005 and 2010) and is based on the following criteria:

1) To date, the forest cover maps at the regional level of Vietnam have been standardized, and quality has been upgraded through several projects with set intervals of 5 years (2000, 2005 and 2010), which also is the time period of implementation of NFIMAP cycle.

2) The period of 5 years for a cycle is chosen to ensure that monitoring and evaluation of forest changes in Vietnam is in line with the plantation forest cycle where the planted trees are mostly fast growing species with a cycle of 6 - 7 years. Therefore, if the period of time to assess forest changes is longer than the cycle of forest plantation, (e.g. 10 years) that will lead to inaccuracies, as many newly areas that are planted at the beginning of the cycle would have been harvested at the end of the cycle.

3) For the past decades, the forest cover in Vietnam have been rapidly fluctuating as a result of the effects of regeneration and deforestation such as conversion of forest use purposes, shifting cultivation etc. Therefore, the time period of 10 years for evaluating forest changes would not fully reflect the changes of the forest.

4) Currently, the NFIS program for the period from 2013 to 2016 has been implemented, of which, to date only Ha Tinh province has been completed, the five remaining provinces in NCC region are still on-going, consequently the forest cover map for the NCC region in 2015 is not yet completed. Therefore, the forest cover map for 2010 is the latest map of the region and so is used for this program.

Consequently, the input forest cover maps for AD calculation serving for the construction of the FREL/FRL were taken from the outcomes of the Project “National forest reference level”

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[2] Project “Potential Forests and Land Related to “Climate Change and Forests” in The Socialist Republic of Vietnam

as based on the level of enhancement of the quality of forest cover maps described above, including the forest cover maps of 2000, 2005 and 2010.

1.2.2 Land uses and forest stratification

This work applies to the forest and land use classification system used in the forest cover maps improved by the JICA Project. This classification system is based on Circular No. 34/2009/TT-BNN. The original forest cover maps for the year 2000 produced by the NFIMAP used in the classification system that was based on Decision 84 while the map for the year 2010 used a classification system that is based on Circular No. 34. With the support from the JICA Project, these maps have been harmonized to a classification system that is based on Circular No. 34.

Table 1.1 Forest and land use classification system for national scale

Type	Forest and land use type	Forest/non-forest
1	Evergreen broadleaves forest - rich	Forest
2	Evergreen broadleaves forest - medium	Forest
3	Evergreen broadleaves forest - poor	Forest
4	Evergreen broadleaves forest - regrowth	Forest
6	Bamboo forest	Forest
7	Mixed woody - bamboo	Forest
10	Mangroves forest	Forest
11	Limestone forest	Forest
12	Plantations	Forest
13	Limestone without forest	Non-forest
14	Bared land	Non-forest
15	Water bodies	Non-forest
16	Residence	Non-forest
17	Other land	Non-forest

Based on the result of the average timber stock volume calculation for the forest types in the NCC region in the report on national reference level establishment conducted by Forest Inventory and Planning Institute (FIPI), the forest type numbers 3, 4 and 7 have more or less the same value of stock volume, however, it is quite difficult to distinguish among those classes when using Landsat data for image interpretation. As a result, it is suggested that those types should be combined in to one forest type to reduce uncertainty during the forest and land use mapping/updating. The harmonized classification system in the NCC is shown in Table 1.2.

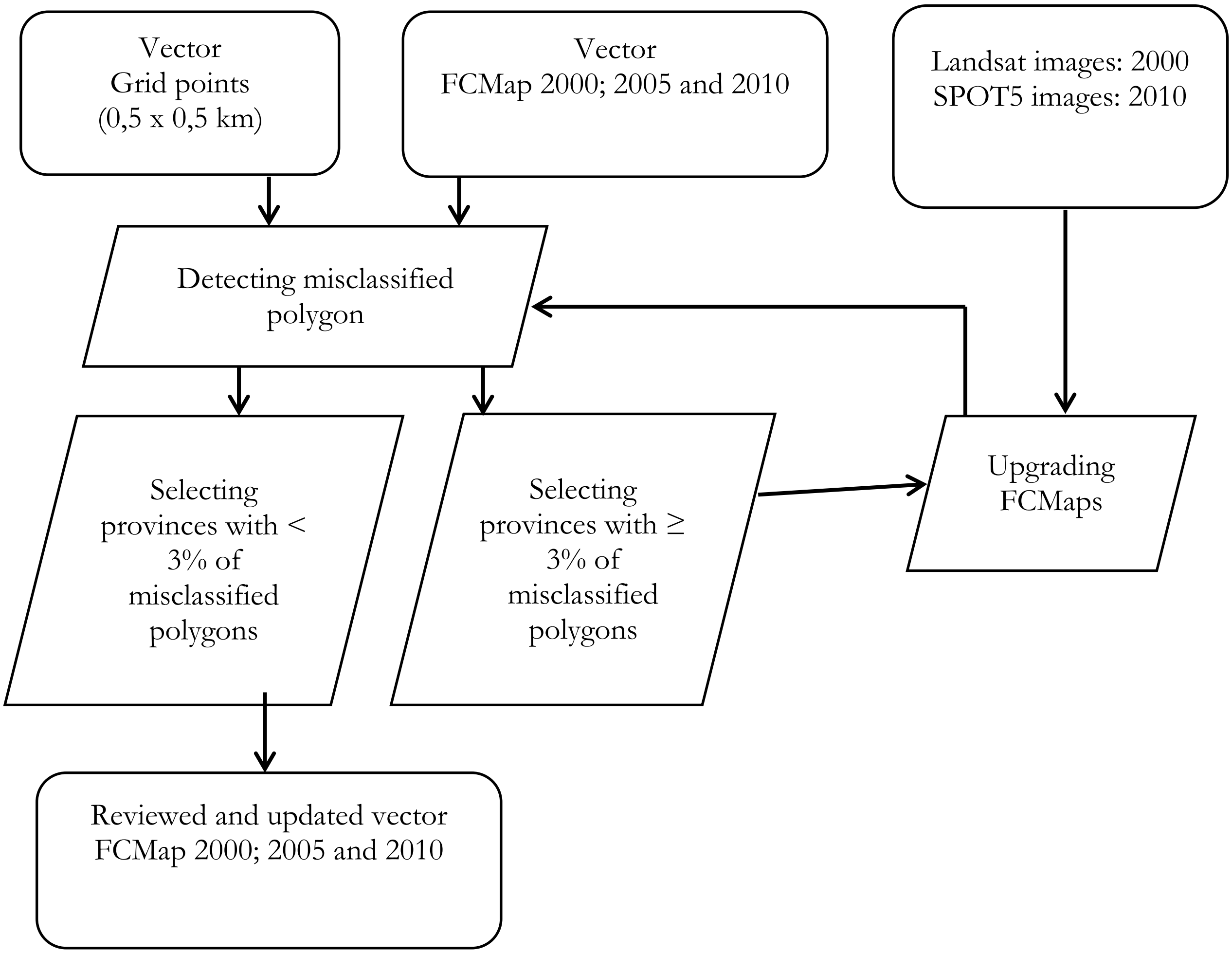
Table 1.2 Forest and land use classification system for the NCC

Type	Forest and land use type	Forest/non-forest
1	Evergreen broadleaves forest - rich	Forest
2	Evergreen broadleaves forest - medium	Forest
3	Evergreen broadleaves forest - poor	Forest
4	Other Forest	Forest
5	Plantations	Forest
6	Non-forest land	Non-Forest

1.2.3 *Review and upgrade forest cover maps*

The review and upgrade process is shown in the Figure 1.1.

Figure 1.1 Method of review and upgrade forest cover maps



There are three existing forest cover maps for the years 2000, 2005 and 2010. Therefore, the review process examines changes of different forest classes and non-forest area among different periods. Misclassification of forest and land use changes are detected to find problems of interpretation of those maps for further upgrade/re-interpretation. The determination of misclassification of changes relied on the following factors:

- The regulation of forest changes: it takes a certain time to change the forest type during the growing and development of forest. According to FIPI (2010), in the Vietnam, the average growth rate of forest stands is about 1.5 - 2% per year, consequently, for a timber volume growth of 100 m^3, it needs a period of 25 - 30 years. Thus, over a period of 10 years, the forest state that has a timber stock volume of less than 100 m^3/ha cannot develop into a rich forest in that period; or a non-forest state (as in 0 timber stock volume) cannot develop to be a forest state having timber stock volume over 100 m^3/ha.

Misclassification of changes during examined periods are discussed and decided by Vietnamese forestry experts as presented in Table 1.3 below:

Table 1.3 Misclassification of changes of forest states during period 2000 – 2005 and 2005 – 2010

Map year X+5	Map year X	Problem-ID
1	3, 4, 5, 6	P2.1
2	4, 5, 6	P2.2

To upgrade the forest and land use map for 2000, 2005 and 2010, the overlaid maps of the two periods are opened on satellite imagery of the same period to test the large polygons having inconsistent changes to correct the forest status name so as to make it appropriate to the rules allowing changes. During the processing and testing, updating and enhancement of forest and land use maps for 2000, 2005 and 2010, the collected reference maps and survey of the permanent sample plots, conducted more or less the same time, were converted to the same projection system to improve map quality using expert interpretation experiences.

1.2.4 Generating forest and land use change maps and matrices

Forest and land use change maps were generated using the intersect tool of ArcGIS by opening the two maps of the beginning and ending years and applying the Analysis Tools\ Overlay\ Intersect tool. This process has been applied for period 2000 – 2005 and 2005 - 2010 over six provinces. The provincial forest and land use change maps are then aggregated to generate the NCC forest and land use change maps.

To generate the forest and land use change matrices, calculations of the area for each polygon in the forest and land use change maps was done using ArcGIS. The attributes of the forest and land use change maps were exported to EXCEL file and using the Pivot Table to generate the forest and land use change matrices.

Based on the forest and land use change map, deforestation, forest degradation, forest enhancement and afforestation can be determined by using the selection tool in ARC/GIS, it can be seen in Table 1.4.

Table 1.4 Forest change in the period of 5 year

Year X	Year X+5					
	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

Forest degradation
Deforestation
Forest quality enhancement
Afforestation
Unchanged

Forest degradation: all forest type changes from higher timber stock volume to lower timber stock volume.

Table 1.5 Forest degradation during a 5 year period

Map year X	Map year X+5	Change-ID
1	2, 3, 4, 5	FD1
2	3, 4, 5	FD2
3	4, 5	FD3
4	5	FD4

Deforestation: All changes from forest to non-forested type

Table 1.6 Deforestation during a 5 year period

Map year X	Map year X+5	Change-ID
1	6	D1
2	6	D2
3	6	D3
4	6	D4
5	6	D5

Forest Enhancement: all forest type changes from lower timber stock volume to higher timber stock volume

Table 1.7 Forest enhancement during a 5 year period

Map year X	Map year X+5	Change-ID
2	1	FE1
3	2	FE2
4	3	FE3
5	3, 4	FE4

Afforestation: all changes from non-forested to forest type

Table 1.8 Afforestation during period of 5 year

Map year X	Map year X+5	Change-ID
6	3	A1
6	4	A2
6	5	A3

1.2.5 Accuracy assessment

The accuracy assessment of the forest cover maps for 2000, 2005 and 2010 are made on the basis of existing data at more or less the same year, and based on the following:

- Satellite images with high spatial resolution;
- Aerial photographs; and
- Ground truth points: sample plots etc.

However, in the project area, there were no high resolution satellite images or aerial photos available for 2000, 2005 and 2010, thus the accuracy assessment cannot be achieved by applying the above remote sensing and aerial photo methods.

The ground truth points system using the sample plots were implemented at various times in 2000, 2005 and 2010 (during the NFIMAP cycles 2, 3 and 4) and have been fully utilized in the improvement of the quality of the forest cover maps in the project "National FREL/FRL construction", thus they cannot continue to be used in the assessment of the accuracy of those maps.

Consequently, the accuracy assessment will be conducted using the following steps:

Step 1. Create forest change maps for the period 2000 – 2005 and 2005 - 2010

- By overlaying the forest cover maps in 2 points of time, the forest change map is created with 23 possible changes, seven misclassification (illogical change) and six stable forest and land use types;
- Based on the Tables 1.5,1.6,1.7,and 1.8 the forest change maps for two points of time will be revised and combined as a group of change to create the final forest change map with 6 main change categories as follows:

Table 1.9 Combination of forest changes

Code	Category	Description
FD	Forest degradation (FD1, FD2, FD3, FD4)	All forest type changes from higher timber stock volume to lower timber stock volume.
DF	Deforestation (D1, D2, D3, D4, D5)	All changes from forest to non-forested type
FE	Forest Enhancement (FE1, FE2, FE3, FE4)	All forest type changes from lower timber stock volume to higher timber stock volume
AF	Afforestation (A1, A2, A3)	All changes from non-forested to forest type
SF	Stable forest	No change in forest type
SNF	Stable non-forest	No change in non-forest type

The vector maps of the forest change for the period 2000-2005 and 2005-2010 will be rasterized with the pixel size of 30*30m to create the raster maps of forest change for these two periods.

Step 2. Sampling design

- Determine sample size:
  - o Calculate the areas of each change category on the final forest change maps;
  - o The number of sample points required per change category is determined by three main parameters: 1) the level of precision required of the estimates, 2) the proportion of each mapped category in the map and 3) the expert-estimated, conservative map accuracy of each category.
  - o If the total number of sample points of any change category is less than 30, then it will be given as 30 in order to be satisfied minimum sample size for that category. The sample points of other change categories will then be recalculated.
- Allocate sample points for each category of change
  - o Based on the total number of determined sample points, the map of sample points will be stratified randomly created for each forest change category by applying ARC/GIS software. Sample points are separated by at least 400 m.

Step 3. Assess every sample point on Landsat images of "year X" and "year X+5"

Landsat images covering NCC region for 2000, 2005 and 2010 will be downloaded from the Webpage: http://earthexplorer.usgs.gov/ . The details are shown in Table 1.10.

Table 1.10 Metadata of Landsat images

Path/Row	Information	2000	2005	2010
125_48	LANDSAT_SCENE_ID	"LE71250482000311SGS00"	"LT51250482005140BKT00"	"LT51250482010186BKT01"
	DATE_ACQUIRED	06/11/2000	20/05/2005	05/07/2010
	CLOUD_COVER	0	0	0
125_49	LANDSAT_SCENE_ID	"LE71250492000311SGS00"	"LT51250492005124BKT01"	"LT51250492010042BKT00"

Path/Row	Information	2000	2005	2010
	DATE_ACQUIRED	06/11/2000	04/05/2005	11/02/2010
	CLOUD_COVER =	7	7	0
126_47	LANDSAT_SCENE_ID	"LE71260472000158SGS00"	"LT51260472005195BKT00"	"LT51260472009238BJC00"
	DATE_ACQUIRED	06/06/2000	14/07/2005	26/08/2009
	CLOUD_COVER =	2	1	1,63
126_48	LANDSAT_SCENE_ID	"LT51260482000310BKT00"	"LT51260482005275BKT00"	"LT51260482009238BKT00"
	DATE_ACQUIRED	05/11/2000	02/10/2005	26/08/2009
	CLOUD_COVER =	0	7	2
127_46	LANDSAT_SCENE_ID	"LE71270462000261SGS00"	"LT51270462004344BKT01"	"LT51270462010040BKT00"
	DATE_ACQUIRED	17/09/2000	09/12/2004	09/02/2010
	CLOUD_COVER	0	1	0
	LANDSAT_SCENE_ID		"LT51270462005314BJC00"	
	DATE_ACQUIRED		10/11/2005	
	CLOUD_COVER		10	
127_47	LANDSAT_SCENE_ID	"LE71270472000261SGS00"	"LT51270472005026BKT01"	"LT51270472010056BKT00"
	DATE_ACQUIRED	17/09/2000	26/01/2005	25/02/2010
	CLOUD_COVER	0	8	0
	LANDSAT_SCENE_ID		"LT51270472005314BKT01"	
	DATE_ACQUIRED		10/11/2005	
	CLOUD_COVER		16	
128_46	LANDSAT_SCENE_ID	"LE71280462000300SGS00"	"LT51280462005065BKT02"	"LT51280462010111BKT01"
	DATE_ACQUIRED	26/10/2000	06/03/2005	21/04/2010
	CLOUD_COVER	9	8	2
128_47	LANDSAT_SCENE_ID	"LT51280472005113BKT00"	"LT51280472005065BKT01"	"LT51280472010303BKT00"
	DATE_ACQUIRED	23/04/2005	06/03/2005	30/10/2010
	CLOUD_COVER	0	0	2

- Overlay the evaluation sample points on the Landsat images in 2000, 2005 and 2010;
- At each of the evaluation sample points, the forest changes was independently evaluated by three expert in the field of remote sensing and forest change monitoring and assessment by applying visual interpretation method.

Step 4. Summarize the results and create errors matrix.

- The independent evaluated results of three experts will be combined as the consensus reference sample points which will be used to create the errors matrix.

Step 5. Accuracy calculating by applying Olofsson's method[3]

[3] Good practices for estimating area and assessing accuracy of land change

1.3 Results and discussion

2.1. Review and update forest cover maps

The numbers of misclassification change points for each province are provided in the Tables 2.1 and 2.2 below:

Table 1.11 Result of misclassification change assessment for the period of 2000 – 2005 (updated)

Province	Misclassification change		Misclassification points detected	Total points	% of total points
	P2.1	P2.2			
Thanh Hoa	5	8	13	44,199	0.03%
Nghe An	11	25	36	65,742	0.05%
Ha Tinh	1	1	2	23,797	0.01%
Quang Binh	14	26	40	31,956	0.13%
Quang Tri	5	9	14	18,895	0.07%
Thua Thien Hue	8	13	21	19,573	0.11%
Total	**44**	**82**	**126**	**204,162**	**0.06%**

Table 1.12 Result of misclassification change assessment in the period of 2005 – 2010 (updated)

Province	Misclassification change		Misclassification points detected	Total points	% of total points
	P2.1	P2.2			
Thanh Hoa	8	11	19	44,199	0.04%
Nghe An	13	7	20	65,742	0.03%
Ha Tinh		1	1	23,797	0.00%
Quang Binh	3	28	31	31,956	0.10%
Quang Tri	8	18	26	18,895	0.14%
Thua Thien Hue	19	20	39	19,573	0.20%
Total	**51**	**85**	**136**	**204,162**	**0.07%**

The result of misclassification of change assessment revealed that the percentage of points having misclassification of change for all provinces in NNC region satisfied the requirement of accurate level (less than 3%). Consequently, no further forest cover maps enhancement is needed for this program.

1.4 Forest cover maps

Forest cover maps are finalized for all provinces and then combined for the NCC region for 2000, 2005 and 2010 are provided in the following figures:

Figure 1.2: Forest cover map of NCC in 2000

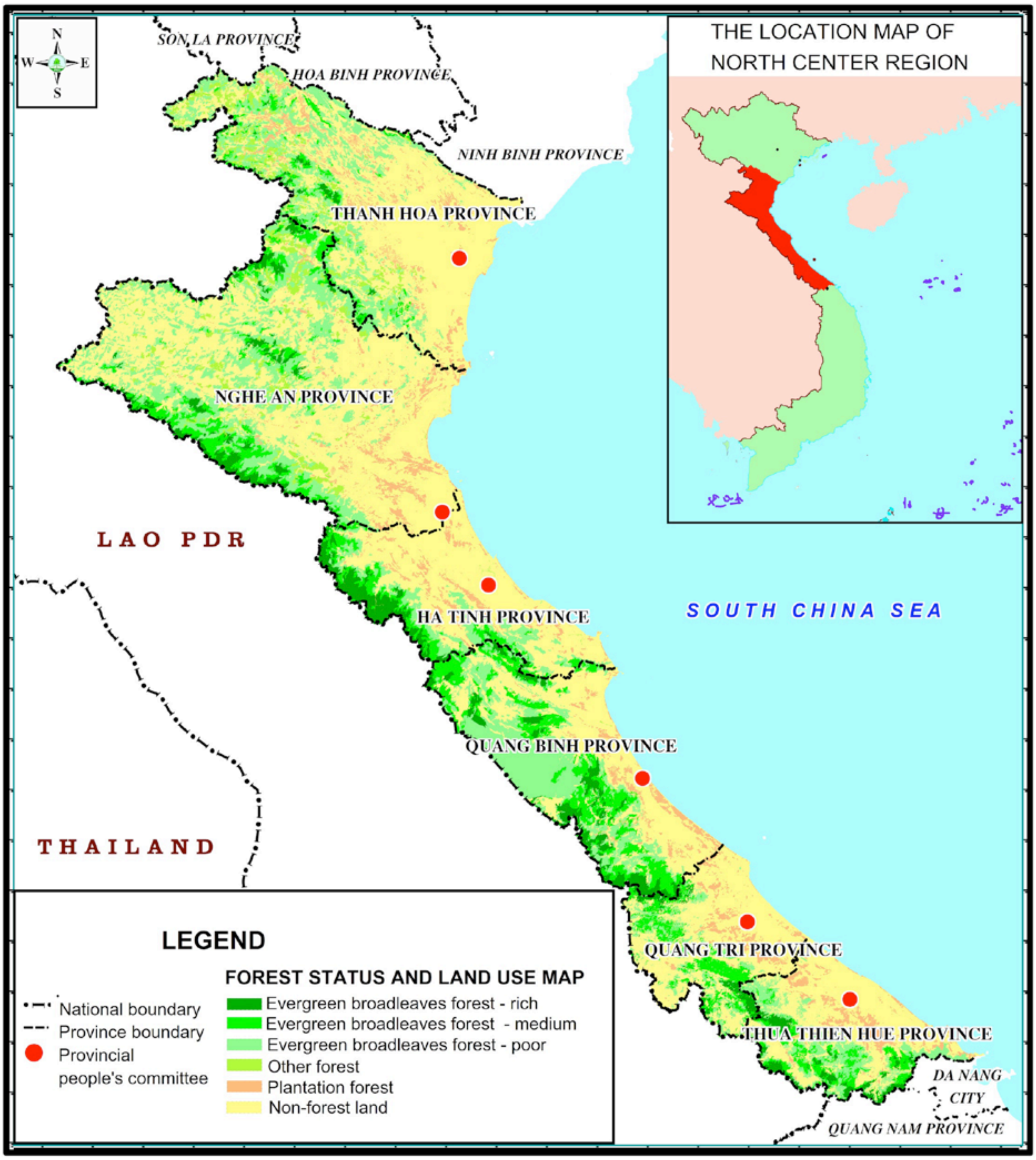


Figure 1.3: Forest cover map of NCC in 2005

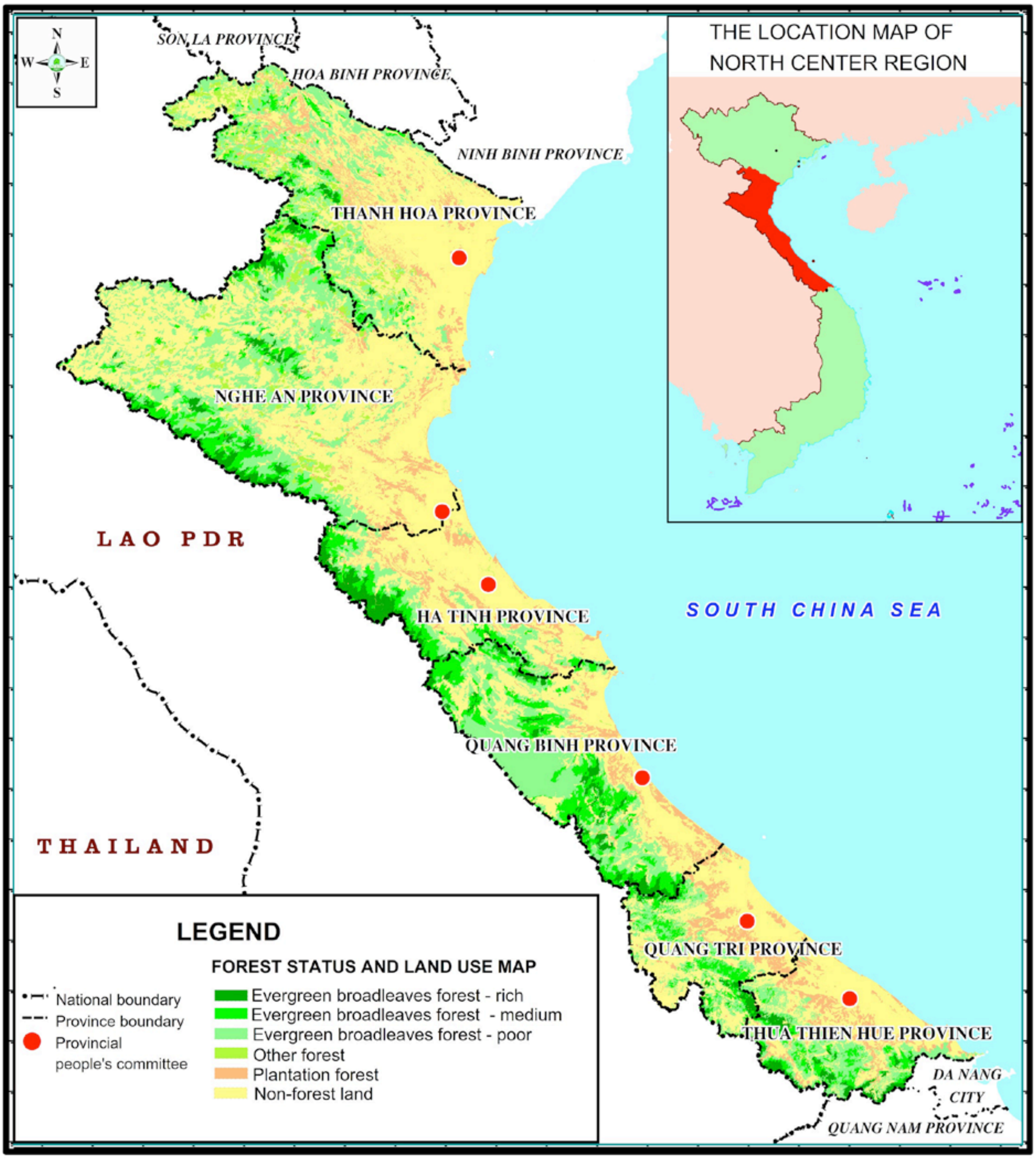
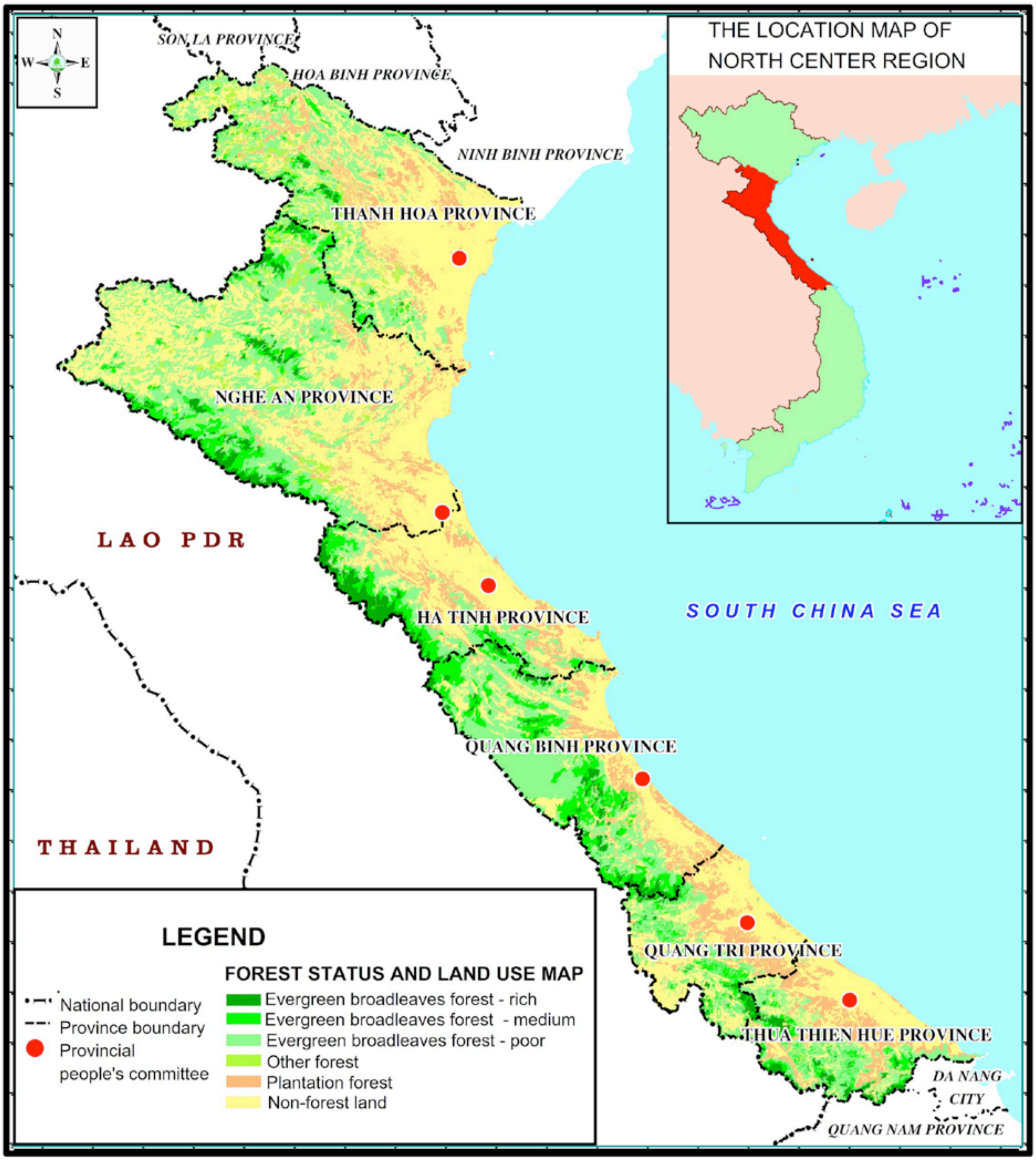


Figure 1.4: Forest cover map of NCC in 2010



1.5 Forest cover changes maps

Forest cover change maps are prepared for two time periods, 2000-2005 and 2005 – 2010. The forest cover change maps are also prepared for every province and whole region.

Figure 1.5: Forest cover change map of NCC for the period of 2000 – 2005

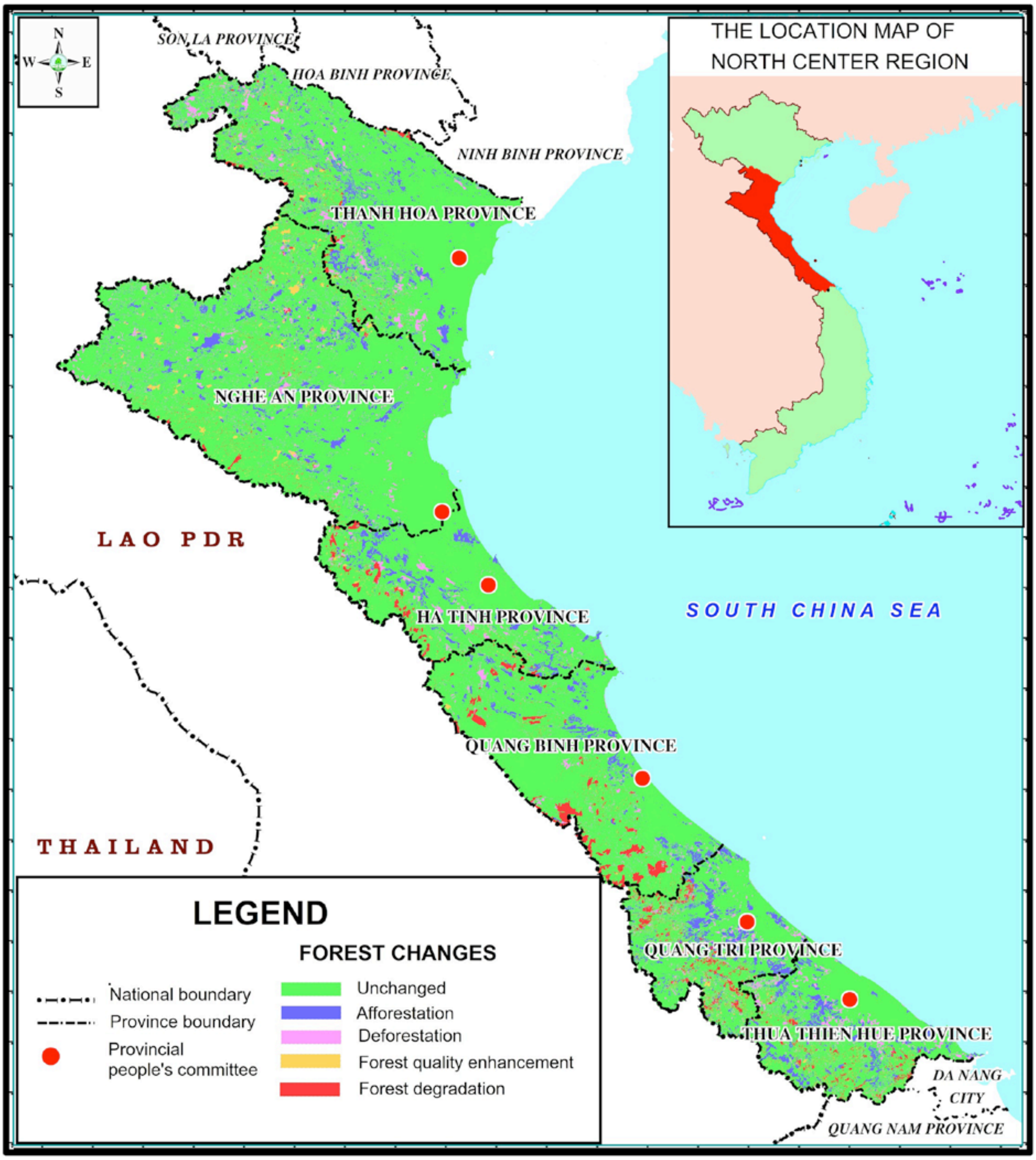
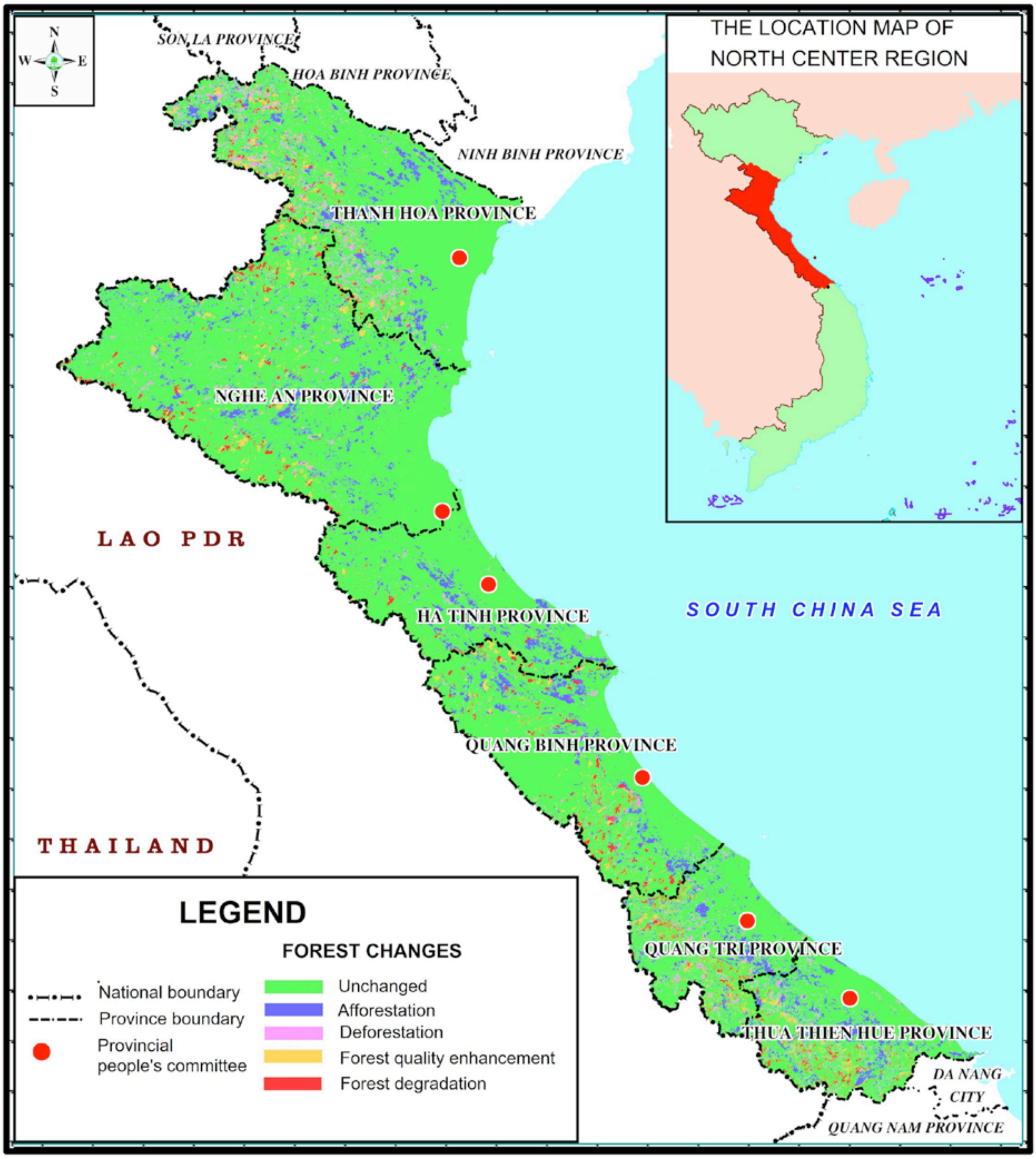


Figure 1.6: Forest cover change map of NCC for the period of 2005 – 2010



1.6 Forest and land use area

The result of forest and land use area calculation for each point of time is shown in the Table 2.3 as follow:

Table 1.13: Area of forest and land use (ha) in the NCC

No	Land uses	2000	2005	2010
1	***Forest land***	***2,319,065***	***2,496,603***	***2.771,531***
1.1	Evergreen broadleaves forest - rich	282,046	233,922	226,626

No	Land uses	2000	2005	2010
1.2	Evergreen broadleaves forest - medium	512,245	497,567	452,900
1.3	Evergreen broadleaves forest - poor	1,053,217	1,160,297	1,315,598
1.4	Other Forest	160,146	149,910	138,755
1.5	Plantations	311,411	454,907	637,651
2	***Non-forest land***	***2,825,443***	***2,647,905***	***2,372,977***
Total		**5,144,508**	**5,144,508**	**5,144,508**

The above results show that the total area of forest land in the NCC region tends to increase in the period of 2000 – 2010 with a total increased area of 452,466 ha, or an average of 45,247 ha per year, equivalent to about 2% per year.

Plantation forests have fairly rapid growth rate of 32,624 ha/year, equivalent of 10.81% per year. This result reflects the efforts of the Government of Vietnam through the 661 Program - 5 million hectares of afforestation during this period. Thus, during the process of FRELs/FRLs construction, it is needed to take account of the outputs from the implementation of forestry projects and/or programs before implementing REDD+, which includes the 661 Program. According to the final report on the 661 Program of the government[4], this program meets the requirements of "high transparency" of information. Therefore, the construction FRELs/FRLs will include the success rate of 661 Program in forest development activities, contributing to reduction of emissions, and increase in the removal capacity of the forest.

Natural forests tend to increase slightly, only about 0.6% per year. However, each forest type has a different rate of increase (or decrease), of these, only evergreen forest - poor is likely to increase, at more than 2%. The forest types that have higher volumes such as evergreen forest - rich and medium, tends to decrease, an equivalent of 2.4% and 1.3% per year respectively. It shows that the forest degradation is still occur quite common in the NCC region in the period 2000 - 2010.

1.7 Land cover changes

Land use change for the period of 2000 – 2005 is extracted from forest cover change maps for this period (see Table 2.4 and Table 2.5).

Table 1.14: Forest change matrix (ha) in the period of 2000 – 2005

2000	2005						Total
	1	2	3	4	5	6	
1	223,087	48,684	8,267	158	18	1,831	**282,046**
2	9,708	420,723	69,415	952	301	11,146	**512,245**
3	669	25,837	918,657	9,104	3,301	95,649	**1.053,217**
4	37	198	14,056	118,194	1,683	25,978	**160,146**
5		15	224	244	267,731	43,197	**311,411**
6	421	2.110	149,677	21,258	181,874	2,470,102	**2,825,443**
Total	**233,922**	**497,567**	**1,160,297**	**149,910**	**454,907**	**2,647,905**	**5,144,508**

[4] Executive Summary The project report on "5 million hectares afforestation" and forest planning, protection and development in period 2011-2020

Legend:

(pink)	Forest degradation
(peach)	Deforestation
(blue)	Forest quality enhancement
(green)	Afforestation
(yellow)	Unchanged

Table 1.15: Area of main forest change (ha) in the period of 2000 – 2005

Province	Forest degradation	Deforestation	Forest Enhancement	Afforestation
1. Thanh Hoa	17.420	45.206	8.373	75.305
2. Nghe An	15.267	49.573	25.158	85.664
3. Ha Tinh	19.191	19.170	3.230	47.127
4. Quang Binh	48.699	15.822	2.697	37.106
5. Quang Tri	25.870	20.182	5.769	55.426
6. Thua Thien Hue	15.434	27.849	4.843	52.180
Total region	**141.882**	**177.802**	**50.068**	**352.809**

A review of the period 2005 - 2010, shows that the total area of degradation forest as well as the deforestation in the NCC region in this period are both larger. Meanwhile, the total area of forest enhancement and afforestation are less. This shows that the development of forest at a later period is better than the previous one. This can be explained through the results of the 661 Program. The initial period was from 2000 to 2005, and was then followed by a 5-year end phase of the program, thus, the forests formed and developed in the late phase of the program were better than the previous one.

For forest degradation, in the period 2000 - 2005, Quang Binh province has the largest area, accounting for nearly 34.3%, followed by Quang Tri with over 18.2% of total area degraded forest. The other provinces do not have a big difference on this kind of forest change, accounting for 10-13% of total area of degraded forest for each province.

The area of deforestation has mostly occurred in Nghe An and Thanh Hoa provinces, and accounts for approximately 27% of the total area. The provinces of Ha Tinh, Quang Tri and Thua Thien Hue have an area of relatively uniform deforestation. Quang Binh has the lowest, accounting for approximately 9% of the total forests lost in this region.

During this period, Nghe An province has the largest area of forest enhancement, accounting for over 50% of the total area. Followed by Thanh Hoa, with over 16%. Quang Tri and Thua Thien Hue provinces are almost the same, at about 11%. Quang Binh and Ha Tinh have the lowest, only about 6.4% of the total area of forest enhancement.

The area of regeneration, restoration of natural forests and new planted forests in Nghe An and Thanh Hoa province occupies the largest proportion in the region, corresponding to 24% and 21%. Ha Tinh, Quang Tri and Thua Thien Hue province represents between 11-15% of the total area of afforestation.

Based on the forest cover change maps prepared, land use change matrix is developed for a period of 2005 – 2010 (see Tables 2.6 and 2.7).

Table 1.16: Forest and land use change matrix (ha) in the period of 2005 – 2010

2005	2010						Total
	1	2	3	4	5	6	
1	202.274	17.593	12.454	212	413	973	233.919
2	23.324	392.902	69.766	1.686	1.869	8.016	497.563
3	849	40.339	1.026.186	16.120	9.423	67.380	1.160.296
4	31	98	25.767	98.949	1.408	23.659	149.911
5	12	22	945	46	429.754	24.120	454.899
6	137	1.945	180.481	21.742	194.785	2.248.830	2.647.919
Total	226.626	452.900	1.315.598	138.755	637.651	2.372.977	5.144.508

Legend:

(pink)	Forest degradation
(peach)	Deforestation
(blue)	Forest quality enhancement
(green)	Afforestation
(yellow)	Unchanged

Table 1.17: Area of main forest change (ha) in the period of 2005 – 2010

Province	Forest degradation	Deforestation	Forest enhancement	Afforestation
1. Thanh Hoa	23.924	50.284	24.287	85.666
2. Nghe An	34.420	19.727	28.650	109.169
3. Ha Tinh	5.811	4.859	1.953	50.352
4. Quang Binh	31.419	10.504	13.872	57.136
5. Quang Tri	17.058	19.460	10.973	42.894
6. Thua Thien Hue	18.312	19.314	10.685	51.791
Total region	**130.944**	**124.147**	**90.420**	**397.008**

The above results (Table 2.7) show that, for the period of 2005 – 2010, the total area of degraded forest in the NCC region is 130,944 hectares. In that, Nghe An province is the largest with an area of 34,420 ha, accounting for 26.3%, followed by Quang Binh province – 31,419 ha, accounting for 24% of the total area of degraded forest in the region. Thanh Hoa, Quang Tri, and Thua Thien Hue provinces have quite a similar area of degraded forest with a total area of 59,294 ha, accounting for 45% of the total area of degraded forest in the region. Ha Tinh province has the lowest degraded forests area, with 5,811 hectares, equivalent to 4.4% of the total area of degraded forest in the region.

The total forest area increasing in quality over this period is 90,420 ha. That is lower than the total area of degraded forest in the NCC region. Of which, Nghe An province has largest area of forest enhancement – 28,650 ha, equivalent to 31.7% and Thanh Hoa province is the second with 24,287 ha, accounting for 26.9% of total area of forest enhancement in the regional. Ha Tinh is a province having the lowest forest enhancement area, accounting for only 2.16%.

The total area of deforestation for the period 2005 - 2010 in the NCC region is 124,147 ha, of which Thanh Hoa province, accounted for over 40.5% of the total deforestation area in the region. Nghe An, Quang Tri and Thua Thien Hue provinces have more or less the same area of deforestation, with nearly 16% for each province. The lowest is Ha Tinh, this area accounts for nearly 4% of the total area in the region.

Among the major changes of forest, the area of afforestation which is increasing in this period is the largest at 397,008 ha, more than three times compared to the deforestation area. This result reflects the efforts to achieve the success of the afforestation and reforestation regeneration by Government of Vietnam during this period. Among them, Nghe An is the most successful province, with 109,169 ha of new forest cover, accounting for nearly 27%, followed by Thanh Hoa province with 85,666 ha, equivalent to 21% of the total afforestation area in the region. The difference in area of afforestation is negligible for the remaining provinces, accounting for 11-15% of total area for each province.

1.8 Accuracy assessment

1.8.1 Determine sample size

The result of determined sample size is shown in the Tables 2.8 and 2.9.

Table 1.18: Sample size for each forest change category in the period of 2000 – 2005

Change category	**SF**	**SNF**	**AF**	**DF**	**FE**	**FD**	Total
Accuracy of class	0,95	0,95	0,9	0,9	0,85	0,85	
Area in pixels	21.646.638	27.442.835	3.919.713	1.975.384	556.260	1.576.310	57.117.140
Wi (Mapped Proportion)	0,38	0,48	0,07	0,03	0,01	0,03	1,00
Si (Standard Deviation)	0,22	0,22	0,30	0,30	0,36	0,36	
Wi*Si	0,08	0,10	0,02	0,01	0,00	0,01	0,23
SE overall accuracy							**0,01**
Total Number of Samples							**536**

	Sample size per stratum						Total
Equal	89	89	89	89	89	89	536
Proportional	203	258	37	19	5	15	536
Allocation of points	**182**	**231**	**33**	**30**	**30**	**30**	**536**

The final result of the determined sample size for each forest change category in the period of 2000 – 2005 showing that the total sample size is 536 points, where as the sample size for DF, FE and FD categories will be given 30 points because the calculated result for these 3 category is less than 30 points. The sample sizes for SF, SNF and AF are allocated as 182, 231 and 33 respectively.

Table 1.19: Sample size for each forest change category in the period of 2005 – 2010

Change category	**SF**	**SNF**	**AF**	**DF**	**FE**	**FD**	Total
Accuracy of class	0,95	0,95	0,9	0,9	0,85	0,85	
Area in pixels	23.887.229	24.984.498	4.410.754	1.379.279	1.004.567	1.454.784	57.121.110
Wi (Mapped	0,42	0,44	0,08	0,02	0,02	0,03	1,00

Change category	SF	SNF	AF	DF	FE	FD	Total
Accuracy of class	0,95	0,95	0,9	0,9	0,85	0,85	
Proportion)							
Si (Standard Deviation)	0,22	0,22	0,30	0,30	0,36	0,36	
Wi*Si	0,09	0,10	0,02	0,01	0,01	0,01	0,23
SE overall accuracy							**0,01**
Total Number of Samples							**538**

	Sample size per stratum						Total
Equal	90	90	90	90	90	90	539
Proportional	226	236	42	13	9	14	539
Allocation of points	**201**	**210**	**37**	**30**	**30**	**30**	**538**

The final result of the determined sample size for each forest change category in the period of 2005 – 2010 showing that the total sample size is 539 points, where as the sample size for DF, FE and FD categories will be given 30 points because the calculated result for these 3 category is less than 30 points. The sample sizes for SF, SNF and AF are allocated as 201, 210 and 37 correspondently.

Figure 1.7 Reference sample points map of NCC for the period of 2000 – 2005

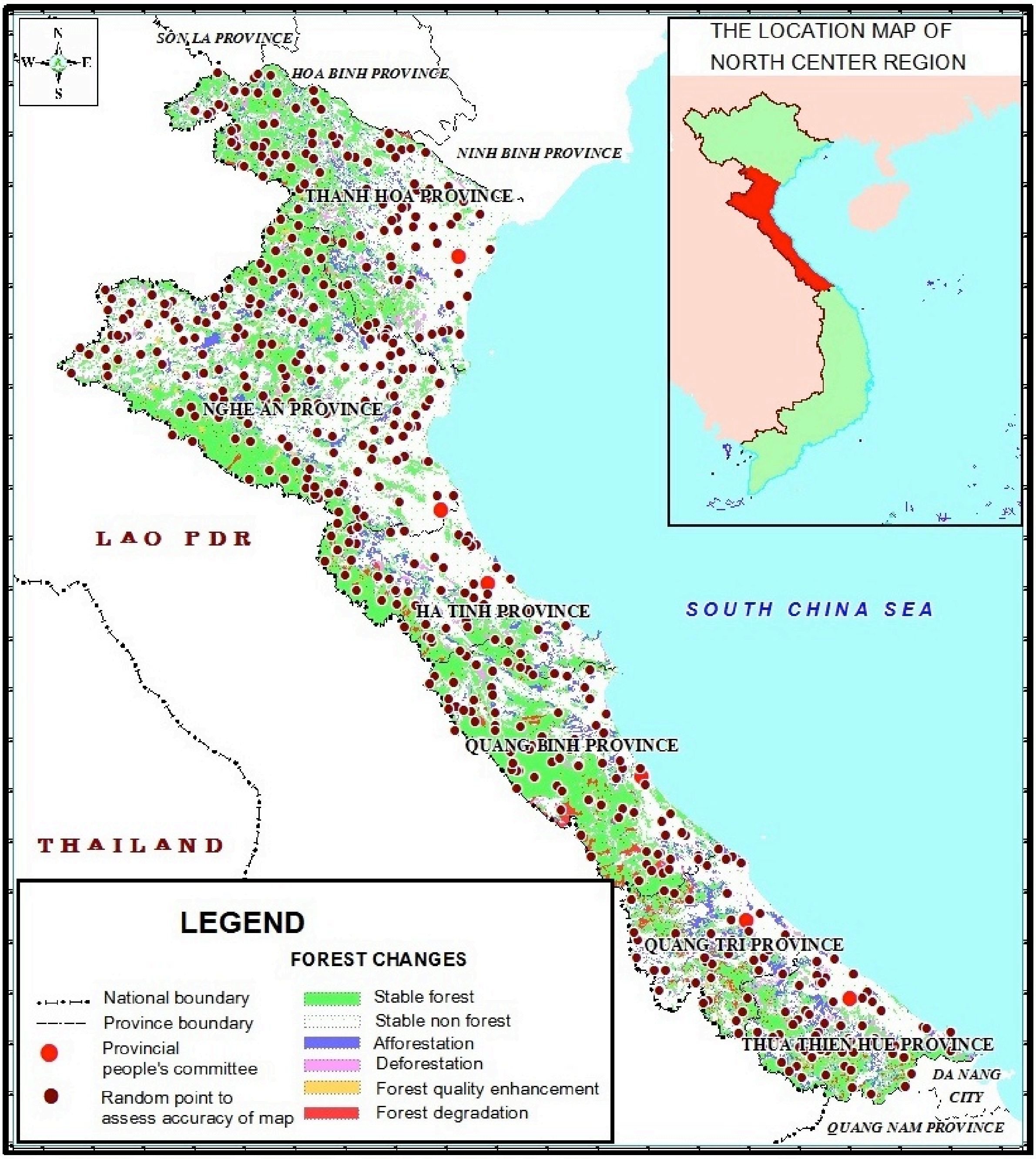
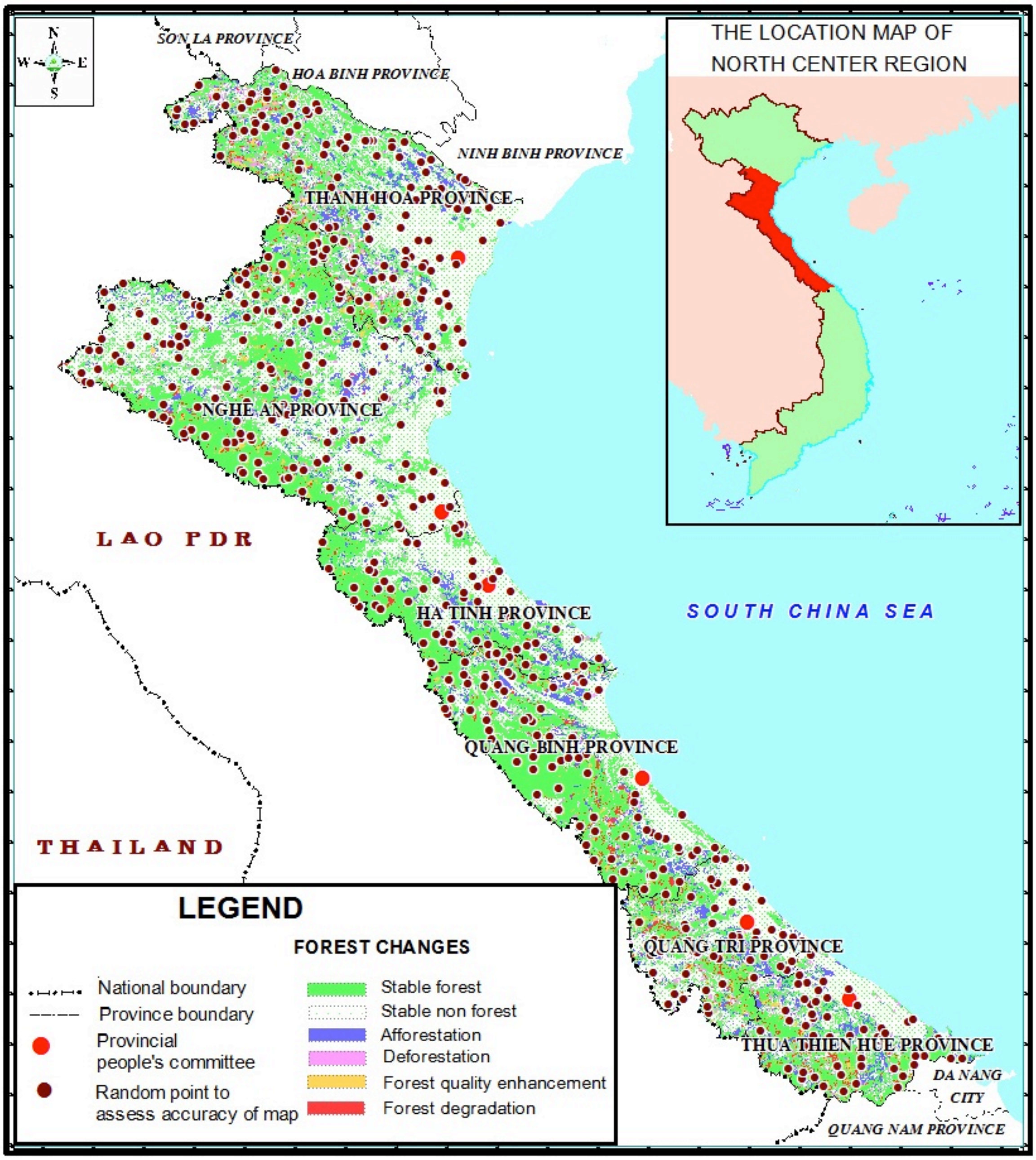


Figure 1.8: Reference sample points map of NCC for the period of 2005 – 2010



1.8.2 Errors matrix

Table 1.20: Errors matrix of forest change in the period of 2000 – 2005

Forest change category		Change Category from Forest change map						Row Totals
		1	2	3	4	5	6	
		SF	SNF	AF	DF	FE	FD	
1	SF	170	13		1		2	186
2	SNF	2	212					214
3	AF		3	31				34
4	DF	4		2	29	1		36
5	FE	4	1			27		32
6	FD	2	2			2	28	34
Column Totals		**182**	**231**	**33**	**30**	**30**	**30**	**536**

Table 1.21: Errors matrix of forest change in the period of 2005 – 2010

Forest change category		Change Category from Forest change map						Row Totals
		1	2	3	4	5	6	
		SF	SNF	AF	DF	FE	FD	
1	SF	193	9	1			2	**205**
2	SNF	5	201	2	1			**209**
3	AF			34				**34**
4	DF	3			27	1		**31**
5	FE					29		**29**
6	FD				2		28	**30**
Column Totals		**201**	**210**	**37**	**30**	**30**	**30**	**538**

1.9 Accuracy assessment results

Table 1.22: Accuracy assessment for forest change in the period of 2000 – 2005

Map Class	Reference Class					
	SF	**SNF**	**AF**	**DF**	**FE**	**FD**
SF	0,3464	0,0265	0,0000	0,0020	0,0000	0,0041
SNF	0,0045	0,4760	0,0000	0,0000	0,0000	0,0000
AF	0,0000	0,0061	0,0626	0,0000	0,0000	0,0000
DF	0,0038	0,0000	0,0019	0,0279	0,0010	0,0000
FE	0,0012	0,0003	0,0000	0,0000	0,0082	0,0000
FD	0,0016	0,0016	0,0000	0,0000	0,0016	0,0227
Cond Ref Class Proportion	0,3576	0,5104	0,0645	0,0299	0,0108	0,0268
SE	0,00872	0,00856	0,00364	0,00308	0,00161	0,00341
95% CI	0,01744	0,01713	0,00729	0,00617	0,00323	0,00682
Adjusted area est (ha)	1.838.234	2.624.236	331.557	153.705	55.530	137.794
95% CI	89.674	88.065	37.462	31.699	16.592	35.039
User accuracy	0,914	0,991	0,912	0,806	0,844	0,824
Producer accuracy	0,969	0,932	0,970	0,932	0,761	0,848

Overall accuracy	**0,944**					

Table 1.23: Accuracy assessment for forest change in the period of 2005 – 2010

Map Class	Reference Class					
	SF	**SNF**	**AF**	**DF**	**FE**	**FD**
SF	0,3937	0,0184	0,0020	0,0000	0,0000	0,0041
SNF	0,0105	0,4207	0,0042	0,0021	0,0000	0,0000
AF	0,0000	0,0000	0,0772	0,0000	0,0000	0,0000
DF	0,0023	0,0000	0,0000	0,0210	0,0008	0,0000
FE	0,0000	0,0000	0,0000	0,0000	0,0176	0,0000
FD	0,0000	0,0000	0,0000	0,0017	0,0000	0,0238
Cond Ref Class Proportion	0,4065	0,4390	0,0834	0,0248	0,0184	0,0279
SE	0,008392	0,008357	0,003589	0,002821	0,000779	0,003110
95% CI	0,016783	0,016714	0,007177	0,005641	0,001558	0,006220
Adjusted area est (ha)	2.090.022	2.257.144	429.016	127.618	94.425	143.191
95% CI	86.290	85.935	36.902	29.004	8.009	31.982
User accuracy	0,941	0,962	1,000	0,871	1,000	0,933
Producer accuracy	0,969	0,958	0,925	0,847	0,958	0,854
Overall accuracy	**0,954**					

1.10 Conclusions and recommendations

For this assignment, the input forest cover maps for activity data calculation serving for FREL/FRL construction were taken from the outcomes of the Project “National forest reference level”.

The misclassification of change assessment revealed that the percentage of points having misclassification of change for all provinces in the NNC region satisfied the accuracy level requirement of less than 3%. Consequently, no further forest cover maps enhancement is needed for this program.

The accuracy assessment was made for the forest change maps in period of 2000-2005 and 2005-2010 by using Landsat images revealed that the overall accuracy is 94.4% and 95.4% respectively. However, the system of satellite imagery with a higher resolution or aerial photos taken in 2000, 2005 and 2010 is still needed to assess the accuracy of forest change maps through periods in a full and exact way.

1.11 References

Karsten Raae et al. (2010). Technical report Technical Assistance in the Development of the National REDD Programme of Vietnam Component of Collecting Information and Analysing Trends of Forest Resources and Forest Carbon Stock for Establishment of the Interim Baseline Reference Scenarios. Danish Forestry Extension and Nordeco

FIPI (2010). Report on silvicultural characteristics of forests in the NCC period of 2006 – 2010, FIPI, Hanoi.

JICA & VNFOREST (2012). The Study on Potential Forests and Land Related to “Climate Change and Forests” in the Socialist Republic of Vietnam. Hanoi, Vietnam.

JICA & VNFOREST (2012). Vietnam NFI (Cycle-4) Verification Survey Final Draft Report

Vu Tien Dien, 2015. Report on forest carbon stock assessment and development of reference level for REDD+ implementation in Vietnam. Ministry of Agriculture and Rural Development, Hanoi, Vietnam.

Pontus Olofsson et al. (2013). Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation.

Pontus Olofsson et al. (2014). Good practices for estimating area and assessing accuracy of land change

Nguyen Dinh Hung et al. (2015). Historical processes of forest cover map generation and review and the description of the latest map review and Activity Data generation process. FIPI, Hanoi.

Appendix 1: Area of forest and land use in 2000 for NCC

Unit: ha

No	Type	Thanh Hoa	Nghe An	Ha Tinh	Quang Binh	Quang Tri	TT. Hue	Total
1	Forest land	451.935	716.641	242.864	502.383	175.688	229.554	2.319.065
1.1	*Natural forest*	*378.749*	*641.866*	*200.197*	*463.423*	*141.756*	*181.662*	*2.007.654*
1.1.1	Evergreen broadleaves forest - rich	15.436	68.828	62.761	76.081	20.500	38.439	282.046
1.1.2	Evergreen broadleaves forest - medium	49.188	121.696	57.472	155.799	71.820	56.270	512.245
1.1.3	Evergreen broadleaves forest - poor	239.572	366.831	79.048	231.378	49.435	86.953	1.053.217
1.1.4	Other Forest	74.553	84.511	916,31	166,25			160.146
1.2	*Plantation forest*	*73.186*	*74.775*	*42.667*	*38.960*	*33.932*	*47.892*	*311.411*
2	Non-forest land	661.015	932.357	356.854	303.154	298.295	273.768	2.825.443
	Total	1.112.950	1.648.998	599.719	805.537	473.983	503.322	5.144.508

Appendix 2: Area of forest and land use in 2005 for NCC

Unit: ha

No	Type	Thanh Hoa	Nghe An	Ha Tinh	Quang Binh	Quang Tri	TT. Hue	Total
1	Forest land	482.197	753.248	270.910	524.569	211.515	254.165	2.496.603
1.1	*Natural forest*	*372.908*	*669.349*	*199.924*	*464.484*	*148.497*	*186.534*	*2.041.696*
1.1.1	Evergreen broadleaves forest - rich	12.949	66.508	52.633	50.410	15.329	36.093	233.922
1.1.2	Evergreen broadleaves forest - medium	46.738	129.039	60.525	157.718	56.503	47.043	497.567
1.1.3	Evergreen broadleaves forest - poor	240.892	397.281	85.870	256.191	76.665	103.398	1.160.297
1.1.4	Other Forest	72.328	76.520	895,67	166,25	0	0	149.910
1.2	*Plantation forest*	*109.289*	*83.899*	*70.986*	*60.084*	*63.018*	*67.631*	*454.907*
2	Non-forest land	630.753	895.750	328.809	280.969	262.468	249.157	2.647.905
	Total	1.112.950	1.648.998	599.719	805.537	473.983	352.880	5.144.508

Appendix 3: Area of forest and land use in 2010 for NCC

Unit: ha

No	Type	Thanh Hoa	Nghe An	Ha Tinh	Quang Binh	Quang Tri	TT. Hue	Total
1	Forest land	517.797	842.967	316.440	571.672	235.446	287.210	2.771.531
1.1	*Natural forest*	*379.247*	*716.834*	*216.678*	*481.867*	*149.028*	*190.225*	*2.133.879*
1.1.1	Evergreen broadleaves forest - rich	14.046	66.729	51.838	44.450	16.251	33.313	226.626
1.1.2	Evergreen broadleaves forest - medium	37.733	116.538	58.536	150.903	46.519	42.670	452.900
1.1.3	Evergreen broadleaves forest - poor	265.696	457.965	105.089	286.348	86.259	114.242	1.315.598
1.1.4	Other Forest	61.772	75.602	1214,67	166,25	0	0	138.755
1.2	*Plantation forest*	*138.550*	*126.133*	*99.762*	*89.805*	*86.418*	*96.985*	*637.651*
2	Non-forest land	595.153	806.031	283.279	233.866	238.537	216.112	2.372.977
	Total	1.112.950	1.648.998	599.719	805.537	473.983	503.322	5.144.508

Appendix 4: Forest change matrix 2000 – 2005 Thanh Hoa province

Unit: ha

2000	2005						Total
	1	2	3	4	5	6	
1	12.097	2.486	713	60	0	80	15.436
2	764	40.874	6.082	470	60	938	49.188
3	74	3.136	202.095	5.753	1.184	27.330	239.572
4	8	87	4.250	54.991	611	14.606	74.553
5	0	0	20	203	70.711	2.252	73.186
6	7	156	27.731	10.851	36.723	585.547	661.015
Total	12.949	46.738	240.892	72.328	109.289	630.753	1.112.950

Appendix 5: Forest change matrix 2000 – 2005 Nghe An province

Unit: ha

2000	2005						Total
	1	2	3	4	5	6	
1	63.842	3.139	1.608	99	0	141	68.828
2	2.389	112.473	4.990	482	1	1.361	121.696
3	206	12.842	318.521	3.331	547	31.385	366.831
4	29	111	9.797	62.366	1.071	11.137	84.511
5	0	0	91	39	69.095	5.549	74.775
6	41	475	62.274	10.204	13.186	846.177	932.357
Total	66.508	129.039	397.281	76.520	83.899	895.750	1.648.998

Appendix 6: Forest change matrix 2000 – 2005 Ha Tinh province

Unit: ha

2000	2005						Total
	1	2	3	4	5	6	
1	51.314	10.715	425	0	14	293	62.761
2	1.255	47.765	7.052	0	114	1.286	57.472
3	59	1.962	64.853	20	851	11.303	79.048
4	0	0	9	671	0	235	916
5	0	0	1	2	36.611	6.053	42.667
6	5	83	13.529	203	33.395	309.639	356.854
Total	52.633	60.525	85.870	896	70.986	328.809	599.719

Appendix 7: Forest change matrix 2000 – 2005 Quang Binh province

Unit: ha

2000	2005						Total
	1	2	3	4	5	6	
1	48.085	26.586	1.086	0	0	324	76.081
2	1.975	129.815	20.750	0	21	3.238	155.799
3	81	670	221.016	0	257	9.354	231.378
4	0	0	0	166	0	0	166
5	0	14	52	0	35.987	2.907	38.960
6	269	633	13.287	0	23.819	265.146	303.154
Total	50.410	157.718	256.191	166	60.084	280.969	805.537

Appendix 8: Forest change matrix 2000 – 2005 Quang Tri province

Unit: ha

2000	2005					Total
	1	2	3	5	6	
1	13.743	3.844	2.582	4	327	20.500
2	1.432	47.840	19.213	105	3.231	71.820
3	97	4.293	38.714	123	6.209	49.435
5	0	0	44	23.473	10.415	33.932
6	57	526	16.112	39.314	242.286	298.295
Total	15.329	56.503	76.665	63.018	262.468	473.983

Appendix 9: Forest change matrix 2000 – 2005 Thua Thien Hue province

Unit: ha

2000	2005					Total
	1	2	3	5	6	
1	34.007	1.913	1.854	0	666	38.439
2	1.893	41.956	11.328	0	1.092	56.270
3	152	2.935	73.458	339	10.069	86.953
5	0	2	15	31.854	16.021	47.892

6	41	238	16.743	35.437	221.308	273.768
Total	36.093	47.043	103.398	67.631	249.157	503.322

Appendix 10: Forest change matrix 2005 – 2010 Thanh Hoa province

Unit: ha

2005	2010						Total
	1	2	3	4	5	6	
1	9.543	2.079	1.162	79	0	86	12.949
2	4.374	30.608	8.674	956	133	1.993	46.739
3	106	4.765	197.673	9.577	521	28.251	240.894
4	11	66	14.727	38.331	742	18.450	72.328
5	0	3	385	36	107.356	1.504	109.283
6	11	211	43.075	12.793	29.798	544.869	630.757
Total	14.046	37.733	265.696	61.772	138.550	595.153	1.112.950

Appendix 11: Forest change matrix 2005 – 2010 Nghe An province

Unit: ha

2005	2010						Total
	1	2	3	4	5	6	
1	59.011	3.518	3.766	134	0	77	66.506
2	7.497	102.665	17.299	724	130	724	129.039
3	166	10.079	365.536	6.423	1.761	13.315	397.281
4	20	31	11.025	59.858	665	4.922	76.521
5	0	0	38	10	83.162	689	83.899
6	34	245	60.301	8.454	40.414	786.304	895.751
Total	66.729	116.538	457.965	75.602	126.133	806.031	1.648.998

Appendix 12: Forest change matrix 2005 – 2010 Ha Tinh province

Unit: ha

2005	2010						Total
	1	2	3	4	5	6	
1	50.478	1.505	640	0	0	10	52.633
2	1.338	56.481	2.432	6	35	232	60.524
3	19	515	82.840	120	1.073	1.303	85.869

4	0	0	14	593	1	287	896
5	0	0	86	0	67.873	3.026	70.986
6	4	35	19.077	495	30.780	278.420	328.811
Total	51.838	58.536	105.089	1.215	99.762	283.279	599.719

Appendix 13: Forest change matrix 2005 – 2010 Quang Binh province

Unit: ha

2005	2010						Total
	1	2	3	4	5	6	
1	39.647	5.908	4.026	0	380	448	50.409
2	4.717	135.379	14.455	0	1.309	1.856	157.716
3	70	9.153	235.891	0	5.341	5.733	256.188
4	0	0	0	166	0	0	166
5	0	1	2	0	57.613	2.467	60.083
6	17	461	31.974	0	25.162	223.362	280.975
Total	44.450	150.903	286.348	166	89.805	233.866	805.537

Appendix 14: Forest change matrix 2005 – 2010 Quang Tri province

Unit: ha

2005	2010					Total
	1	2	3	5	6	
1	12.435	1.791	923	2	179	15.329
2	3.720	37.018	13.629	154	1.982	56.503
3	78	7.233	59.366	559	9.432	76.667
5	0	1	20	55.129	7.868	63.017
6	18	477	12.320	30.574	219.077	262.467
Total	16.251	46.519	86.259	86.418	238.537	473.983

Appendix 15: Forest change matrix 2005 – 2010 Thua Thien Hue province

Unit: ha

2005	2010					Total
	1	2	3	5	6	

1	31.160	2.792	1.936	31	174	36.093
2	1.678	30.751	13.278	108	1.227	47.042
3	410	8.593	84.880	168	9.346	103.398
5	12	18	414	58.621	8.567	67.631
6	53	516	13.734	38.057	196.798	249.158
Total	33.313	42.670	114.242	96.985	216.112	503.322

2 Emissions Factor Report

2.1 Introduction

This report is prepared under the FCPF to support the develop of a reference level for the north central coast (NCC) as a part of the proposal for the Emission Reduction Program (ER-P). The aim of this report is to calculate the emission and removal factors for every classified land use and forests for the estimation of emissions and removals for the period of 2000 – 2010 for development of the reference level.

In Vietnam the dataset of NFIMAP is available for 4 cycles (1991-1995; 1996-2000; 2001-2005; and 2006-2010), but the quality of these datasets are very different. The dataset of NFIMAP cycle 4 is reported to be the highest quality and this dataset has been reviewed and updated several times. Therefore, this dataset is used for the estimation of emission and removal factors and applied in the nationally developed allometric equations for the NCC for the tree level biomass estimation. The tree level biomass estimation is then compiled for every forest type. The accuracy of emission and removal factors is also assessed

2.2 Dataset and methods

2.2.1 Dataset used

Dataset of NFIMAP cycle 4 (2006-2010) is used for the construction of emission and removal factors. This dataset is reported to be at high quality and has also been reviewed and updated several times during the study by JICA and for the preparation of the national reference level for REDD+ (JICA 2012; MARD, 2015). The use of this dataset is consistent with the national reference level and the dataset includes forest cover maps and measurement data of secondary sample plots in primary sample units (PSUs)[5].

Table 2.1 Numbers of primary sample units in inventory cycle 4

ID	Forest types	Number of PSU	Number of SSP
1	EBF-R	78	1,225
2	EBF-M	172	2,398
3	EBF-P	304	5,281
4	Other forest	77	1,080
5	Plantations	42	444
6	Non-forest land	1,325	172
Total		**1,998**	**10,600**

The estimate of the EF and RF is based on measurement data from 753 PSUs and 11,653 SSPs for cycle 4. In these SSPs, information available includes the DBH data of all trees bigger than 5 cm, species name and tree height measured for three trees in each SSP.

[5] The dataset is available at FIPI. The access of the data needs to be authorized by VNForest

Other dataset used for the calculation of the EF and RF are allometric equations that were nationally developed under the support of UN-REDD Vietnam for the NCC[6]. These equations are available for tree level biomass estimations using different predictors such as DBH, DBH and tree height, DBH, tree height and wood density (Sola et al 2014). The equations available for several woody forests[7] and bamboo forests (3 species) are available at the national and regional level[8].

The research reports related to emission factors for mangrove forest (Phuong *et al*, 2014) and available wood density database (Chave *et al*, 2009; UN-REDD Vietnam, 2012) are also used to calculate EF and RF.

2.3 Methods to generate EF and RF

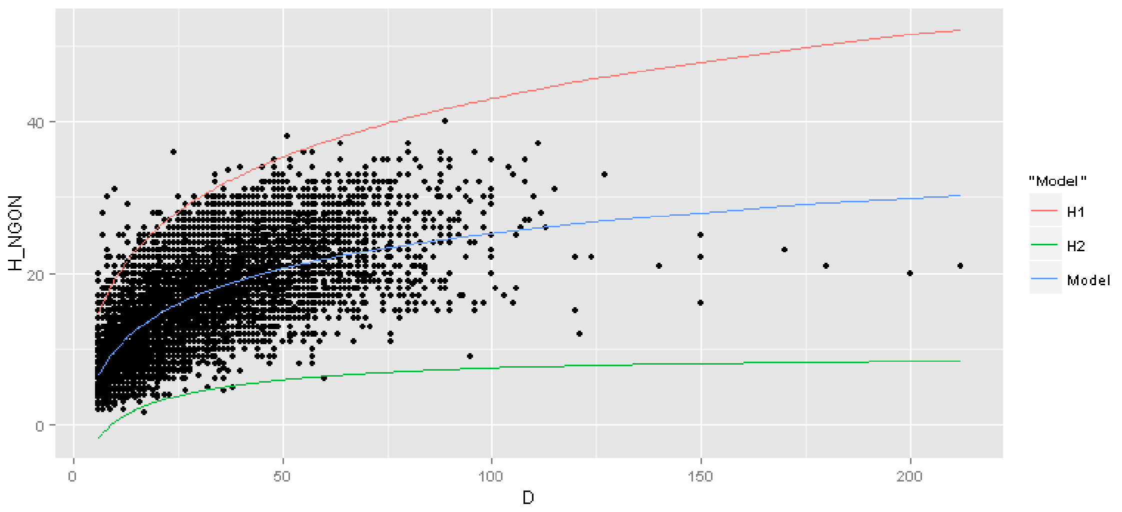
2.3.1 Review and update of the forest dataset

In this work, the updated dataset of NFIMAP cycle 4 is again reviewed and checked independently for elimination of illogical and typo mistakes. This is done by comparing recorded data in field form and digitized dataset. In Vietnam, the National Forest Inventory Program started in 1991 and all requirements for forest inventory including sampling design, field measurement, data analysis and control and reporting is regulated (FIPI, 1995). The main steps for reviewing and updating the forest dataset used for calculation of the EF and RF are as follows:

- Identify and remove the repeated trees caused by data entry mistakes;
- Entry data of missing trees;
- Checking and correcting name of species;
- Checking tree height and DBH by displaying data of DBH and tree height on graphic to find abnormal data (Figure 5.1). This curve is developed for every provinces in the region. The trees with height above red curve and/or below green curve need to be checked.

[6] UN-REDD Vietnam phase I developed numbers of equations for tree level biomass estimation. The equations are validated and can be used at eco-region level and national level with different options of predictors such as DBH, DBH and H, DBH, H and Wood Density (WD).
[7] Including evergreen broadleaved forests and deciduous forests
[8] Regional equations available at Northeast, North Central Coast, South Central Coast and Central Highland.

Figure 2.1 Displaying DBH-H relations for checking abnormal data



2.3.2 Estimation of biomass and carbon stock for all forest types

The AGB of individual trees in the SSPs will be estimated using allometric equations developed by UN-REDD Vietnam for NCC (Gael Sola et al, 2014). Under the UN-REDD Vietnam, a numbers of AE for tree level biomass estimation are developed for national and major eco-regions (northeast, north central coast, central highland and southeast). A single equation is also developed for national scale application. The equations are prepared for evergreen broadleaf forests, deciduous forest and bamboo forests that cover most forest area in Vietnam, particularly evergreen broadleaf forests. There are several choices available for using the developed AE depending on data availability measured such as DBH, tree height and WD. The AE using different predictors have different accuracies. To understand the accuracy of application of different predictors used in the equations, the application of three types of equations for the above biomass estimation, the following AEs are applied.

1) Aboveground biomass estimation of biomass for of evergreen broadleaf forests (including plantations), the following AEs are used:

- AGB = 0.1245*DBH^2.4163 (1)

  (observation = 110; SE = 18.37%; R^2 = 0.99)
- AGB = 0.0421* (DBH^2 * Hmt)^0.9440 (2)

  (observations = 110; SE = 16.23%; R^2 = 0.99)
- AGB = 0.699*(DBH^2 * Hmt * WD/10)^0.940 (3)

  (observations = 110; SE = 13.73%; R^2 = 0.99)

Where:

AGB is above ground biomass expressed in kg;

DBH is diameter at breast height expressed in cm;

Hmt is height of tree along its stem in meter and Hmt = Htop*1.04 (FIPI, 1995);

WD is wood density expressed in gram/cm^3. WD data are taken from national studies (mainly Vietnam Academy of Forest Sciences) that was compiled as a WD database by UN-REDD Vietnam (UN-REDD Vietnam, 2012). In the case where there is no WD data available for tree species, the value of WD will be taken from global WD database, and if not, the average WD value of tree species in Vietnam (0.584) is used[9].

2) Aboveground biomass estimations for bamboo forests, the equations used are based on bamboo species. The equations are as follows (UN-REDD, 2015).

- *Bambusa balcooa*: AGB = 0.1021*DBH^2.2100*H^0.0612 (4)
  (observation = 120; SE = 15.2%; R^2 = 0.92)
- *Dendrocalamus membranaceus*: AGB= 0.1527*DBH^2.1044*H^0.1013 (5)
  (observation = 80; SE = 18.2%; R^2 = 0.91)
- *Bambusa chirostachyoides*: AGB= 0.4514*DBH^1.5022*H^0.3558 (6)
  (observation = 120; SE = 18.2%; R^2 = 0.92)
- *Indosasa angustata*: AGB= 0.3704*DBH^1.6460*H^0.2829 (7)
  (observation = 70; SE = 18.2%; R^2 = 0.92)

After calculation of the tree level AGB of every tree in the SSP, the AGB of the plots is calculated for every forest type existing on the PSU. The general formula for calculation of AGB of measurement plots is as follows:

$$AGB_i = \sum_{j=1}^{n_i} AGB_{ij} \quad (8)$$

Where:

AGBi is total AGB of all trees and bamboos in the measured plot *i*. This is expressed in kg or tonnes of dry mass per plot.

n_i is numbers of measured trees in the plot *i*;

AGB_{ij} is AGB of tree *j* in plot *i*;

To estimate Below Ground Biomass (BGB), it is estimated for every measurement plot using root to shoot ratio (R). As Vietnam has no specific data on R and the development of such a factor is very costly, therefore, the default value of R of 0.20 (IPCC 2006) is used for the calculation of BGB as follows.

$$BGB_i = AGB_i \times 0.20 \quad (9)$$

Total biomass (TB) is calculated for every measurement plot by summing AGB and BGB in each measurement plot:

TB*i* = AGB*i* + BGB*i* (10)

Carbon stock estimation is accounted for based on biomass and carbon fraction (CF). The formula for calculation is as follows:

$$C_i = TB_i \times CF \quad (11)$$

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[9] WD data in Vietnam is available for more 300 species and most of them are natives. As Vietnam has thousands native species and the species vary from region to region therefore, an average WD value of known species is applied for species having no data on WD.

Where:

TBi is total biomass of plot *i* (include AGB and BGB), expressed in kg

CF is carbon fraction and default value of CF (0.47) is used (IPCC 2006)

After the carbon stock of all measurement plots is estimated, based on area of measurement plot, the carbon stock per ha of forest type is calculated as follows:

$$C\ (tC/ha) \quad = \frac{C_i \times 10^4}{10^3 \times \mathrm{A}} \qquad (12)$$

Where: C*i* is the carbon stock of plot *i*; A is area of measurement plot in m^2 (for woody forest, measurement plot area is 500 m^2 and this is 100 m^2 for bamboo forest).

Once the carbon stock per ha of all forest types is estimated, the average value of carbon stock per ha for every forest type is calculated as follows:

$$\bar{X}_i = \frac{1}{np_i}\sum_{j=1}^{np_i} x_{ij} \qquad (13)$$

Where:

$\bar{X}_i$ is average value of carbon stock for forest type *i*;

x_{ij} is carbon stock of measurement plot *j* for forest type *i*;

Regarding the other forests (bamboo and mangrove forest are combined), its carbon stock is calculated using weighted value. The calculation of carbon stock for this forest type is as follows:

$$C\ (tC/ha) = \frac{Cb*Ab + Cm*Am}{Ab+Am}$$

Where: *Cb* is average carbon stock (tC/ha) of bamboo forest calculated from its biomass using equations;

Ab is area of bamboo forest (ha);

Cm is average carbon stock (tC/ha) of mangrove forests;

Am is area of mangrove forests (ha)

Regarding the mangrove forests, there are no measurement plots in PSU in mangrove forests, however there are a numbers of studies on biomass of mangroves. A review report on biomass and carbon stock suggests that the average weighted carbon stock for mangrove forest in the North (NE, NCC and SCC) is 35.2 tC/ha and for the South (SE and SW) is 64.4 tC/ha and national level is 58.0 tC/ha (Phuong et al 2015).

2.3.3 Uncertainty assessment of estimated forest carbon stock

The co-variance (CV) for carbon stock of forest type *i* is estimated as follows:

$$CV\%_i = \frac{SE_i \times \sqrt{np_i}}{\bar{x}_i} \times 100 \qquad (14)$$

Where: SE_i is the standard error of carbon stock in the measurement plot of forest type *i*.

np_i is the number of measurement plots for forest type *i*;

As the measurement plot is not sampled randomly, therefore SE is estimated as follows (Tomppo 2010).

$$SE_i = \frac{1}{\sum_{j=1}^{l_i} m_{ij}} \sqrt{\frac{l_i}{l_i - 1} \sum_{j=1}^{l_i} \left(y_{ij} - \bar{x}_i . m_{ij}\right)^2} \qquad (15)$$

Where:

l_i is a minimum number of measurement plot of forest type *i* in a primary sample plot;

y_{ij} is value of all measurement plots of forest type *i* in primary sample plot *j*;

$\bar{x}_i$ is average value of carob stock of forest type *i*;

m_{ij} is number of measurement plots of forest type *i* in a primary sample plots *j*.

The error (E) for carbon stock of forest type *i* is estimated as follows:

$$E\%_i = \frac{t_{\alpha, l_i - 1} \times CV\%_i}{\sqrt{np_i}} \qquad (16)$$

Where:

$t_{\alpha, l_i\text{-}1}$ is value of *t* distribution with l_i-1 free degree at confidence of 1-α. In this estimation, confidence used is 90% (α = 0.1).

2.3.4 Estimation of EF and RF

After completion of calculating average carbon stock for every forest types in the region these values will be used to estimate EF/RF for every change in forests and land uses. As for mangrove forests, there is no measurement plot and carbon stock of mangrove forest is taken from study (Phuong et al 2015). The general formula for estimation of EF and/or RF is as follows and this calculation is based on land use matrices.

$$EF\ or\ RF_{ij} (\text{tCO2e/ha}) = \left(C_i - C_j\right) \times 44/12 \qquad (17)$$

Where:

$EF\ or\ RF_{ij}$ is EF or RF when the change incurred from land use *i* to land use[10] *j*. In this estimation, the post carbon stock of deforestation is assumed to be zero (0). Also, carbon stock of non-forestland (rocky mountain, resident and water areas and other land) is considered zero (IPCC 2006).

C_i and C_j is carbon stock per ha of forest type *i* and *j* corresponding to the changes;

If C*i* > C*j*, such change is considered emissions;

If C*i* < C*j*, such change is considered removal or sequestration;

[10] i.e. This is change from one land cover class to another using the same classification scheme used to develop the reference Land cover map and the land cover change analysis

2.4 Results

2.4.1 Review of the forest data set

A total of 10,600 secondary sample plots (SSP) of 1,998 PSUs in NFIMAP cycle 4 (of which 10,428 SSP of 673 PSU for forests) was reviewed and updated. The main mistakes found are type and name of tree species. The basic information on forest quality is shown in Table 5.2.

Table 2.2 Basic information on forest quality

Forest types	Average density (trees/ha)	Average wood stock (m^3/ha)
1. EBF-R	594	354
2. EBF-M	560	167
3. EBF-P	1427	64
4. Other forests	7346	12
5. Plantation	500	57

2.4.2 Forest carbon stock

Time average carbon stock of all classified forest type estimated based on data of NFIMAP cycle 4 and the methods mentioned above. The following table provides carbon stock estimation for forest types (see Table 5.3).

Table 2.3 Average aboveground forest carbon stock (tC/ha) of forest types

Forest types	No. of PSUs	Carbon stock (tC/ha) estimated using DBH	Carbon stock (tC/ha) estimated using DBH and H	Carbon stock (tC/ha) estimated using DBH, H and WD
1. EBF-R	78	148.2	129.2	140.7
2. EBF-M	172	72.2	61.0	65.7
3. EBF-P	304	31.5	27.7	28.8
4. Other forest	77	22.6	22.5	22.5
5. Plantations	42	24.3	21.2	22.4

Analysis of covariance and error of carbon stock estimation shows that there is no significant covariance and error of carbon stock estimated using different predictors. The high values of covariance are found for bamboo forests and plantations and error of carbon estimation for rocky mountain forests is quite high (see Table 5.4 and Annex for details).

Table 2.4 Covariance and error of above forest carbon stock estimation

Forest types	CV (%) of carbon stock estimated using DBH	CV (%) of carbon stock estimated using DBH and H	CV (%) of carbon stock estimated using DBH, H and WD	Error (%) of carbon stock estimated using DBH	Error (%) of carbon stock estimated using DBH and H	Error (%) of carbon stock estimated using DBH, H and WD
1. EBF-R	44.3	43.0	43.7	8.2	8.0	8.1
2. EBF-M	34.7	32.1	34.7	4.3	4.0	4.3
3. EBF-P	77.2	78.5	78.8	7.3	7.4	7.4
4. Other forest	111.2	111.3	111.0	20.8	20.8	20.7
5. Plantations	208.8	220.8	222.4	21.2	21.7	23.5

As the results of forest carbon estimation, it is suggested to use only DBH for forest biomass and carbon stock estimation. Using DBH as a predictor can reduce uncertainty as this data can be measured quite accurately. The measurement of tree height and wood density can also generate its own uncertainty, therefore tree height and WD are used as predictors in forest carbon estimation.

2.4.3 Estimation of EF and RF

As the analysis, the carbon stock used for calculating EF and RF is shown in Table 5.5

Table 2.5 Carbon stock used for calculation of EF and RF for NCC based on DBH

Land use and forest	Carbon stock (tCO_2/ha)	STDEV (tCO2/ha)	Error (%)	Remarks/sources
1. EBF-R	543.5	240.6	8.2	Calculated
2. EBF-M	264.9	91.8	4.3	Calculated
3. EBF-P	115.5	89.2	7.3	Calculated
4. Other forests	82.9	91.6	20.8	Calculated
5. Plantations	89.0	74.5	24.3	Calculated
6. Non-forest land	0	na	0	IPCC 2006

As mentioned the EF and RF is calculated based on AD for 2 periods of 2000 – 2005 and 2005 – 2010 and carbon stock per ha of land use based on estimation using dataset of NFIMAP cycle 4 and IPCC default values, the EF and RF is estimated in Table 5.6.

Table 2.6 Estimation of EF and RF (tCO_2e/ha) for NCC[11]

2000/2005	2005/2010					
	1	2	3	4	5	6
1. EBF-R	0	279	428	461	454	543
2. EBF-M	-279	0	149	182	176	265
3. EBF-P	-428	-149	0	33	26	115
4. Other forests	-461	-182	-33	0	-6	83
5. Plantation	-454	-176	-26	6	0	89
6. Non-forest	-543	-265	-115	-83	-89	0

2.5 Discussion

There are several studies on forest carbon stock, however the values of forest carbon stock vary among them. The differences in forest carbon stock estimation are related to the method used and the forest dataset (see Annex 2 & 3 for details). The study of JICA used wood stock data generated by NFIMAP to estimate carbon stock using default value of BCEF, R and CF provided IPCC guidelines (IPCC 2006). In the work of development of national reference and this study, the nationally developed allometric equations are directly used for estimation of forest biomass then converted to forest carbon stock. In addition to that, there is intensive improvement in reviewing and updating the measurement data made during the NFIMAP cycles. However, there are still small differences between the estimation of forest carbon stock prepared for national reference level and for this study. Such differences are normal as in this study, the allometric equations applied are equations developed for NCC and the equations show higher accuracy as the data used for equations construction is taken from NCC. Improving forest dataset also influences estimation results. Given the fact that future improvement of data collection and processing to be used for updating EF and RF is needed if more predictors for biomass estimation are expected to be used. Vietnam is implementing national forest inventory and statistics that is planned to complete in 2016 and that can provide good sources of data for improving EF and RF.

2.6 Conclusions and recommendations

The above forest carbon stock is estimated using the dataset of NFIMAP cycles 4 and nationally developed allometric equations prepared for the NCC. The accuracy of such estimation is better if more predictors used in the equations, particularly evergreen broadleaf forests. Theoretically the more variable used in equations for estimation of forest biomass can produce better results, however in this study there are concerns about the uncertainties in estimating tree height and wood density. Therefore, the use of DBH for biomass estimation should be sufficient. Other forest types such as bamboo forests, limestone forests and plantation have quite high covariance and error. This may be caused by insufficient sampling plots and/or the sampling design of the NFIMAP as wood stock of these forest types varies greatly. It is suggested that to reduce such variation, the forest classification should be based on carbon stock and there is a need for improvement of data collection and processing in the NFIMAP.

[11] Single C stock for 2000 – 2010, therefore the EF and RF is similar for the period

2.7 References

Gael Sola, Akiko Inoguchi, Javier Garcia-Perez, Emily Donegan, Luca Birigazzi and Matieu Henry, 2014. Allometric equations at national scale for estimating tree and forest biomass in Viet Nam. Part A: Context, method and summary of the results, UN-REDD Vietnam, FAO, Hanoi.

Dien, V.T, 2015, Carbon stock assessment and development of FRL for REDD+ in Vietnam. Ministry of Agriculture and Rural Development, Hanoi, Vietnam.

IPCC, 2006. Guidelines for national greenhouse gas inventories. Vol. 4, Agriculture, forestry and other land use (AFLOLU). Institute for Global Environmental Strategies, Hayama, Japan.

JICA, 2012. Potential forest and land related to “Climate change and forest” in the Socialist Republic of Vietnam, Hanoi.

FIPI, 1995. Mannual on national forest inventory. Agriculture Publishing House, Hanoi.

MARD, 2015. Vietnam’s submission of national forest reference levels to United Nations Framewrok Convention on Climate Change. UN-REDD Vietnam, Hanoi.

Vu Tan Phuong, Tran Thi Thu Ha, Nguyen Thi Hai, Ha Thi Mung, 2015. Development of Emission Factors for a National FREL/FRL for REDD+ for Government’s submission to the UNFCCC.UN-REDD Programme, Hanoi, Vietnam.

Tomppo, E., Schadauer, K., McRoberts, R.E., Gschwantner, Th., Gabler, K. & Ståhl, G. 2010. Introduction. In: Tomppo, E., Gschwantner, Th., Lawrence, M. & McRoberts, R.E. (eds.). National Forest Inventories - Pathways for common reporting. Springer, p. 1-18. ISBN 978-90-481-3232-4.

Annex 1 Standard deviation and errors for above forest carbon stock estimated using different predictors

Forest type	Carbon stock based on DBH (tC/ha)	STDEV of Carbon stock based on DBH (tC/ha)	Standard error based on DBH (%)	Carbon stock based on DBH &H (tC/ha)	STDEV of Carbon stock based on DBH & H (tC/ha)	Standard error based on DBH & H (%)	Carbon stock based on DBH, H & WD (tC/ha)	Standard error based on DBH, H & WD (tC/ha)	Standard error based on DBH, H & WD (%)
1. EBF-R	148.2	65.6	8.2	129.2	55.5	8.0	140.7	61.5	8.1
2. EBF-M	72.2	25.0	4.3	61.0	19.6	4.0	65.7	22.8	4.3
3. EBF-P	31.5	24.3	7.3	27.7	21.7	7.4	28.8	22.7	7.4
4. Other forests	22.5	25.0	20.8	22.5	25.0	20.8	22.5	25.0	20.7
5. Plantations	24.3	20.3	21.2	21.2	18.1	21.7	22.4	20.9	23.5

Annex 2 Summary of methods for EF and RF development of 3 key studies

Study	Methods and Data sources
JICA (2012)	**Stratification:** 17 land uses are classified, of which 12 are forests **Methods:** EF is estimated for every inventory cycles for period 1990-2010. The EF is used for estimation of emissions and removals for every inventory cycle. Equations used are as follows: EF=(AGB+BGB)*CF*44/12 AGB=GS*BCEF BGB=AGB*R Where: GS – growing stock (m^3/ha); R is root to shoot ratio; CF is carbon faction **Data sources**: GS is calculated based on NFIMAP data (DBH and H). BCEF is taken from default values of IPCC 2006 (range from 0.70 – 4.00 depending on growing stock) R (=0.270) is default value CF (=0.47) is default value
Vietnam's Reference Level submitted to UNFCCC (2016)	**Stratification:** 17 land uses are classified, of which 12 are forests **Methods:** EF and RF are estimated using only NFIMAP data of cycle 4 (2006 – 2010). EF and RF are used to estimate emissions and removals for all inventory cycles. Nationally developed equations at national scale for AGB estimation developed by UN-REDD Vietnam are applied. The equations using three predictors (DBH, H and WD) are used for estimation of AGB of forests (except for mangrove forests and coniferous forests). Estimation of coniferous forest biomass based on its estimated wood volume and biomass expansion factor (BEF = 1.3) **Data sources:** Data of DBH and H are taken from NFIMAP cycle 4 with reviews and updates. WD data is taken from available values of WD in Vietnam and global WD data (Chase et al, 2009) for missing species. Carbon stock of mangrove is derived from literature review Default values of CF (=0.47) and R (=0.20) are used;
Reference Level for NCC under FPCF (2016)	**Stratification:** Two forest types (poor and regrowth evergreen broadleaf forests) are merged. Some forest types not appear in NCC. A total of 12 land uses are used, of which 7 land uses are forests. **Methods:** EF and RF are estimated using only NFIMAP data of cycle 4 (2006 – 2010). EF and RF are used to estimate emissions and removals for 2000 - 2010. Nationally developed equations for AGB estimation for NCC developed by UN-REDD Vietnam are applied. The equations using different options of predictors (DBH; DBH and H; DBH, H and WD) are used for estimation of AGB of forests (except for mangrove forests). Bases on equations application for AGB estimation, the biomass estimation by equations using DBH as predictors are selected. **Data sources:** Data of DBH and H are taken from NFIMAP cycle 4 with reviews and updates. WD data is taken from available values of WD in Vietnam and global WD data (Chase et al, 2009) for missing species. Carbon stock of mangrove is derived from literature review Default values of CF (=0.47) and R (=0.20) are used;

Annex 3 Comparison of estimated carbon stock (tC/ha) using NFIMAP 4 dataset

ID	Forest types	JICA Study	Vietnam's national RL	NCC's RL	Difference of JICA & NCC	Difference between RL & NCC'RL
1	EBF-rich	142.7	137.1	148.2	-5.7	-11.1
2	EBF-medium	76.6	73.9	72.2	4.40	1.7
3	EBF-poor	40.2	31.7	31.5	8.70	0.20
4	Other forests	na	na	22.5	na	na
5	EBF-regrowth	33.6	26.1	na	na	na
6	Deciduous forest	49.9	30.9	na	na	na
7	Bamboo forest	22.1	14.5	na	na	na
8	Mixed timber & bamboo forest	51.8	41.2	na	na	na
9	Coniferous forest	57.0	92.7	na	na	na
10	Mixed broadleaf & coniferous forest	70.6	63.6	na	na	na
11	Mangrove forest	16.7	58.0	na	na	na
12	Limestone forest	43.3	19.1	na	na	na
13	Plantation	26.1	16.3	24.3	1.80	-7.90

3 Reference Level Report

3.1 Introduction

This report is prepared under the FPCF support to develop a forest reference level (FREL /FRL/RL) for North Central Coastal (NCC) region of Vietnam as a part of the proposal for ER-program. The aim of this report is to construct reference level as a baseline for assessing interventions of REDD+ activities. The reference level is required for accounting a real emissions reduction and removal enhancement.

The reference level is developed based on two key parameters namely the activity data (AD) and emissions and removal factors (EF). The development of activity data and emission and removal factors are presented in separate reports: Development of Activity Data for the NCC, and The Development of Emissions and Removals Factors for the NCC.

This report presents the methodological framework for construction of reference level for NCC, the proposed reference level, uncertainty analysis and possibilities of emissions reduction and removal enhancement.

3.2 Methodological frame for the construction of the FREL/FRL

3.2.1 Forest definition

The definition of forests used for Forest Reference Emission Level/Forest Reference Level (FREL/FRL) for Vietnam, applies the definitions provided under Circular 34 (2009)[12]. This definition is in line with the definition of forests used for the national GHG inventory[13]. It is also consistent with the definition as described in the Emission Reduction Program Idea Note (ER-PIN) submitted in May 2014 to the Forest Carbon Partnership Facility.

Following this definition, an area is identified as a forest when it meets the following three criteria:

1. An ecosystem of which the major component is perennial timber trees, bamboos and palms of all kinds of a minimum height of 5 meters (except new forest plantations and some species of coastal submerged forest species), and capable of providing timber and non-timber forest products and other direct and indirect values such as biodiversity conservation, environmental and landscape protection.

   New forest plantations of timber trees and newly regenerated forests of forest plantations are identified as forests if they reach the average height of over 1.5 meters for slow-growing species, and over 3.0 meters for fast-growing species and a density of at least 1,000 trees per hectare.

   Agricultural and aqua-cultural ecosystems with scattered perennial trees, bamboos or palms etc. will not be regarded as forests.

2. Having a minimum tree cover of 10% for trees that constitute the major component of the forest.

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[12] Issued by Ministry of Agriculture and Rural Development in 2009.
[13] MONRE, 2014. First Biannual Updated Report (BUR) for 2010

3. Having a minimum plot area of 0.5 hectares or forest tree strips of at least 20 meters in width of at least three tree lines.

3.2.2 Stratification

As noted above Circular 34 regulates the forest definition and forest classification. In this Circular, there are a numbers of criteria for classifying forest such as based on wood stock, biological characters etc. To reduce the complexity of such a system and for the purpose of improving estimation of forest carbon stock and emissions and removals, the harmonization of forest and land uses classification is proposed (Karsten et al, 2010). JICA (2012) also use this proposed classification in its study. In this system, there are 17 land uses, of which 12 land uses are forests. However, in this study, we simplify by merging rehabilitated evergreen broadleaf forest and rocky forests into poor forest; bamboo and mangrove forests are combined into other forest; and all non-forest lands (bare land, water body, residential area and other) are combined as carbon stocks of those are considered zero. The reason for this is that the sub-classifying evergreen broadleaf forest based on wood stock needs to be consistent and carbon stock for rehabilitated evergreen broadleaf forest and poor evergreen broadleaf forest is quite similar (Dien, 2015). In addition, the number of PSU for such forest types are quite limited and if they are separated, the accuracy of the carbon stock estimation is not confident. Such simplified forest classification will help reduce uncertainty in the AD and emission factors. The forest stratification used for construction of reference level includes five types of forestland and non-forest land (see Table 3.1).

Table 3.1 Stratification of land use types

ID	Forest type	Code	Forest / Non-forest
1	Evergreen broadleaf forest, rich forest	EBF-R	Forest
2	Evergreen broadleaf forest, medium forest	EBF-M	Forest
3	Evergreen broadleaf forest, poor forest	EBF-P	Forest
4	Other forests	OFO	Forest
5	Plantation	PLA	Forest
8	Non-forest lands	NOF	Non-forest

3.3 Description of Sources and Sinks selected

The sources considered in the ER program are deforestation and forest degradation. Those contribute significant emissions in the project areas. However, there also exist significant carbon sinks that are removals from forest enhancement and reforestation. The sources and sinks considered for the program are presented in the Table 3.2.

Table 3.2 Sources and sinks included in the ER program

Sources/Sinks	Included?	Justification / Explanation
Emissions from deforestation	Yes	Deforestation is mainly taken place in natural forests such as conversion of forests to agricultural cultivation, infrastructure development etc. In the project area, the spatial analysis of deforestation shows significant area of deforestation. The annual average forest loss is 27,282 ha for a period of 2000 - 2010.
Emissions from forest degradation	Yes	Forest degradation is the gradual reduction in the density of biomass due to anthropogenic variables such as illegal logging. This is a source t to significant loss of forest biomass. It is estimated that in the project area, annual forest area of 47,695 ha is degraded during a period of 2000 – 2010.
Removal from forest enhancement	Yes	Forest enhancement is accelerated through promoting natural regeneration and forest enrichment. Over the past 20 years, a number of programs on recovering forest vegetation has been implemented. In the project area, it is estimated that annual area of 14,000 ha of forests has been regenerated and enhanced.
Removal from reforestation	Yes	Vietnam has made great efforts in implementing reforestation programs to convert non-forests area to forested area. Those programs contributed considerably to the increase of forest cover of the country, particularly for the period of 2000 onward. It is estimated that annual rate of reforestation in the project area for period of 2000 – 2010 is about 80,000 ha.
Emissions and/or removals from conservation of carbon stock	No	The national REDD+ activities are not clearly defined the conservation of carbon stock. In this context, the conservation of carbon stock is not accounted for as it is conservatively assumed emissions are equal to removals.
Emissions and/or removals from sustainable management of forests	No	There is unclear definition of this activity under national REDD+ scheme and there are no clear boundaries for forest areas under sustainable management. Therefore, this activity is included either in above REDD+ activities.

3.3.1 Carbon pools and gases included

Carbon pools to be included in the construction of FREL/FRL are above ground biomass (AGB) and below ground biomass (BGB). The reason for inclusion of the BGB is that studies indicate that BGB constitutes from 0.2 to 1.0 of the AGB pool, depending on the forest type, and therefore is a significant pool. This pool is often estimated indirectly via a root-to-shoot (R/S) ratio. Viet Nam does not have a country-specific R/S ratio, and therefore will apply the IPCC default value. This will cause a high uncertainty estimate for this pool. However, due to the high costs of developing country-specific R/S ratio, there are no plans for conducting future research in Viet Nam. Other carbon pools such as dead wood, litter layer and soil organic carbon are excluded as a national dataset on such pools is not available and if using Tier 1 approach for such pools will create more uncertainties. (See table 3.3 for details)

Table 3.3 Carbon pools included construction of FREL/REL

Carbon Pools	Selected?	Justification / Explanation
Above Ground Biomass (AGB)	Yes	This is the largest carbon pool and is impacted by the sources of deforestation and forest degradation.
Below Ground Biomass (BGB)	Yes	but The BGB is a significant carbon pool. As there is no country specific data on BGB, it is estimated using IPCC 2006 default values.
Dead wood	No	This carbon pool is not significant because of the poor forest quality. Phuong et al (2009) indicates that average dead wood biomass of forests accounts for less than 2% of total AGB biomass. In addition, in the national forest inventories there are no data on dead wood. The national GHG inventories for LULUCF and National submissions of reference level to UNFCCC have not included this pool.
Litter	No	Conservative. IPCC 2006 (Vol 4, Chapter 2) notes that Tier 1: Carbon stock of DOM is assumed to be 0 for non-forestland use categories. The conversion of forests to non-forests, the carbon of post deforestation is also considered 0. Furthermore, litter data is not collected under the national forest inventories and this pool is also excluded in national GHG inventories and national submission of reference level
Soils	No	Conservative. IPCC 2006 notes that as Tier 1 soil carbon does not change for forest remaining forests. Other emissions and/or removals from conversion of forest to non-forests and non-forest to forests may be lower than reference level and not significant. Therefore such exclusion is conservative.
Harvested Wood Products	No	Not required by the Methodological Framework and is thus excluded.

Gases included in the estimation of FREL/FRL are only CO_2. Non-CO_2 gases[14] such as CH_4, CO, N_2O, NOx etc. caused by burning of biomass (for example, forest fire) is not counted as such an emission is not significant. Non-CO_2 emissions resulted from burning biomass accounts for 0.04 % of total Viet Nam's emissions (MONRE, 2010).

[14] In National GHG inventory, it only requires to estimate emission of CH_4, N_2O and NOx if this is significant.

Table 3.4 Gases included in construction of FREL/REL

Greenhouse gases	Selected?	Justification / Explanation
CO_2	Yes	The ER Program shall always account for CO_2 emissions and removals. The emissions are caused by deforestation and forest degradation. The removals are generated from reforestation and forest enhancement.
Non-CO2	No	Non-CO_2 gases (such as CH4, CO, N2O) are emitted only through incidents of forest fires. The national statistics of Viet Nam report on average 2,339 ha of forest burning per year during the period 2005-2013 (0.01% of the country area). In addition, The BUR (MONRE, 2014) indicated that non-CO_2 gases emissions caused by burning of biomass (for example, forest fire) accounted for less than 10 % of total region's emissions. Therefore, non-CO2 emissions are not significant and are excluded.

3.3.2 Reference period

Since the start of preparing the ER programme, it is noted that the requirements of the reference period for the ER-Program area, as noted in the Carbon Fund Methodological Framework (2013), the reference period should be 10 years from the latest data available prior to 2013. Therefore, the reference period used to construct the reference level for the ER program area is from mid 2000 to mid 2010[15].

However, the newly adopted requirement of the Methodological Framework for reference period that requires the reference period must be 10 years back since the first visit of Technical Advisory Penal to the Country. This means the reference period for Vietnam should be at least 10 years back from July 2016.

Vietnam has a long history of national forest inventory, monitoring and assessment programme (NFIMAP) since 1990 and it is implemented in 5 years cycle. To dates, data of national forest inventories are only available for 1990 – 2010. Vietnam is now implementing the national forest inventory and statistics and this data is expected to be published in early 2017.

Given that situation and new requirements of the Methodological Framework, it is decided that Vietnam will update the reference period. It is planned that the updated reference period will be from 2005 – 2015. To develop reference level for such period, the generation of AD for period 2010 – 2015 will be implemented following consistent methodologies used in NFIMAP and availability of forest data generated by national forest inventory and statistic to be published in 2017. Therefore, the use of reference period of 2000 – 2010 for reference development is considered temporary period.

[15] Forest inventories take multiple years we assume that time 1 = mid 2000 and time 2 – mid 2010, that is 10 years.

3.3.3 References for the calculations of the FREL/ FRL

Viet Nam considers it more transparent to present removals and emissions separately rather than presenting net emissions/removals. This separation allows a more adequate representation of the trends in both emissions and removals over time and it provides an improved way of monitoring the different efforts of enhancing forest carbon stocks and reducing emissions from deforestation and forest degradation. In the NCC, the separation of emissions and removals are also applied.

JICA (2012) indicates that it is difficult to foresee the trend of emissions and removals in the future. The historically time averaged emissions and removals based on forest inventory data over a period of 2000-2010 is used as the reference level for REDD+ activities in the NCC and this is consistent with FPCF Methodological Framework (FPCF, 2013).

3.3.4 Scope of REDD+ Activity Data included

Five (5) REDD+ activities are defined[16]. However, the indicators for sustainable forest management activities are not clear and there remains a question of how carbon benefits can be gained from sustainable management of forest and conservation of forest carbon stock. The following definitions are applied for the five REDD+ activities in the context of Vietnam, which are all accounted for under FREL/FRLs of Viet Nam. A land use change matrix is used to detect REDD+ Activities (see Table 3.5).

- **Reducing emissions from deforestation ("Deforestation")**: Activity of conversion of forests to non-forest land, as identified per NFIMAP[17] results with modifications based on updates[18]. Where a series of activities including deforestation may have occurred within a single cycle of NFI, the deforestation activity occurring as a transitional activity will not necessarily be captured by the NFI, thus will be reported as degradation;

- **Reducing emissions from forest degradation ("Degradation")**: Activity resulting in a downward shift in terms of carbon stock between forest types, including Evergreen broadleaf forest volume-based sub-types of "rich, medium, and poor" (based on the average standing volume per ha) and other forest types (deciduous, bamboos etc.);

- **Enhancement of forest carbon stocks from reforestation ("Reforestation"): Any a**ctivity resulted in land use change from non-forest land to forest land;

- **Enhancement of forest carbon stocks from forest restoration ("Restoration"):** Activity resulting in upward shift of carbon stock between forest types, including Evergreen broadleaf forest volume-based sub-types of "rich, medium, and poor" (based on the average standing volume per ha) and other forest types (deciduous, bamboos etc.);

- **Conservation of forest carbon stock:** Forest types remaining in the same forest types, are regarded as "conservation of forest carbon stock". For these forest types, it

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16 Decision 1/CP.16 of UNFCCC

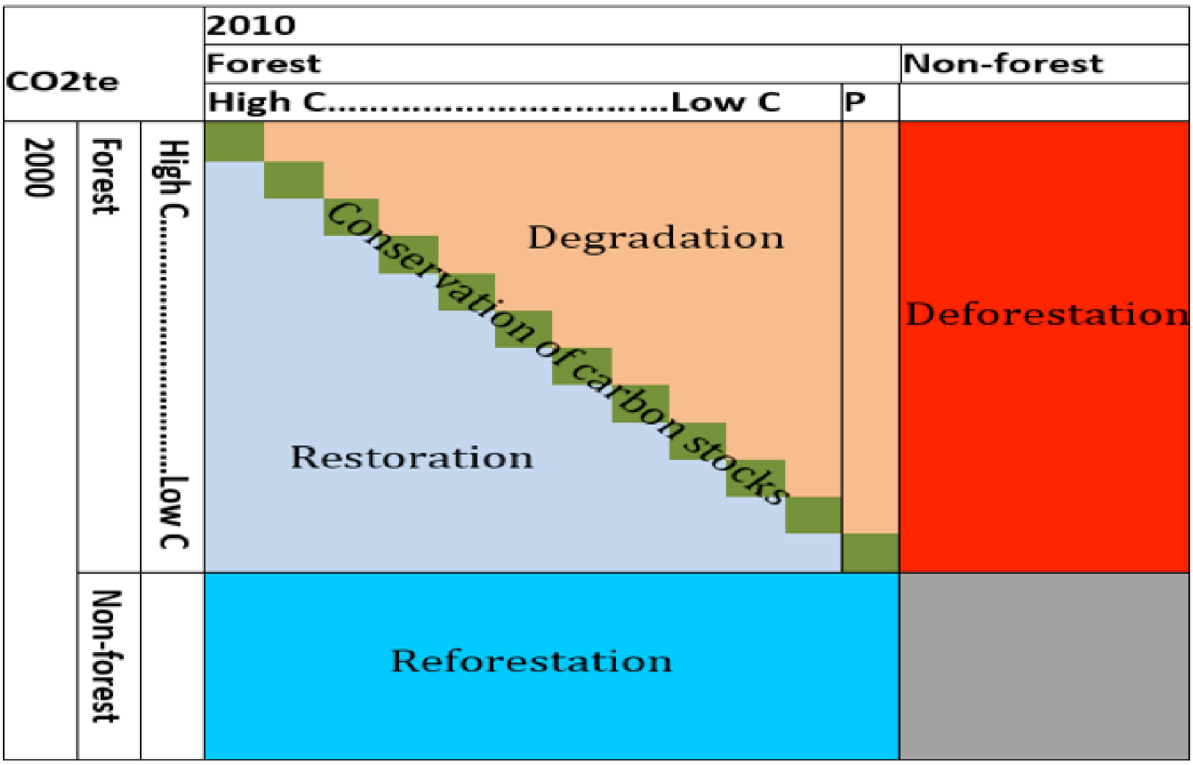
17 Including both plot measurements and remotely sensed information.

18 Updates were made to the original results of the NFI cycles 1-4 by the same implementing body Forest Inventory and Planning Institute (FIPI) under MARD with technical and financial assistance from (in sequential order) Finland, Japan, MARD and UN-REDD throughout 2011-2015.

is assumed to have no net emissions and removals. The future forest inventories, changes of carbon stock in forests remaining the same forest type may be monitored more robustly and the corresponding emissions/removals accounted for; and

- **Sustainable management of forests:** Since Viet Nam does not have exact boundaries for areas for sustainable management of forests, this activity is included as part of the Restoration or Conservation of forest carbon stocks.

Table 3.5 Matrix of land use change



3.3.5 Transparent, complete, consistent and accurate information used in the construction of the FREL/FRL

A Tier 3 approach of IPCC is applied for generating the AD for the construction of the reference level. To date, Viet Nam has completed four cycles of NFIMAP (1991-1995; 1996-2000; 2000 – 2005; and 2006-2010). All forest cover maps of four inventory cycles have been updated using different remote sensing images and consistent forest definition with support of Finland (Karsten Raae et al., 2010), JICA (2012), MARD (Dien 2015) and UN-REDD Vietnam (2015). During these updates, all forest changes within these inventory cycles are checked to detect illogical changes and corrections are made to the forest cover maps with reference to the satellite imageries taken near the time of map creation. Under preparation of FPCF program, the updated forest cover maps of cycle 3 (2000-2005) and cycle 4 (2006-2010) for NCC and six provinces of the NCC are again updated as described in the AD report. The AD and land use change matrices are then generated from the updated forest cover maps for all classified land uses and forests for provincial and regional level for two periods of 2000-2005 and 2005 – 2010 (Dien, 2016).

Table 3.6 Area of Land uses and forests (ha) for 2000, 2005 and 2010 for the NCC

ID	Land uses	2000	2005	2010
1	**Forest land**	**2,319,065**	**2,496,603**	**2,771,531**
1.1	Evergreen broadleaves forest - rich	282,046	233,922	226,626
1.2	Evergreen broadleaves forest - medium	512,245	497,567	452,900
1.3	Evergreen broadleaves forest - poor	1,053,217	1,160,297	1,315,598
1.4	Other Forest	160,146	149,910	138,755
1.5	Plantations	311,411	454,907	637,651
2	**Non-forest land**	**2,825,443**	**2,647,905**	**2,372,977**
Total		**5,144,508**	**5,144,508**	**5,144,508**

Under the NFIMAP programs, the plot measurement data are available at national and regional level. The raw data of NFIMAP cycle 4 for NCC are checked and corrected to apply nationally developed allometric equations for biomass estimation for the classified forest types based on different predictors (DBH, H and WD). Forest carbon stock estimated using DBH predictor is selected (see EF report). The errors of forest carbon stock estimation are assessed with 90% confidence (see Table 6.4). Using the land use change matrices generated (see AD report) and estimated carbon stocks using NFIMAP cycle 4 and nationally developed equations for the NCC. The emission and removal factors are calculated for all provinces and then summed up for the whole region (see details in Phuong 2016, Report on development of emission and removal factors for the NCC).

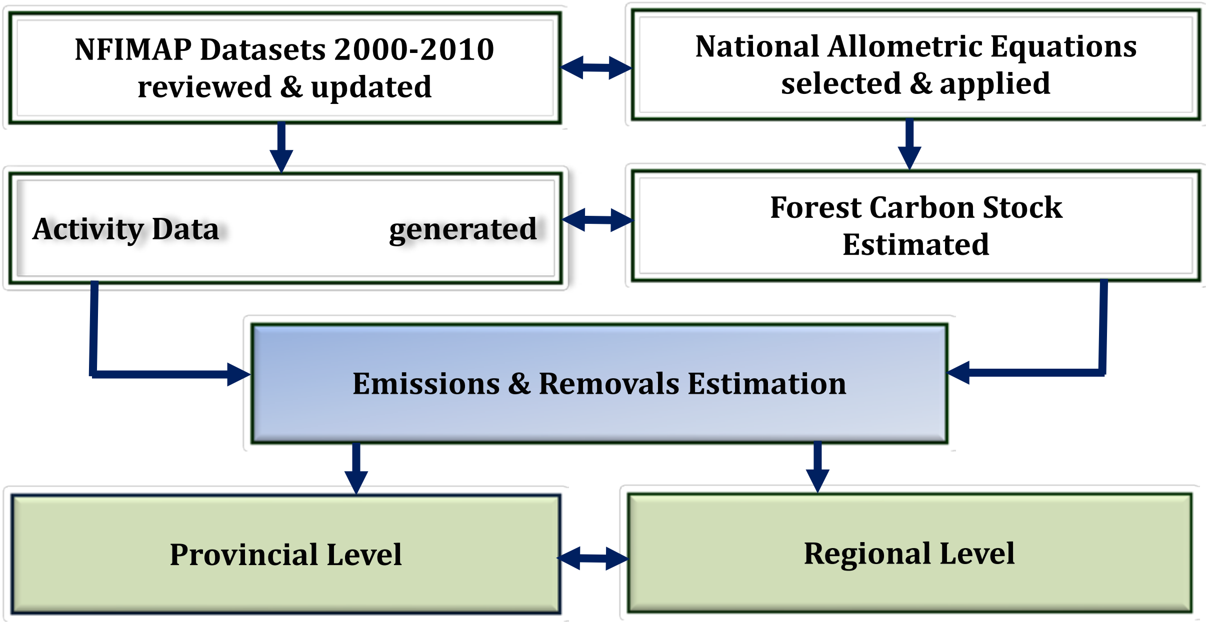
Table 3.7 Carbon stock used for construction of reference level

Land use and forest	Carbon stock (tCO_2e/ha)	STDEV (tCO_2e/ha)	Error (%)	Remarks/sources
1. EBF-R	543.5	240.6	8.2	Calculated
2. EBF-M	264.9	91.8	4.3	Calculated
3. EBF-P	115.5	89.2	7.3	Calculated
4. Other forests	82.9	91.6	20.8	Calculated
5. Plantations	89.0	74.5	21.2	Calculated
6. Non-forest land	0	na	0	IPCC 2006

3.3.6 Construction of reference level

The approach for the estimation of emissions and removals is based on AD data and estimated forest carbon stock using national equations and measurement data of the NFIMAP cycle 4. The emissions and removals are estimated for 2 periods (2000-2005 and 2005-2010) for every province and then summed up to regional level (see Figure 3.1).

Figure 3.1 Approach to Reference Level construction



Based on AD generation (area data of deforestation, forest degradation, reforestation, forest enhancement for period 2000 – 2005 and 2005-2010) and estimation of EF or RF, the emission and removals are estimated as follows[19]:

$$\text{Emissions or Removals} = \sum_{i=0}^{n} \text{Ai x EF/RFi}$$

Where:

E is emissions caused by deforestation and forest degradation;

R is removals resulted from reforestation and forest enhancement;

Ai is AD for land use change *i*;

EF/RFi is emission/removal factors for land use change *i*.

3.3.7 Uncertainty analysis

3.3.8 Identification of uncertainty sources

Assessment of uncertainty for estimation of emissions and removals for the reference period follows the IPCC guidelines (Chapter 3, IPCC, 2006). Table 6.5 shows potential causes of uncertainties that may be associated with reference level construction and the application of uncertainties assessment in the context of development of the reference level for the NCC.

Table 3.8 Potential causes of uncertainties in RL construction and uncertainties assessment scope

Potential Cause of Uncertainty	Relevance for the NCC RL/REL?	Applied (yes/no) and explanations
Lack of completeness	Not believed to be relevant.	Not applicable.

[19] The detailed spreadsheet on calculation of emissions and removals is available

Potential Cause of Uncertainty	Relevance for the NCC RL/REL?	Applied (yes/no) and explanations
	The components of forest emissions and removals are generally known in theory, significant unknown gaps are unlikely	
Model	Relevant, significant. Uncertainty in statistical models used to estimate biomass as function of tree parameters, models to estimate aggregate biomass/ha, and models to classify forest type as a function of spectral signature	Applicable, errors of forest carbon stock estimation are assessed (see EF report)
Lack of data	Relevant, minor. Data do not exist to estimate contributions from several pools (litter, deadwood, soil) and gases (CH4, NOx) which are assumed to be small (< 10%) relative to contribution of C from AGB and BGB.	Not applicable
Lack of representativeness of data	Not believed to be relevant. Emission factors come from a statistical systematic sample across the whole NCC region. Activity data comes from wall to wall forest cover mapping.	Not applicable.
Statistical random sampling error	Relevant, significant. Affects estimation of Emission Factors from forest inventory sample.	Not applicable as no data and information.
Measurement error	Relevant, minor. Measurement of tree species group, DBH assumed to be with minimal error.	Not applicable as no data and information
Misreporting or misclassification	Relevant, significant. Activity Data comes from wall to wall satellite mapping, it is known that classification errors will exist.	Applicable, see AD report
Missing data	Not believed to be relevant. Sampling and forest cover mapping covers 100% of the area of interest.	Not applicable

3.3.9 Uncertainty assessment

Assessment of AD uncertainty follows the following steps (see details in AD report):

- Step 1. Create forest change maps for the period 2000 – 2005 and 2005 - 2010
- Step 2. Sampling design
- Step 3. Assess every sample point on Landsat images of “year X” and “year X+5”

- Step 4. Summarize the results and create errors matrix.
- Step 5. Accuracy calculating by applying Olofsson's method

Uncertainty of EF/RF relates to the carbon estimation for classified forests. A propagation errors of carbon estimation is applied. A propagation error is derived from: i) error of sampling; ii) error of equations used for biomass estimation; iii) error of converting BGB from AGB; and iv) error of using carbon fractions for converting biomass to carbon stock.

As the lack of detailed estimation of uncertainties for forest area changes, a Tier 1 approach is used for assessment of uncertainties of emissions and removals estimated in reference level. The formula for uncertainty assessment is as follows:

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

Where: *Utotal* is percentage uncertainty in the products of parameters

Ui is percentage uncertainty associated with each the parameters

The uncertainty will be estimated for emissions and removals as the main products. As limited independent data information and during the updating forest cover maps the different remote sensing information was used. As noted in Table 6.5, the uncertainty analysis of emissions and removals estimation considers the uncertainty parameters of AD, EF and RF. The other potential sources associated with uncertainties are not included due to the lack of detailed assessment.

3.3.10 Quantification of uncertainties

The overall uncertainty of AD is over 90% (see details in AD report). The uncertainties of forest carbon estimation are from 4.3 – 159% depending on the forests (see EF report).

The propagations of uncertainties of forest carbon stock is derived from error of aboveground biomass estimation based on error of sampling and error of used equations, error of belowground biomass using root to shoot ratio, error of carbon fraction (see Table 3.9).

Table 3.9 Uncertainty assessment of forest carbon stock for the NCC

Parameters	**EBF-R**	**EBF-M**	**EBF-P**	**OFO**	**PLA**
1. AGB error from sampling (calculated in EF report)	0.082	0.043	0.073	0.208	0.243
2. AGB error from biomass equation (UNREDD, 2015)	0.096	0.096	0.096	0.180	0.100
3. Root to shoot ratio error (GOFC-GOLD sourcebook 2015)	0.200	0.200	0.200	0.200	0.200
4. Carbon Fraction factor (IPCC 2006)	0.027	0.027	0.027	0.027	0.027
Total Error (% SE)	**23.8**	**22.8**	**23.5**	**34.1**	**30.9**

The uncertainty is estimated separately for emissions and removals associated with deforestation, forest degradation, reforestation and forest restoration. The formula for estimating uncertainty is as follows:

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 \ldots (U_n * x_n)^2}}{|x_1 + x_2 \ldots + x_n|}$$

Where: U_1, U_2, U_3,…Un is percentage of uncertainty associated with each of the parameters

X_1, X_2, … Xn is the value of each parameters

Utotal is percentage uncertainty in the sum of parameters

3.4 Results of the reference level construction

3.4.1 Estimation of emissions and removals

Estimation of emissions and removal is counted for two periods 2000-2005 and 2005-2010 for every province and then the whole NCC region based on the developed AD on deforestation, forest degradation, reforestation and forest restoration, EF and RF. The estimation shows that emissions from deforestation and forest degradations for the region in 2000-2010 are 86.0 Mt CO_2e or the annually averaged emission is 8.6 Mt CO_2e/yr. The removals for this period are -97.7 Mt CO_2e or the annually averaged removal is -9.7 Mt CO_2e/yr. It indicates that for the period 2000-2005, a net emission for the NCC is 5.7 MtCO_2e while it is -17.4 MtCO_2e for 2005-2010 (see Table 3.10 and details in Annex 1-8 for emissions and removals matrices).

Table 3.10 Reference emissions and removal for the NCC in 2000 – 2010

Activities	**Emissions (+)/Removal (-) for 2000-2005 (tCO_2e)**	**Emissions (+)/Removal (-) for 2000-2005 (tCO_2e)**	**Total emissions (+)/Removals (-) for 2000-2010 (tCO_2e)**
1. Deforestation	20,982,057	14,534,612	35,516,669
2. Forest degradation	28,157,613	22,346,890	50,504,503
3. Reforestation	-36,003,733	-40,549,097	-76,552,830
4. Forest restoration	-7,370,632	-13,795,261	-21,165,893
5. Total emissions	**49,139,670.2**	**36,881,502**	**86,021,172**
6. Total removals	**-43,374,365**	**-54,344,358**	**-97,718,724**
7. Net emissions	**5,765,305**	**-17,462,856**	-11,697,551

Emissions and removals vary from province to province during the period 2000 – 2010. Quang Binh is a province having highest emissions, with total emissions of 21 Mt CO_2e, but Ha Tinh is lowest emitting province, with 8.2 Mt CO_2e. Removal amount is highest in Nghe An province, about -24 Mt CO_2e and lowest removal amount is found in Quang Binh province (-8.4 Mt CO_2e). Out of six provinces in the NCC region, two provinces Nghe An and Ha Tinh are the provinces having a net carbon sequestration and the remaining provinces are carbon emitting (see Table 3.11).

Table 3.11 Emissions and removals (CO_2e) for period of 2000 – 2010 by NCC provinces

Activities /items	Thanh Hoa	Nghe An	Ha Tinh	Quang Binh	Quang Tri	T. T Hue
1. Deforestation	10,354,543	7,714,860	2,872,923	3,987,774	5,087,363	5,499,207
2. Forest degradation	5,173,448	8,203,984	5,366,614	17,057,482	8,045,606	6,657,369
3. Reforestation	-16,155,817	-20,692,028	-9,566,485	-10,025,874	-9,805,962	-10,306,665
4. Forest restoration	-3,353,362	-7,069,262	-1,128,805	-3,401,221	-3,234,443	-2,978,813
5. Total emissions	**15,527,991**	**15,918,844**	**8,239,537**	**21,045,256**	**13,132,969**	**12,156,576**
6. Total removals	**-19,509,179**	**-27,761,289**	**-10,695,289**	**-13,427,095**	**-13,040,405**	**-13,285,479**
7. Net emissions	-3,981,188	-11,842,445	-2,455,752	7,618,161	92,564	-1,128,903
8. Annually averaged emissions	**1,552,799**	**1,591,884**	**823,954**	**2,104,526**	**1,313,297**	**1,215,658**
9. Annually averaged removals	**-1,905,918**	**-2,776,129**	**-1,069,529**	**-1,342,709**	**-1,304,040**	**-1,328,548**

This estimation of emissions and removals is lower than the figures reported in the ER-PIN. In the ER-PIN, the emissions and removals for this period are taken from the JICA (2012) study. These differences in emissions and removals estimation mainly result from the differences in AD and forest carbon stock. Emissions of the NCC estimated in the JICA study was 16.0 Mt CO_2e/year for the period of 2000 – 2010 and that is about two times higher than the emissions estimated for this region in the same time period under the Viet Nam's reference level submission to UNFCCC (8.3 Mt CO_2e/year). The lower estimations of emissions and removals for NCC in this study is a consequence of continuous improvement of the AD and application of nationally developed equations for forest biomass estimation that lead to improving accuracy of the estimation.

3.4.2 Uncertainty assessment

Uncertainty of emissions estimated for 2000-2005 is from 29-31% and this is 29- 40 % for removals. Those figures for 2005-2010 are 29-30% and 29-39% respectively. The overall uncertainty of emissions associated with deforestation and forest degradation is 18-26% and this value for removals associated with reforestation and forest restoration is 20-28%[20] (see details in Table 3.12).

[20] Details of uncertainty assessment is calculated in a separate spreadsheet

Table 3.12 Estimated uncertainties for emissions and removals for the NCC 2000 - 2010

Emissions/Removals	2000 - 2005		2005 - 2010		Weighted average uncertainty 2000-2010 (%)
	Amount (tons)	Uncertainty	Amount (tons)	Uncertainty	
1. Emissions caused by Deforestation	20,982,057	26%	14,534,612	26%	19%
2. Emissions caused by Forest degradation	28,337,241	29%	22,581,591	29%	26%
3. Removals resulting from reforestation	-36,003,733	28%	-40,549,097	28%	20%
4. Removal resulting from forest restoration	-7,413,305	29%	-13,902,006	29%	22%

3.4.3 National context and reference level updating

The forest cover of Viet Nam quickly reduced from 43% in 1943 to 28% in 1990. Between this period, about 5 million ha of forest was lost, mainly natural forests (Phuong et al 2012). Understanding the importance of forests and their environmental protection function, since 1990 the Government of Viet Nam has invested in a number of nation-wide reforestation, restoration and forest protection programs. Of these, the most notable was the Program 661 “Five Million Hectare Reforestation Program”[21] (1998-2010) and this made considerable contributions to increase Viet Nam’s forest cover. For the whole country, for the period 1998 – 2010, the program is reported to have planted 2.4 million ha of plantations, restoring 1.7 million ha of natural forests and 0.9 million ha of industrial crops and fruit trees (GoV, 2011). The influence of this program on the forest cover in the NCC has resulted in an increase in forest cover from 32% in 1990 to about 54% in 2010 (Hung et al 2015).

As considerable efforts and investment in rehabilitating and restoring forest areas, Viet Nam should not be “penalized” with FREL/FRLs which set Viet Nam for positive performance only if it surpasses such past efforts, a performance that is difficult to achieve in the future, for the following reasons including: 1) reduced area available for planting, and 2) termination of funding for the 661 Program (the 661 Program was financed partly by Official Development Assistance). Therefore, it is suggested to adjust the reference level for the NCC by not counting the area of plantation and restored forests established by the 661 Program during 1998 – 2010 (but mainly from 2000-2010). The rate of reforestation and forest restoration implemented for the period of 1995-2000 is considered as the baseline to assess the contribution of 661 Program. The rate of reforestation for 1995-2000 for the NCC detected on the forest cover map is 27,732 ha/year (Dien 2016). As for the period 2000 – 2010, the total area of plantation detected on the map was 625,235 ha, however, it is impossible to differentiate the plantation area created by the 661 Program. Therefore, the statistical data on the 661 Program reported by the provinces is used for updating the reference level. The report from the provinces on the 661 Program indicates that the total plantation area established by the 661 Program for 2000 – 2010 was 376,215 ha (see details in Table 3.13).

[21] Approved by Decision of Prime Minister No. 661/QD-TTg dated on 29 August 1998. This program is also known as 661 Program.

Table 3.13 Plantation area (ha) established by the 661 Program in NCC, 2000-2010

Year	Thanh Hoa	Nghe An	Ha Tinh	Quang Binh	Quang Tri	Thua Thien Hue	Total
2000	4,000	3,054	5,127	4,500	4,988	3,951	25,621
2001	3,900	3,068	5,392	4,500	5,304	2,708	24,872
2002	4,200	5,392	4,013	4,600	4,825	3,665	26,695
2003	4,500	7,140	4,561	5,000	4,354	3,105	28,660
2004	3,000	6,895	7,185	5,594	5,312	3,613	31,599
2005	5,000	7,208	6,065	3,837	3,743	4,173	30,026
2006	9,500	6,804	7,694	13,801	2,779	4,598	45,175
2007	9,500	5,476	6,090	14,011	3,002	4,332	42,411
2008	9,500	7,079	9,517	3,835	2,946	4,138	37,014
2009	11,000	9,254	6,410	3,287	3,420	5,726	39,097
2010	13,378	12,064	9,191	1,085	4,895	4,433	45,045
Total forest area of 661 for 2000-2010 (ha)							**376,215**

Source: statistics of provincial 661 project management unit)

The assessment report (VAFS, 2016) indicates that the success rate of plantations from the 661 Program is 87% and this rate is applied to adjust the removal reference level for the NCC considering national circumstances. With the 87% success rate for the 661 Program is proposed to be used for calculation of removal contribution generated by 661 program for downward adjustment. The proposed removal generated by 661 Program is calculated in the Table 3.14.

Table 3.14 Estimated removals of 661 program, 2000-2010

Year	Area counted, 87% survival rate of total area (ha)	Carbon stock (tCO_2e/ha)	Removal (tCO_2e)
2000	22,290	88.97	-1,983,099
2001	21,639	88.97	-1,925,159
2002	23,224	88.97	-2,066,228
2003	24,934	88.97	-2,218,346
2004	27,491	88.97	-2,445,846
2005	26,123	88.97	-2,324,075
2006	39,302	88.97	-3,496,639
2007	36,897	88.97	-3,282,654
2008	32,202	88.97	-2,864,956
2009	34,014	88.97	-3,026,182

Year	Area counted, 87% survival rate of total area (ha)	Carbon stock (tCO_2e/ha)	Removal (tCO_2e)
2010	39,190	88.97	-3,486,601
Total	**327,307**		**-29,119,786**

Since the deduction of removals regenerated by 661 program from removal reference level is accepted, the downward adjustment for removal reference level is as follows:

Table 3.15 Proposed adjustment of removals reference for NCC, 2000-2010

Items	Emissions (+)/Removal (-) in t CO2e
Total emissions	86,021,172
Total removal (no adjustment)	-97,718,724
Net emissions (no adjustment)	-11,697,551
Estimated removal of 661 (87% success)	**-29,119,786**
Proposed adj. removals	**-68,598,937**
Proposed Net adj. emissions	**17,422,235**

3.4.4 Estimated reference level for the NCC

Historical emissions associated with deforestation and forest degradation and removals generated by reforestation and forest enhancement are estimated for reference period for ER program. The Table 3.16 below summarizes the estimated reference level.

Table 3.16 The estimated ER Program Reference level

ERPA term year *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (removal deduction from 661 Program over reference period, tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)	
					Emissions	Removals (with adjustment)
2017	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2018	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2019	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2020	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2021	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2022	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2023	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2024	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
2025	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894

ERPA term year *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (removal deduction from 661 Program over reference period, tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)	
					Emissions	Removals (with adjustment)
2026	3,551,667	5,050,450	-9,771,874	-2,911,979	8,602,117	-6,859,894
Total	**35,516,669**	**50,504,503**	**-97,718,724**	**-29,119,786**	**86,021,172**	**-68,598,937**

3.4.5 Conclusions and recommendations

Emission and removal reference level for the NCC are estimated separately using the forest dataset of NFIMAP cycles 3 and 4 with review and updates. The reference level is constructed using time average approach for period of 2000 – 2010. During the reference period, it is estimated that the annual emissions reference level is 8.6 Mt CO_2e and annual removal is 9.7 Mt CO_2e.

Vietnam is one of the few countries that has made great efforts in restoring the forests through its national 661 Program for a period of 1998 - 2010. Therefore, Vietnam should be rewarded for such efforts. It is proposed that the adjustment of removal by deducting the removal from 661 Program for reference period should be accepted. It is proposed that 661 Program is considered a national context for downward adjustment of reference level for this region. The adjustment is made to the removal reference level and the proposed annual adjusted removal reference level is -6.8 Mt CO_2e/yr.

Uncertainty analysis of emissions and removals estimation for constructing reference level is calculated. The overall uncertainty of emissions associated with deforestation and forest degradation is 22-29% and the uncertainty of removals estimation associated with reforestation and forest restoration is 22-28%.

Vietnam is one of the few countries that has made great effort to restore the forests through its national 661 Program for the period 1998 - 2010. Therefore, Vietnam should be rewarded for such efforts. It is proposed that the updating of removal by deducting the removal from 661 Program for reference period should be accepted. The updating will be officially calculated based on scientifically sound evidence.

The existing policies of Vietnam create strong political commitment and a legal base for implementing emissions reduction and removal enhancement in the coming years. It is estimated that by 2020, the potentials for emissions reduction in the NCC would be 20 Mt CO_2e and the removal enhancement would be -12 Mt CO_2e.

It is recommended that improving reference level can be made in the future if the missing data are collected, including data for estimating other carbon pools (under-storey vegetation, dead wood and litter and soils) and data for the 661 Program (survival rate, species composition etc.). However, cost-effectiveness of the approach for REDD+ implementation also needs to be considered. In addition, other potential causes associated with uncertainties in emissions and removals could be improved in the future. The coming forest inventories should consider the assessment of uncertainties in sampling and measurement for completed analysis of uncertainties.

3.4.6 References

FPCF, 2013. Carbon fund Methodological Framework. FPCF, Hanoi.

GoV, 2011. Final Report of implementation of 5 Million Hectare reforestation program and plan for forest protection and development period of 2011 – 2020.Government of Vietnam Office, Hanoi.

GOFC-GOLD, 2015, A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation. GOFC-GOLD Report version COP21-1, (GOFC-GOLD Land Cover Project Office, Wageningen University, The Netherlands).

JICA, 2012. Potential forest and land related to “Climate change and forest” in the Socialist Republic of Vietnam, Hanoi.

IPCC, 2006. Guidelines for national greenhouse gas inventories. Vol. 4, Agriculture, forestry and other land use (AFLOLU). Institute for Global Environmental Strategies, Hayama, Japan.

Karsten Raae et al., 2010. Technical report Technical Assistance in the Development of the National REDD Programme of Vietnam Component of Collecting Information and Analysing Trends of Forest Resources and Forest Carbon Stock for Establishment of the Interim Baseline Reference Scenarios. Danish Forestry Extension and Nordeco.

MONRE, 2014. The Initial Biannual Updated Report of Vietnam to the UNFCCC. MONRE, Hanoi, Vietnam.

MONRE, 2015. Intended nationally determined contribution of Vietnam. http://www4.unfccc.int/submissions/INDC/Published%20Documents/Viet%20Nam/1/VIETNAM'S%20INDC.pdf.

Nguyen Dinh Hung, Ngo Van Tu, Vu Tan Phuong, Do To Nhu, Vu Quang Hien, Pham Duc Cuong and Pham Tuan Anh. 2015. Report on construction of national reference level for REDD+ implementation in Vietnam (unpublished). UN-REDD Vietnam, Hanoi.

Vu Tien Dien, 2015. Report on forest carbon stock assessment and development of reference level for REDD+ implementation in Vietnam. Ministry of Agriculture and Rural Development, Hanoi, Vietnam.

Vu Tan Phuong, Tran Thi Thu Ha, Nguyen Thi Hai, Ha Thi Mung, 2015. Development of Emission Factors for a National FREL/FRL for REDD+ for Government’s submission to the UNFCCC.UN-REDD Programme, Ha Noi, Viet Nam

Vu Tien Dien, 2016. Report on development of Activity Data for North Central Coastal for Development of reference level for FPCF program (unpublished). FPCF, Hanoi.

Vu Tan Phuong and Vu Tien Dien, 2016. Report on development of emission and removal factors for North Central Coastal for FPCF program (unpublished). FPCF, Hanoi.

3.4.7 Appendix

Table 3.17 Emissions (+) and removals (-) matrices for 2000 - 2010 for the NCC (tCO_2e)

2000 - 2005

	2005					
2000	1	2	3	4	5	6
1. EGF - R	0	13,561,888	3,538,923	72,999	8,017	995,239
2. EGF - M	-2,704,330	0	10,376,436	173,222	52,912	2,952,564
3. EGF - P	-286,575	-3,862,212	0	296,224	87,257	11,038,391
4. Other forest	-16,936	-36,098	-457,355	0	-10,266	2,152,710
5. Plantation	0	-2,695	-5,917	1,487	0	3,843,153
6. Non-forest	-228,851	-558,916	-17,273,468	-1,761,584	-16,180,914	0

2005 - 2010

	2010					
2005	1	2	3	4	5	6
1. EGF - R	0	4,901,027	5,330,793	97,816	187,587	529,026
2. EGF - M	-6,497,420	0	10,428,851	306,965	328,823	2,123,223
3. EGF - P	-363,252	-6,029,988	0	524,512	249,104	7,775,944
4. Other forest	-14,453	-17,827	-838,393	0	-8,588	1,960,508
5. Plantation	-5,331	-3,900	-24,977	280	0	2,145,910
6. Non-forest	-74,199	-515,326	-20,828,332	-1,801,672	-17,329,568	0

Table 3.18 Emissions (+) and removals (-) matrices for 2000-2010 for Thanh Hoa (tCO_2e)

2000 - 2005

	2005					
2000	1	2	3	4	5	6
1. EGF - R	0	692,583	305,289	27,576	0	43,575
2. EGF - M	-212,821	0	909,213	85,577	10,509	248,571
3. EGF - P	-31,616	-468,717	0	187,191	31,306	3,154,010
4. Other forest	-3,547	-15,890	-138,284	0	-3,730	1,210,312
5. Plantation	0	0	-536	1,237	0	200,350
6. Non-forest	-3,717	-41,193	-3,200,309	-899,192	-3,267,175	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	579,199	497,589	36,235	0	46,765
2. EGF - M	-1,218,597	0	1,296,628	174,054	23,350	528,004
3. EGF - P	-45,365	-712,342	0	311,631	13,774	3,260,329
4. Other forest	-5,080	-12,101	-479,197	0	-4,526	1,528,856
5. Plantation	0	-554	-10,168	217	0	133,773
6. Non-forest	-6,076	-55,960	-4,971,020	-1,060,093	-2,651,081	0

Table 3.19 Emissions (+) and removals (-) matrices for 2000-2010 for Nghe An

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	874,404	688,330	45,424	0	76,454
2. EGF - M	-665,642	0	745,924	87,645	172	360,534
3. EGF - P	-88,321	-1,919,594	0	108,390	14,451	3,621,981
4. Other forest	-13,389	-20,208	-318,775	0	-6,533	922,892
5. Plantation	0	0	-2,414	238	0	493,702
6. Non-forest	-22,532	-125,750	-7,186,722	-845,595	-1,173,098	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	979,980	1,612,125	61,581	27	41,651
2. EGF - M	-2,088,483	0	2,585,917	131,800	22,852	191,901
3. EGF - P	-71,216	-1,506,682	0	208,985	46,563	1,536,643
4. Other forest	-9,373	-5,726	-358,745	0	-4,055	407,840
5. Plantation	0	0	-996	63	0	61,262
6. Non-forest	-18,391	-64,860	-6,958,985	-700,522	-3,595,572	0

Table 3.20 Emissions (+) and removals (-) matrices for 2000-2010 for Ha Tinh

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	874,404	688,330	45,424	0	76,454
2. EGF - M	-665,642	0	745,924	87,645	172	360,534
3. EGF - P	-88,321	-1,919,594	0	108,390	14,451	3,621,981
4. Other forest	-13,389	-20,208	-318,775	0	-6,533	922,892
5. Plantation	0	0	-2,414	238	0	493,702
6. Non-forest	-22,532	-125,750	-7,186,722	-845,595	-1,173,098	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	979,980	1,612,125	61,581	27	41,651
2. EGF - M	-2,088,483	0	2,585,917	131,800	22,852	191,901
3. EGF - P	-71,216	-1,506,682	0	208,985	46,563	1,536,643
4. Other forest	-9,373	-5,726	-358,745	0	-4,055	407,840
5. Plantation	0	0	-996	63	0	61,262
6. Non-forest	-18,391	-64,860	-6,958,985	-700,522	-3,595,572	0

Table 3.21 Emissions (+) and removals (-) matrices for 2000-2010 for Quang Binh

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	7,406,231	464,735	0	0	175,913
2. EGF - M	-550,130	0	3,101,725	0	3,730	857,684
3. EGF - P	-34,814	-100,148	0	0	6,783	1,079,449
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-2,398	-1,378	0	0	258,618
6. Non-forest	-146,039	-167,642	-1,533,373	0	-2,119,153	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	1,645,915	1,723,351	0	172,803	243,291
2. EGF - M	-1,313,955	0	2,160,740	0	230,276	491,759
3. EGF - P	-29,942	-1,368,265	0	0	141,193	661,558
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-134	-59	0	0	219,502
6. Non-forest	-9,065	-122,084	-3,689,927	0	-2,238,590	0

Table 3.22 Emissions (+) and removals (-) matrices for 2000-2010 for Quang Tri

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	1,070,884	1,105,265	0	1,654	177,929
2. EGF - M	-398,823	0	2,872,017	0	18,405	855,827
3. EGF - P	-41,466	-641,762	0	0	3,251	716,522
4. Other forest	0	0	0	0	0	0
5. Plantation	0	0	-1,154	0	0	926,632
6. Non-forest	-31,222	-139,336	-1,859,453	0	-3,497,638	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	498,956	395,125	0	809	97,008
2. EGF - M	-1,036,199	0	2,037,306	0	27,155	525,019
3. EGF - P	-33,260	-1,081,147	0	0	14,779	1,088,453
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-91	-540	0	0	699,974
6. Non-forest	-9,994	-126,415	-1,421,800	0	-2,720,103	0

Table 3.23 Emissions (+) and removals (-) matrices for 2000-2010 for Thua Thien Hue

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	532,900	793,401	0	0	361,993
2. EGF - M	-527,278	0	1,693,403	0	19	289,350
3. EGF - P	-65,176	-438,669	0	0	8,967	1,162,066
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-297	-403	0	0	1,425,333
6. Non-forest	-22,418	-63,017	-1,932,260	0	-3,152,742	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	777,748	828,758	0	13,948	94,692
2. EGF - M	-467,494	0	1,984,789	0	18,996	325,004
3. EGF - P	-175,528	-1,284,579	0	0	4,439	1,078,608
4. Other forest	0	0	0	0	0	0
5. Plantation	-5,331	-3,119	-10,937	0	0	762,159
6. Non-forest	-28,695	-136,725	-1,584,975	0	-3,385,834	0

4 Measurement Monitoring and Reporting

4.1 Background

An Emission Reduction (ER) Program Identification Note for the North Central Coast, six provinces (the ER Program area), was proposed in June 2014 by the Government of Vietnam at the tenth meeting of the FCPF Carbon Fund Participants. Subsequently, the Government of Vietnam and the World Bank signed a Letter of Intent in January 2015 agreeing, in principle, to pay for emissions reductions and carbon sequestration generated through the implementation of the program. The financing by the Carbon Fund is provided on the basis of verified results (quantified reduction in deforestation and enhancement of forest area) and complements other investments and streams of finance that support sustainable climate-smart development in the program area. The proposed program builds on the technical assistance and funding from the FCPF and World Bank's support in Vietnam provided through a REDD+ Readiness Preparation Grant.

Before an Emission Reduction Payment Agreement (ERPA) can be signed between the Government of Vietnam and the Carbon Fund, an Emission Reduction Program Document (ER-PD) needs to be prepared by the Government detailing technical (e.g., carbon accounting), operational (e.g. implementation and financing plan) and program design (e.g., benefits sharing) features of the ER Program area. The expected preparation period for such an operation is estimated to be 18-24 months (starting with the signature of the Letter of Intent). Prior to World Bank appraisal and final decision, the ER-PD will be subject to a comprehensive internal review by a Technical Advisory Panel that is contracted by the World Bank FCPF and the project needs to submit a number of key documents including the Readiness Assessment Package report (or R-Package/ R-Assessment) at the end of the readiness phase. A Strategic Environmental Social Assessment (SESA) and an Environmental and Social Management Framework (ESMF) are also required.

In order to prepare for the ER-PD, a team of consultants, including a National Measurement, Reporting and Verification (MRV) (or Measurement Monitoring and Reporting (MMR) in the ER-PD) Consultant, has been formed. The National MRV Consultant will play a key role in the development of MRV approach for the ER program that will produce estimates of emissions reductions achieved in the ER program area. The MRV system needs to consider the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidelines and be consistent with the requirements of UNFCCC and FCPF Carbon Fund Methodological Framework, and national circumstance and capacities.

The consultant is expected to provided technical advice on development of MRV approach for the ER program taking into consideration data and information from the Vietnam national forest inventories and data and information on forest management in the six provinces to ensure that the quality of data and information used in forest and carbon stock assessment is in accordance with the FCPF Carbon Fund Methodological Framework and also take account the recommendations of the 10th meeting of the Carbon Fund.

4.2 Approach to MRV

4.2.1 Definition of forest

The definition of forests used for the Forest Reference Emission Level/Forest Reference Level (FREL/FRL) for Vietnam, applies the definitions provided under Circular No. 34

(2009)[22]. This definition is in line with the definition of forests used for the national GHG inventory. It is also consistent with the definition described in the Emission Reduction Program Idea Note (ER-PIN) submitted in May 2014 to the Forest Carbon Partnership Facility (FCPF).

Following this definition, an area is identified as a forest when it meets the following three criteria:

1. An ecosystem of which the major component is perennial timber trees, bamboos and palms of all kinds of a minimum height of 5 meters (except new forest plantations and some species of coastal submerged forest species), and capable of providing timber and non-timber forest products and other direct and indirect values such as biodiversity conservation, environmental and landscape protection.

   New forest plantations of timber trees and newly regenerated forests of forest plantations are identified as forests if they reach the average height of over 1.5 meters for slow-growing species, and over 3.0 meters for fast-growing species and a density of at least 1,000 trees per hectare.

   Agricultural and aqua-cultural ecosystems with scattered perennial trees, bamboos or palms etc. will not be regarded as forests.

2. Having a minimum tree cover of 10% for trees, which constitute the major component of the forest.

3. Having a minimum plot area of 0.5 hectares or forest tree strips of at least 20 meters in width and of at least three tree lines.

ID	Forest type	Forest / Non-forest
1	Evergreen broadleaf forest, rich forest	Forest
2	Evergreen broadleaf forest, medium forest	Forest
3	Evergreen broadleaf forest, poor forest/regrowth/mixed bamboo-woody/Limestone forest	Forest
4	Other forest (Bamboo forest/Mangrove forest)	Forest
5	Plantation	Forest
6	Non-forest land	Non-forest

4.3 REDD+ activities monitored

The following definitions are applied for the five REDD+ activities, which are all accounted for under FREL/FRLs of Viet Nam;

- **Reducing emissions from deforestation (“Deforestation”)**: Activity of conversion of forests to non-forest land.
- **Reducing emissions from forest degradation (“Degradation”)**: Activity resulting in a downward shift in terms of carbon stock between forest types, including Evergreen broadleaf forest volume-based sub-types of “rich, medium, and poor” (based on the average standing volume per ha) and other forest types (deciduous, bamboos etc.) (See Table 1).

[22] Issued by Ministry of Agriculture and Rural Development in 2009.

- **Enhancement of forest carbon stocks from reforestation ("Reforestation"):** Activity of land use change from non-forest land to forest land.
- **Enhancement of forest carbon stocks from forest restoration ("Restoration"):** Activity resulting in upward shift of carbon stock between forest types, including evergreen broadleaf forest volume-based sub-types of "rich, medium, and poor" (based on the average standing volume per ha) and other forest types (deciduous, bamboos, etc.).
- **Conservation of forest carbon stock:** Forest types remaining in the same forest types, are regarded as "conservation of forest carbon stock". These areas are accounted for, but understood that no carbon benefits will be derived (i.e., zero net emissions/removals).
- **Sustainable management of forest:** Since Viet Nam does not have exact boundaries on areas for sustainable management of forests, this activity is included as part of the Restoration or Conservation of forest carbon stocks.

4.4 Pools and gases monitored

Carbon pools to be included in the construction of FREL/FRL are above ground biomass (AGB) and below ground biomass (BGB). The reason for inclusion of BGB is that studies indicate that BGB constitutes from 0.2 to 1.0 of AGB pool, depending on the forest type, and therefore is a significant pool. This pool is often estimated indirectly via a root-to-shoot (R/S) ratio. Viet Nam does not have a country-specific R/S ratio, and therefore will apply the IPCC default value. This will cause a high uncertainty estimate for this pool. However, due to high costs of developing country-specific R/S ratio, there are no plans for conducting future research in Viet Nam.

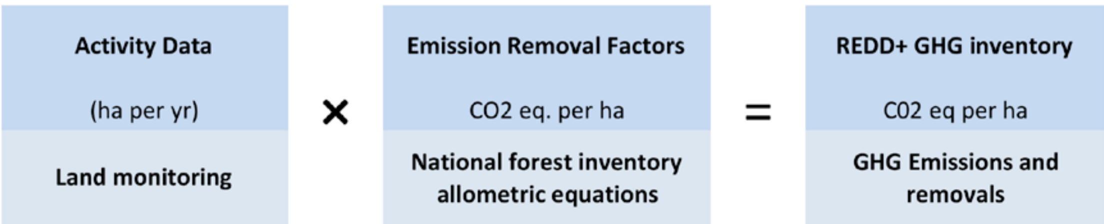
Other carbon pools such as dead wood, litter layer and soil organic carbon are excluded as national dataset on such pools is not available and if using Tier 1 approach for such pools will create more uncertainties.

Gases included in estimation of FREL/FRL are only CO_2. Non-CO_2 gases such as CH_4, CO, N_2O, NOx etc caused by burning of biomass (for example, forest fire) is not counted as such emission is not significant[23] and data on biomass of burnt forests are not available.

4.5 Approach for estimating emissions and/ or removals

The approach for estimating emissions/removals follows the IPCC guidelines, multiplying the activity data with the emission/removal factors

Figure 4.1Approach for estimation of emissions/ removals



[23] In the initial BUR (2010) of Vietnam, Non-CO_2 emissions resulted from burning biomass is only accounted for 0.04 % of total Vietnam's emissions.

4.6 Implementation organisation

A national forest monitoring system for REDD+ is being developed and this will allow sub-national forest monitoring. Each province will operationalize a revised and elaborated Annual Forest and Forestry Land Monitoring and Reporting Program, which will follow national guidelines and standards. Since the Accounting Area of the ER Program consists of six provinces, the ER Program forest monitoring system will be an aggregation of all data generated by the annual monitoring system operating in each province so it is fully consistent with the evolving national forest monitoring system for REDD+.

Responsibility of the relevant Ministries, agencies and localities are as follows:

1) Ministry of Agriculture and Rural development (MARD)

MARD will be the manager of the ER Program. MARD will establish a central Program Management Unit (PMU) to manage the implementation of ER Program.

2) Vietnam Administration of Forestry (VNFOREST)

The VNFOREST will conduct the checking and supervision of the forest monitoring process in the Accounting Area, including:

- Cooperation with the ER Program in selecting suitable national and international consultants.

- Connect with People's Committees, branches and agencies of provinces in MRV implementation at provincial level.

- Organize of annual and final acceptance check of MRV product quantity and quality; receive outcomes and register carbon certificates for the Accounting Area.

- Update the central forest database annually.

3) Central Program Management Unit (PMU)

- Support MARD in activities such as the approval of the MRV implementation plans in six provinces; review and selection of technical issues, standard procedures including field survey manual, field data collection quality control, biomass calculation method, and technical guidelines of each specific work step.

- Support MARD on the approval of cost estimate of each work item and in identification of financial resources.

- Selects suitable national service providers and national consultant teams for implementing change detection using satellite imagery for the ER Program, field verification and the update of forest cover maps, accuracy assessment of the land cover change map, calculation of emission reduction, uncertainty assessment of emission reduction results.

- Select suitable international consultants for validation of emission reduction results.

4) Provincial People Committees and Provincial Program Management Units

Provincial People Committees (PPCs) of the six provinces in the Accounting Area will be the owner of the provincial program. Each PPC will establish a Provincial Program Management Unit (PPMU) to manage all the work in that province. The PPMU will:

- Support PPCs in establishing provincial MRV teams to verify the potential changes identified by remote sensing and update the confirmed changes to the provincial forest database.

- Cooperate with the central PMU to develop resource plans (human resource and cost) for MRV implementation at the provincial level.

5) Forest Inventory and Planning Institute (FIPI)

Since FIPI has been implementing the National Forest Inventory, Monitoring and Assessment Program (NFIMAP)[24] - which data were used to develop the FREL/FRL for the ER Program, has been being the main agency to implement the forest inventory step of the National Forest Inventory and Statistics (NFIS) period 2011-2016,[25] and has a mandate to implement the improved NFIMAP in the future, FIPI will implement the following work:

- Develop technical guidelines including a field data collection and survey manual; Satellite imagery processing manual; QA/QC guideline and forms; field data management and processing manual;

- Conduct forest change detection using remote sensing;

- Conduct a field inventory and quality control;

- Conduct training, technological transfer for provincial MRV team on field verification and update of forest cover maps;

- Provide potential national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission results.

6) Central specialized agencies (VAFS etc.)

The central specialized agencies such as VAFS will act as a potential service providers for the following tasks:

- Conduct a quality assurance for the field inventory implemented by FIPI;

- Conduct an accuracy assessment of land cover change map 2015-2020 in the Accounting Area;

- Provide potential national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission results.

7) Local communities

Article 32.2 of the current Forest Protection and Development Law (2004) specifies that "*Forest owners shall have to make forest statistics and inventory and monitor forest resource developments under the guidance of, and submit to the inspection by, specialized forestry agencies of the provinces…*". Therefore, local communities can participate in the monitoring system either:

(i) Directly, as forest owners (individual households or collectively as village communities under community forest management); or
(ii) Indirectly as subcontracted service providers to larger state-managed forest owners (e.g. State forest companies or protected area management boards).

The roles of ethnic minorities people and local communities in the implementation of the proposed ER Program forest monitoring system are as follows:

(i) Identifying and monitoring the key drivers of forest cover change, forest degradation, and carbon stock enhancement across the landscape;
(ii) Assisting in field data collection for estimating forest carbon stocks and EFs/RFs; and
(iii) Assisting in accuracy assessments of (spatial and non-spatial) activity data generated for REDD+, for verifying or validating remote sensing products.
(iv) Accessing AD, EF and emission reduction information from the national REDD+ information system and conducting basic analysis to inform a refinement of management interventions.

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[24] See Annex 1 for more information on NFIMAP.
[25] See Annex 1 for more information on NFIS period 2011-2016.

Participatory forest monitoring under the proposed ER Program will be integrated into an improved annual forest cover change monitoring program (Annual Monitoring of Forest and Forestry Land Program) which will be implemented by the Forest Protection Department (FPD) under VNFOREST, which has the mandate and human resource capacity (with ranges at all levels of administration, from national to commune level), to engage with forest owners and local communities.

4.7 Monitoring activity data for forest using remote sensing

4.7.1 Selecting approach for representing Activity Data

Activity data (AD), or the extent over which a human activity occurs, are data on the area of a category that potentially results in GHG emissions or removals, over a given period of time. The IPCC (2006) describes three overall approaches for the representation of land use and Indicator 14.2 in the FCPF Methodological Framework Document requires that deforestation is determined using Approach 3. To be consistent with this indicator, Approach 3 is therefore applied in the Accounting Area to monitor all REDD+ activities and is the most informative and applicable for MMR due to tracking of land-use conversion in a spatially explicit data format.

a) Generating forest cover maps

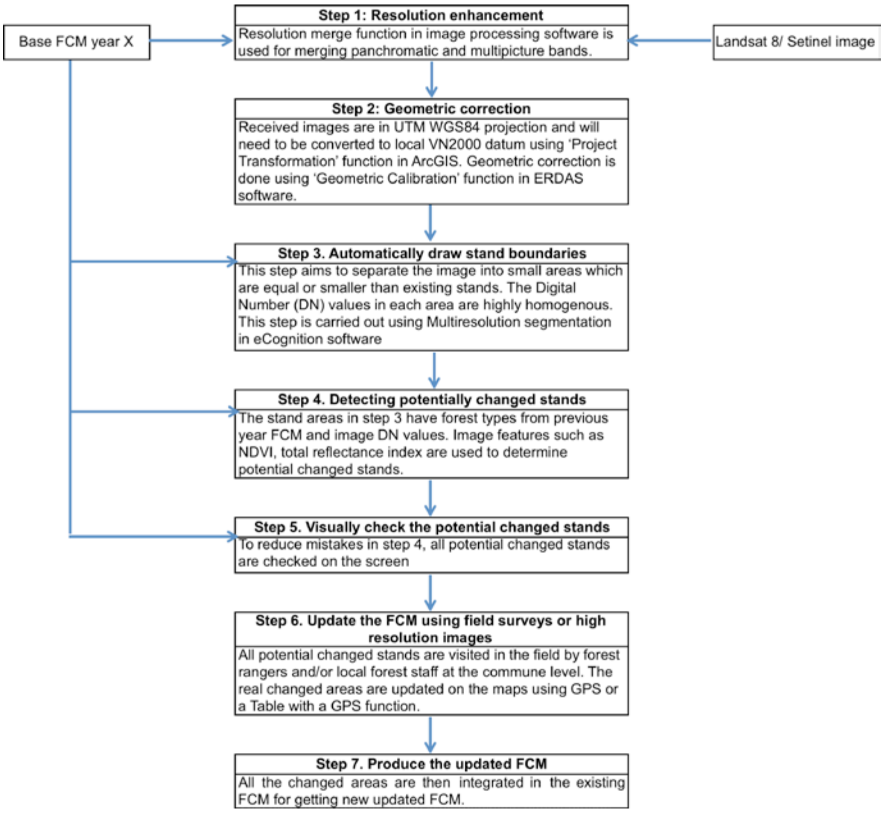
Currently, the National Forest Inventory and Statistics (NFIS) Project has been carrying out in Viet Nam since 2011. This project will generate forest cover maps (FCMs) at 1:10,000 for Viet Nam and to date 40 provinces (including Thanh Hoa, Nghe An and Ha Tinh provinces) have FMCs. The FMCs of the remaining 20 provinces will be completed in 2016. The status of provincial forest statistics maps for the six NCC provinces is given in Table 7.1 below:

Table 4.1 Status of provincial FCMs of the six NCC provinces

Province	Year of baseline FCM	Note
Thanh Hoa	2014	Completed
Nghe An	2014	Completed
Ha Tinh	2012	Completed
Quang Binh	2015	On-going
Quang Tri	2015	On-going
Thua Thien - Hue	2015	On-going

The “Annual Monitoring of Forest and Forestry Land” Program need to update the FCMs annually and report from the commune through the district and province up to the national level by the end of each year. Although this still has some limitations, the Program is planned to be improved to generate the AD for the MMR system with sufficient accuracy. One of the main drawbacks of the “Annual Monitoring of Forest and Forestry Land” Program is that it does not use remote sensing imagery for updating the FCMs. The improved approach under the MMR of the ER-P is proposed as follows: (i) using medium resolution remote sensing imagery to identify the potential forest change areas; (ii) using high resolution remote sensing imagery together with ground surveys to update the FCMs at identified areas.
The following Figure 9.2 summarises the processing steps applying Approach 3 for updating the FCM annually:

Figure 4.2 Approach for the annual update of the FCM



All forest and bare land stands in the baseline map are examined based on medium resolution satellite images such as Landsat 8 and/or Sentinel. The image features of each stand are calculated for examination. For example, low homogeneity value in a stand indicates a potential change of forest type in the stand; high normalized difference vegetation index (NDVI) value in the bare land stand indicates a potential change from bare land to forest etc. Currently Landsat 8 and Sentinel images are considered to be the most suitable[26].

Mapping using GPS or Tablet would take a long time and involve high expenditure in large changed areas. Therefore, buying high resolution images for mapping is considered to be more cost effective. There are some kind of high resolution images such as VNREDSat-1, SPOT-6, and SPOT-7 which could also be used.

b) *Generating a forest and land cover change map and matrix*

By using the above procedure, annual FCMs with almost similar quality be generated for each province in the NCC region from 2015. The provincial forest and land use change map will be generated by intersecting the provincial FCMs in year X with the corresponding provincial FCMs in year X+1 for all the NCC provinces. They will then be combined to generate a regional NCC forest and land cover change map. A matrix of changed area (i.e., AD) will be extracted from this regional map. This matrix contains basic information for estimating emissions and removals for each of the REDD+ activities.

4.8 Accuracy assessment of land cover change map

As described above, the AD are extracted from the land cover change map period 2015-2020, which is generated by overlaying two forest cover maps in 2015 and 2020. The land cover change map are subject to interpretation errors in each forest cover map and the role

[26] The Landsat 8 satellite image include a spatial resolution of 30 m, image size 180 x 180 km, and revisit cycle of 16 days. The characteristics of Sentinel satellite image characters include spatial resolution of 10m, a swath width of 290km and a five day revisit cycle. Both types of satellite images are free of charge.

of the accuracy assessment is to characterize the frequency of errors for each of the land cover change classes.

Different components of the monitoring system affect the quality of the area estimates, including:

- Quality and suitability of satellite data (i.e., in terms of spatial, spectral, and temporal resolution);
- Radiometric / geometric pre-processing (correct geolocation);
- Cartographic standards (i.e., land category definitions and MMU);
- Interpretation procedure (algorithm or visual interpretation);
- Post-processing of the map products (i.e., dealing with no data, conversions, integration with different data formats); and
- Availability of reference data (e.g., ground truth data) for evaluation and calibration of the system.

The method for assessing the accuracy of a map uses *independent reference data* (of greater quality than the map) to obtain—by the accounting area—the *overall accuracy, errors of omission* (excluding an area from a category to which it does truly belongs), and *errors of commission* (including an area in a category to which it does not truly belong).

Reference data should be distinguished from the *training data* and must be acquired using a probability sampling design. The proposed method for obtaining reference data is based on interpretation of high resolution satellite images such as SPOT-5,6,7 or equivalent which were taken in 2015 and 2020 with the assistant of the Open Foris Collect Earth software.[27] A stratified sampling method will be used to randomly generate the observation points. At the maximum, there will be 36 classes (including 30 land cover change classes and 6 stable classes) in the land cover change map. The number of observation points is estimated to be 50 points per class, or 1,800 points for all 36 classes.

The method described in Olofsson et al. (2013)[28] and Olofsson et al. (2014)[29] will be applied to build a confusion matrix, estimate un-biased areas per each class, derive errors of area estimates as well as calculate the user's accuracies per class, producer's accuracies per class and overall accuracy. The detailed steps are as follows:

Step 1: Generate the error matrix of observation points from the accuracy assessment. The error matrix has the following form:

		Reference data					
		Class 1	Class 2	Class 3	...	Class 36	Total
Map data	Class 1	$n_{1\cdot 1}$	$n_{1\cdot 2}$	$n_{1\cdot 3}$	...	$n_{1\cdot 36}$	$n_{1\cdot}$
	Class 2	$n_{2\cdot 1}$	$n_{2\cdot 2}$	$n_{2\cdot 3}$	...	$n_{2\cdot 36}$	$n_{2\cdot}$
	Class 3	$n_{3\cdot 1}$	$n_{3\cdot 2}$	$n_{3\cdot 3}$	...	$n_{3\cdot 36}$	$n_{3\cdot}$
	...	...	...	...	...	...	...
	Class 36	$n_{36\cdot 1}$	$n_{36\cdot 2}$	$n_{36\cdot 3}$	...	$n_{36\cdot 36}$	$n_{36\cdot}$

[27] Available at http://www.openforis.org/tools/collect-earth.html.

[28] Olofsson, P.; Foody, G.M.; Stehman, S.V.; Woodcock, C.E. Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. Remote Sens. Environ. 2013, 129, 122–131.

[29] Olofsson, P.; Foody, G.M.; Herold, M.; Stehman, S.V.; Woodcock, C.E.; Wulder, M.A. Good practices for estimating area and assessing accuracy of land change. Remote Sens. Environ. 2014, 148, 42–57.

	Reference data					
	Class 1	Class 2	Class 3	...	Class 36	Total
Total	$n_{\cdot 1}$	$n_{\cdot 2}$	$n_{\cdot 3}$	...	$n_{\cdot 36}$	$n_{36\cdot}$

Where n_{ij} presents the number of observation points that has map class *i* and reference class *j*; $n_{i\cdot}$ presents the total number of observation points that has map class *i*; $n_{\cdot j}$ presents the number of observation points that has reference class *j*.

Step 2: Express the error matrix in term of area proportions

$$\hat{p}_{ij} = W_i \frac{n_{ij}}{n_{i\cdot}}$$

Where *Wi* is the proportion of area mapped as class *i*.

Step 3: Estimate the proportion of area for each class. The proportion of area of class *k* is calculated using the following formula:

$$\hat{p}_{\cdot k} = \sum_{i=1}^{36} \hat{p}_{ik}$$

And the area of class *k* is calculated by using formula:

$$\hat{A}_k = \hat{p}_{\cdot k} \times A$$

Where *A* is the total map area.

Step 4: Estimate the standard error of the proportion of area. Apply the following formula:

$$S(\hat{p}_{\cdot k}) = \sqrt{\sum_{i=1}^{36} W_i^{\,2} \frac{\frac{n_{ik}}{n_{i\cdot}}\left(1 - \frac{n_{ik}}{n_{i\cdot}}\right)}{n_{i\cdot} - 1}}$$

Step 5: Estimate the standard error of the estimated area by using the formula:

$$S(\hat{A}_k) = A \times S(\hat{p}_{\cdot k})$$

Step 6: Estimate the 95% confidence interval as:

$$\hat{A}_k \pm 1.96 \times S(\hat{A}_k)$$

4.9 Estimating emissions/ removal factors using forest inventory

To be consistent with FRL setting, emission/removal factors estimates for the monitoring period are also derived from the measurement data of sample plots. Only parameters for estimating the AGB pool are measured. BGB pool will be estimated using the IPCC default Root-to-shoot ratio. The monitoring interval for emission/removal factors is five years.

4.9.1 Sampling design selected

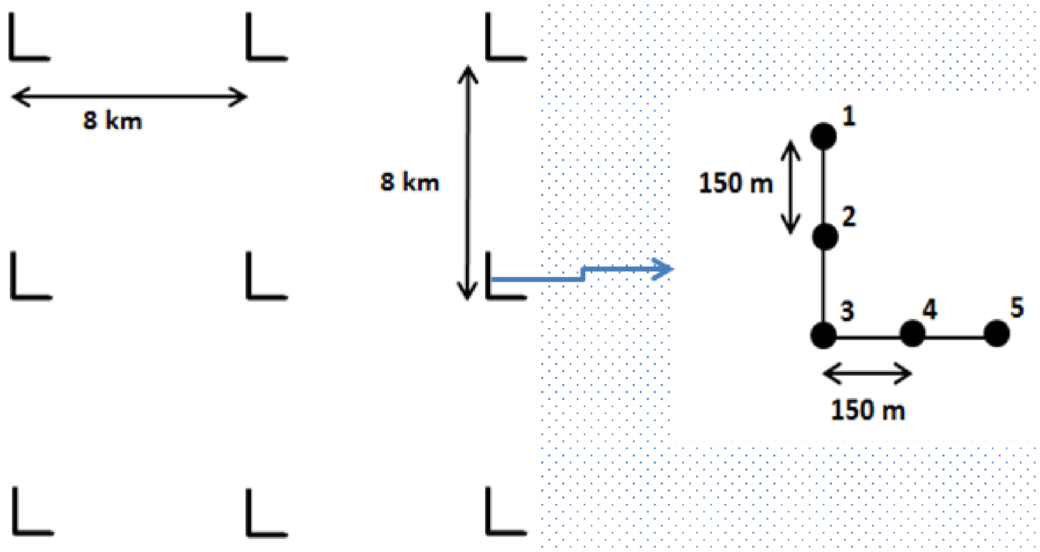
After the completion of Cycle IV, Viet Nam received support from FAO-Finland through the "Support to National Assessment and Long-term Monitoring of the Forest and Trees Resources in Vietnam (NFA)" Project to improve the sampling design of the NFIMAP to implement it in the 2016-2020 and subsequent cycles. The NFA Project has successfully developed an improved sample plot system that is more efficient. This improved sampling design has been reviewed by international experts from United States Forest Service and the World Bank and was highly regarded. Forest Inventory and Planning Institute (FIPI) is now preparing necessary steps for approving the improved sample plot system to be implemented in the 2016-2020 cycle. If this improved sample plot system is approved, it will also function as the national MRV system for REDD+. Therefore, for the MRV system in the NCC region to be consistent with the emerging national MRV system, the sample plot system proposed by the NFA Project is selected for generating the EFs/RFs for the MRV system in the NCC region.

The sample plot system is designed by the systematic method covering all six ER-P provinces (Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue). On each intersection (grid point) one cluster is established (Figure 4).

The main parameters of sampling design are:

- The distance between the clusters is 8km x 8km
- The cluster is in L shape
- The number of the sample plots in one cluster is five
- The distance between the sample plots is 150m

Figure 4.3 Shape and distance between clusters, sample plots



Note that the sample plot number 3 is located at the corner of the L shape.

The numbers of clusters and plots per provinces are provided in Table 4. The precise locations of the sample plots will be kept confidential, so as to avoid possible manipulation of the results over time.

Table 4.2 The number of clusters and plots by provinces

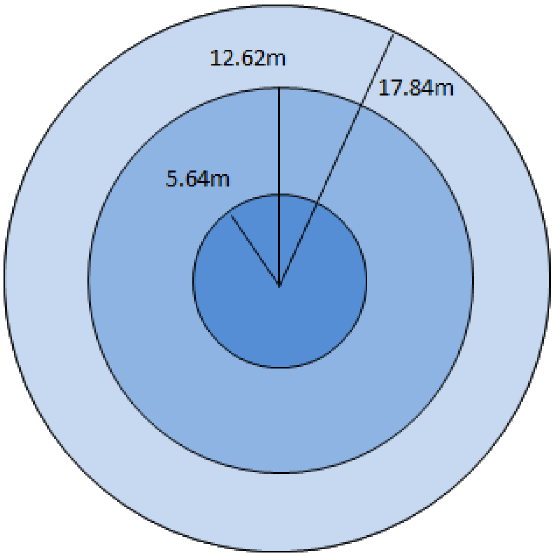
No	Province	Number of Clusters (N_C)	Number of Plots (N_P)
1	Thanh Hoa	179	895
2	Nghe An	252	1,260
3	Ha Tinh	87	435
4	Quang Binh	125	625
5	Quang Tri	72	360
6	Thua Thien Hue	74	370
	ToTal	**789**	**3,945**

4.10 Sample plot design

4.10.1 Tree measurement

One sample plot consists of three concentric circular sub-plots with radiuses of 5.63 m (SP1), 12.62 m (SP2) and 17.84 m (SP3), respectively(see Figure 7.4) The distance mentioned here refers to horizontal distance.

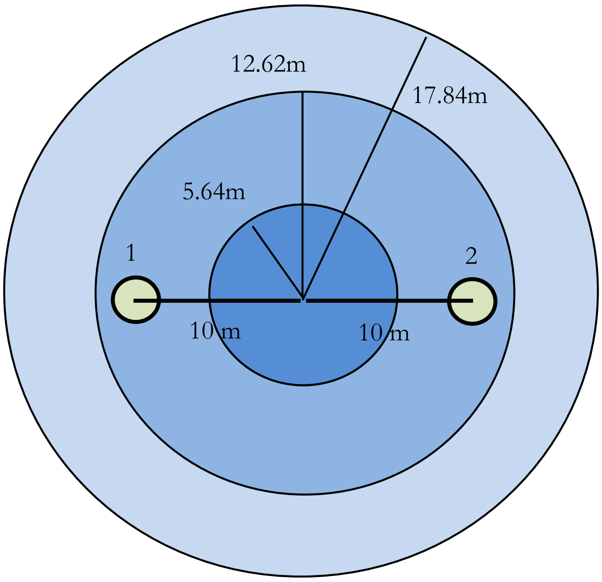
Figure 4.4 Sample plot design

	- Sub-plot with the area of 1,000 m^2 and radius of 17.84m (SP3): Measuring all trees with the diameter at the height of 1.3 m (DBH) ≥ 40 cm. - Sub-plot with area of 500m^2 and radius of 12.62m (SP2): + Measuring trees with DBH ≥ 20cm + Measuring dead, stump-cut trees; + Measuring shrubs, ground cover vegetation + Measuring climber with D ≥ 2cm - Sub-plot with area of 100m^2 and radius of 5.64m (SP1) + Measuring trees with DBH ≥ 6cm + Measuring bamboos with DBH ≥ 2cm

4.10.2 Regeneration measurement

On each sample plot, there are 2 sub-plots for regeneration measurement with the radius of 1.5 m and the centres locating on the East-West axis and 10 m far from the centre of the sample plot (Figure 7.5).

Figure 4.5 Sub-plots for regeneration measurement



4.11 Parameters to be collected in the field

4.11.1 Sample plot description

On each sample plot, the parameters describing the plot are collected as below:

a) Name of cluster and plot;
b) Coordinates of plot centre
c) Slope
d) Forest or land use type
e) Past forest or land use type
f) Forest function: Special forest, production forest or protected forest
g) Planting year (for plantation)
h) Soil type; soil structure
i) Province; district; commune; forest ownership;

4.11.2 Aboveground biomass parameters

*** Tree parameters**

Tree parameters are recorded on all land types. *Tree number*, *species name*, *DBH*, *Health* and *Origin* will be recorded for **all tally trees**. Trees are selected and measured in each sample plot in the following manner:

i) Within 5.64 m radius; all trees with DBH ≥ 6 cm will be recorded;

ii) Within 12.62 m radius; all trees with DBH ≥ 20 cm will be recorded;

iii) Within 17.84 m radius; all trees with DBH ≥ 40 cm will be recorded.

- **Tree number:** Tree number, starting from number 1 for each sample plot; Numbering principle: The marking is carried out from the plot centre towards plot boundary starting from the North in the clockwise direction.

- **Species name:** Species names are recorded in the field for every tally tree. If a species is unknown to the crew, the crew takes a photo of the tree and asks advice later from a botanist.

- **DBH:** The diameter at the 1.3 m height of the stem.

- **H_t:** Top height (0.1 m) is measured for all **sample trees**.

- **H_b:** Bole height (0.1 m) is only measured for **sample trees** with DBH ≥ 20 cm.

- **Stump diameter**: is measured in centimetre with one decimal digit for all sample trees.

Note: Stump height is measured at the level of the upper most root collar. If no root collars exist, stump height is default to be 15 cm from the ground level.

**** Bamboo parameters***

Only bamboos with DBH ≥ 2 cm located within the 5.64 m radius sub-plot are collected, regardless of their origin (natural or planting). The measurement is described as follows:

For every bamboo species, three stems of normal growth by maturity (young, medium-aged, old, dead) are selected for measuring DBH, H_t, D_{avg} and H_{avg}. It is necessary to distinguish two cases:

(1) Scattered bamboos: species name, D_{avg}, H_{avg} should be measured; number of trees by maturity (young, medium-aged, old, dead) is counted in the plot.

(2) Bamboos growing in clumps: Identify the species name; count the trees by maturity (young, medium-aged, old, dead) for each clump. If a bamboo clump is only partly inside the plot, only those stems that are inside the plot are calculated and considered when defining the average height.

*** Regeneration parameters**

Regeneration parameters are recorded on all forest and land use types planned for forestry purpose. Trees are selected and measured in each sample plot in the following manner:

- Identify species name and counted number of each species by height level (< 0.5 m: H1, 0.6 m to 1.0 m: H2; 1.1 m to 1.5 m: H3; 1.6 m to 2.0 m: H4; 2.1 m to 3.0 m: H5; > 3.0 m: H6) and regeneration origin (seed or shoot).

*** Shrub and ground cover vegetation parameters**

Shrub and ground cover vegetation are estimated visually in the SP2 sub-plot.

- Shrub closure

Shrub closure is calculated as the percentage of shrub canopies in the SP2 sub-plot.

Shrub closure is usually visually estimated (observing the total area and estimating the average closure of the shrub as percentage of the plot), but if the use of spherical densitometer is possible, this device can also be used. Shrub closure is classified into the following five classes:

0 No data, no applicable;
1 < 10%, very open shrub canopy cover;
2 10%–39%, open shrub canopy cover;
3 40%–69%, sparse shrub canopy cover; and
4 ≥ 70%, closed shrub canopy cover

Shrub mean height (0.1 m)

Mean shrub height is estimated and recorded in meters to one decimal digit within the SP2 sub-plot.

Ground vegetation coverage

The ground vegetation coverage is estimated as the percentage of the ground cover canopies in the SP2 sub-plot.

Ground vegetation coverage is usually visually estimated (observing the total area and estimating the average coverage of ground vegetation as percentage of the plot). Ground vegetation coverage is classified into the following five classes:

0 No data, no applicable;
1 < 10%, very open ground cover vegetation;
2 10%–39%, open ground cover vegetation;
3 40%–69%, sparse ground cover vegetation; and
4 ≥ 70%, closed ground cover vegetation

Ground vegetation mean height (0.1m)

Ground vegetation mean height is estimated and recorded in meters to one decimal digit within the SP2 sub-plot.

*** Climber**

Climber: Measurement is carried out only for the climbers with the radius >= 2cm in the SP2 sub-plot.

- Species name, diameter, and length of climber located in SP2 are recorded;

- Number of climbers located in SP2 is counted.

4.12 Method of estimating EFs/ RFs from collected data

The method for estimating EFs/RFs should be consistent with that in Reference Level setting.

The AGB of individual trees in the measurement plots will be estimated using allometric equations developed by the UN-REDD Programme Vietnam for the North Central Coast (NCC) Agro-ecological Region. The following equations are applied to evergreen broad leave forests and plantations:

- $AGB = 0.1212 \times DBH^{2.4154}$ (1)

  (Number of samples = 331; Adjusted R^2 = 0.854; S% = -11.4%; MAE% = 33.6%)
- $AGB = 254.495 \times D2H^{0.947}$ (2)

  (Number of samples = 331; Adjusted R^2 = 0.878; S% = -2.0%; MAE% = 19.1%)
- AGB = $AGB = 0.699 \times D2HWD^{0.940}$ (3)

  (Number of samples = 331; Adjusted R^2 = 0.918; S% = 2.2%; MAE% = 17.6%)

Where:

AGB is above ground biomass expressed in kg;

DBH is diameter at breast height expressed in cm;

Hmt is height of tree along its stem in m and is calculated using Hmt=Htop*1.04, where Htop is the total vertical height expressed in m;

WD is wood density expressed in gram/cm^3. WD data are taken from national studies (mainly by Vietnam Academy of Forestry Sciences - VAFS) that was compiled as WD database by UN-REDD Vietnam. In case, there is no WD data available for tree species, value of WD will be taken from global WD database. And if not, average WD value of tree species in Vietnam (0.584) is used;

$D2H = \left(\frac{DBH}{100}\right)^2 \times Hmt$ is a surrogate of volume (m^3).

$D2HWD = \left(\frac{DBH}{100}\right)^2 \times Hmt \times WD \times 1000$ is a surrogate of aboveground biomass (kg);

$S\% = 100 * \frac{\sum_1^n (\widehat{AGB}_i - AGB_i)}{\sum_1^n AGB_i}$ is the percentage AGB error of a set of n sample trees;

$\text{MAE}\% = \frac{100}{n} \sum_{i=1}^n \frac{|\widehat{AGB}_i - AGB_i|}{AGB_i}$ is the mean absolute AGB error per sample tree.

As for bamboo forests, the equations for tree level biomass estimation of different bamboo species are as follows (UN-REDD, 2015).

- *Bambusa balcooa*: $AGB = 0.0612 \times DBH^{2.0848} \times Hmt^{0.2779}$ (4)

  (Number of samples = 120; Adjusted R^2 = 0.875; S% = n.a.; MAE% = n.a.)
- *Dendrocalamus membranaceus*: $AGB = 0.1013 \times DBH^{1.9667} \times Hmt^{0.2779}$ (5)

  (Number of samples = 120; Adjusted R^2 = 0.875; S% = -13%; MAE% = 16.0%)
- *Bambusa chirostachyoides*: $AGB = 0.3558 \times DBH^{1.2155} \times Hmt^{0.2779}$ (6)

  (Number of samples = 120; Adjusted R^2 = 0.875; S% = n.a.; MAE% = n.a.)
- *Indosasa angustata*: $AGB = 0.2829 \times DBH^{1.4307} \times Hmt^{0.2779}$ (7)

  (Number of samples = 120; Adjusted R^2 = 0.875; S% = n.a.; MAE% = n.a.)

For other bamboo species, the equation of the most similar bamboo species above will be applied.

After calculation of tree level AGB of every tree in the measurement plots, the AGB of the plots is calculated for every forest type. The general formula for calculation of AGB of measurement plots is as follows:

$$AGB_i = \sum_{j=1}^{n_i} AGB_{ij} \qquad (8)$$

Where:

AGBi is total AGB of all trees and bamboos in the measured plot *i*. This is expressed in kg or tonnes of dry mass per plot.

n_i is numbers of measured trees in the plot *i*;

AGB_{ij} is AGB of tree *j* in plot *i*;

To estimate Below Ground Biomass (BGB), it is estimated for every measurement plot using root to shoot ratio (R). As Vietnam has no specific data on R and the development of such factor is very costly, therefore, the default value of R (0.20) is used for calculation of BGB as follows.

$$BGB_i = AGB_i \times 0.20 \qquad (9)$$

Total biomass (TB) is calculated for every measurement plot by summing AGB and BGB in each measurement plot:

TB*i* = AGB*i* + BGB*i* (10)

Carbon stock estimation is accounted for based on the biomass and carbon fraction (CF). The formula for calculation is as follows:

$$C_i = TB_i \times CF \qquad (11)$$

Where:

TBi is total biomass of plot *i* (include AGB and BGB), expressed in kg;

CF is carbon fraction and default value of CF (0.47) is used.

After carbon stock of all measurement plots is estimated, based on area of measurement plot, carbon stock per ha of forest type is calculated as follows:

$$C\ (tC/ha) \quad = \frac{C_i \times 10^4}{10^3 \times \mathrm{A}} \qquad (12)$$

Where:

C*i* is carbon stock of plot *i*; A is area of measurement plot in m^2 (for woody forest, measurement plot area is 500 m^2 and this is 100 m^2 for bamboo forest).

Once the carbon stock per ha of all forest types is estimated, the average value of carbon stock per ha for every forest type is calculated as follows:

$$\bar{C}_i = \frac{1}{np_i}\sum_{j=1}^{np_i} c_{ij} \qquad (13)$$

Where:

$\bar{C}_i$ is average value of carbon stock for forest type *i*;

c_{ij} is carbon stock of measurement plot *j* for forest type *i*;

After completion of calculating the average carbon stock for every forest type in the region. These values will be used to estimate EF/RF for every change in forests and land uses. As for mangrove forests, there is no measurement plot and carbon stock of mangrove forest is taken from a study[30]. The average carbon stock of non-forest land is assumed to be zero (0). The general formula for estimation of EF/RF is as follows:

$$EF/RF_{ij}(\mathrm{tCO2e/ha}) = \left(\bar{C}_i - \bar{C}_j\right) \times 44/12 \qquad (14)$$

Where:

EF/RF_{ij} is EF/RF for land cover change *ij* (conversion from land cover *i* to land cover *j*).

$\bar{C}_i$ and $\bar{C}_j$ are carbon stocks per ha of land cover types *i* and *j* corresponding to the changes;

If $\bar{C}_i > \bar{C}_j$, such change is considered emissions;

If $\bar{C}_i < \bar{C}_j$, such change is considered removal or sequestration;

44/12 is a constant to convert mass of C to equivalent mass of CO_2.

[30] Phuong V.T, et al, 2015. Development of emission factors for a National FREL/FRL for REDD+ for the Government's submission to UNFCCC. VAFS and UN-REDD Vietnam, Hanoi.

4.13 Quality assurance/ quality control (QA/QC)

The instructions and guidelines for QA for measurements of field inventory work are planned to be applied to all six ER-P provinces.

4.13.1 Scope of the instructions

The Quality Assurance/Quality Control (QA/QC) team (or teams) controls the quality of measurements of the plots measured by other field teams. The controlling measurements are conducted within 1–2 weeks after the measurements by the initial team. The purpose of the QA/QC is to ensure that the team has conducted measurements according to the instructions and in a correct way. Furthermore, results of control measurements can be used for training purposes, that is, to find out issues unclear to the teams after training.

The results of the control measurements are reported by using a control measurement checklist. The QA/QC team hands over the checklists to the field work manager. Feedback is given both to the field team and field work manager who is in charge of field work. The QA/QC team shall detect and observe shortcomings and errors in measurements conducted by normal field teams in the feedback session. Differences in measurements between QA/QC team and field team are stated, and unclear issues are clarified. It must be taken into account that every field team is controlled.

The reports can be used for evaluating reliability of the field data. Measurements that were found to be difficult shall be emphasized in future training. To evaluate the reliability of the field data, data quality objectives need to be defined. FIPI is going to develop a full QA/QC protocol, including data quality objectives, for field inventory of the improved sample plot system in 2016. Therefore, the data quality objectives for field inventory in the NCC region will be defined at a later stage to be consistent with the national system.

The QA/QC team is equipped with same equipment and devices as the field teams. Measurement data shall be recorded in hardcopy form and handed over to responsible persons.

4.14 Carrying out the control measurements

4.14.1 Preparations

The QA/QC team leader is responsible for practical arrangements of the team. Field staff will help/inform the QA/QC team in practical issues including determination of clusters to be measured, the need of local guides etc. QA/QC team leader shall make timetable and select the clusters requiring control measurements. All plots in controlled cluster shall be checked and re-measured. However, the control measurements should concentrate on plots that are located in forest.

Information of the control measurement shall only be provided to the field team once they have completed the cluster measurements. They have no idea about which plots and clusters to be controlled.

4.14.2 Data transfer

QA/QC team utilizes the data collected by original field team for control measurements. It is more practical to use the original data other than blank data in re-measurements, even if the measurements by QA/QC teams can be influenced by results produced by the ordinary team.

QA/QC team leader request the fieldwork manager or team leader to provide field data, which should be available in paper forms.

4.14.3 Field work

QA/QC team performs measurement in a careful manner and records all the parameters as original measurements. To separate original measurements and control measurements, the cluster number subject to re-measurement must be saved with minus sign "–", i.e., Plot 1 → –Plot 1.

4.14.4 Feedback and reporting

The QA/QC team leader gives feedback to the original field team as soon as possible, preferably on the same day. Feedback can be given in a meeting. All members of the original field team should be present for the feedback and listen to comments provided by the QA/QC team. The differences and shortcomings are pointed out in the feedback session, and reasons for errors are discussed. Feedback session should encourage and motivate teams to continue good work. The feedback should be considered as a part of training. The field teams are able to correct possible errors in their work when they get immediate feedback from the QA/QC team.

QA/QC team leader fills a control measurement checklist after re-measurements. The form is filled in by selecting YES/NO with additional information and explanations on the comment column. QA/QC team leader writes down the form of the observed systematic differences in the measurements between teams, misinterpretations of the instructions, and seriousness of any errors. This report can be utilised in feedback session. The checklist is sent to field work manager.

The QA/QC team leader and field work manager should keep following which field teams have measured, when, where and how many clusters/plots. A separate table should be designed and used. The QA/QC team leader and field work manager shall decide whether additional control is needed for some of the field teams.

4.14.5 Analysis of the results

Differences in measurements between the QA/QC and original field teams will be analyzed later. Measurement checklist and data saved in database will be utilized in analysis. Analysis is done by experts and details of the analysis are agreed later. Analysis can include, e.g.:

a) Table of Yes/No answers from checklist

b) Summary table of main results

c) Summary table of each measurements

- Results from tree level, e.g. bias in diameter and sample tree height
- Results from regeneration plots
- Etc.

4.15 Calculating emission reduction

4.15.1 Calculating emissions/ removals

Based on AD generation and estimation of EF/RF, the emission and removals are estimated as follows:

$$\mathrm{E/R} = \sum_{i=1}^{n} \sum_{j=1}^{n} AD_{ij} \times EF/RF_{ij} \qquad (15)$$

Where:

E/R is the emissions/removals;

N is the number of classes;

AD_{ij} are AD for land use change from land cover type *i* to land cover type *j*;

EF/RF_{ij} is the emission/removal factor for land cover change from land cover type *i* to land cover type *j*.

4.15.2 Calculating emissions reduction and removals enhancement

The emission reduction and removal enhancement are calculated by subtracting the emissions/removals calculated above from the reference levels.

4.16 Conducting uncertainty assessment

4.16.1 Uncertainties in AD

As mentioned above, the accuracy assessments will be conducted for the land cover change map for the period 2015-2020. From the results of accuracy assessment of the land cover change map period 2015-2020, area estimates and their associated uncertainties (errors at the 95% confidence interval) per change class are obtained. $\hat{A}_{ij}$ presents the area estimate of land cover change class from land cover class i in 2015 to land cover class j in 2020, and E_AD_{ij} presents the associated absolute error at 95% confidence interval for $\hat{A}_{ij}$, the percentage error is calculated using the formula:

$$E\_AD\%_{ij} = \frac{E\_AD_{ij}}{\hat{A}_{ij}} \times 100 \qquad (16)$$

4.17 Uncertainties in EF/RF estimates

The co-variance (CV) for carbon stock of forest type *i* is estimated as follows:

$$CV\%_i = \frac{SE_i \times \sqrt{np_i}}{\bar{x}_i} \times 100 \qquad (17a)$$

Of which: SE_i is standard error of carbon stock in measurement plot of forest type *i*. As the measurement plot is not sampled randomly, therefore SE is estimated as follows (Dahm, 2006).

$$SE_i = \frac{1}{\sum_{j=1}^{l_i} m_{ij}} \sqrt{\frac{l_i}{l_i - 1} \sum_{j=1}^{l_i} \left(y_{ij} - \bar{x}_i . m_{ij}\right)^2} \qquad (17b)$$

Where:

l_i is a minimum number of measurement plot of forest type *i* in a primary sample plot;

y_{ij} is value of all measurement plots of forest type *i* in primary sample plot *j*;

$\bar{x}_i$ is average value of carob stock of forest type *i*;

m_{ij} is number of measurement plots of forest type *i* in a primary sample plots *j*.

The error (E) for average carbon stock of forest type *i* is estimated as follows:

$$E\%_i = \frac{t_{\alpha,l_i-1} \times CV\%_i}{\sqrt{np_i}} \quad (18)$$

Where:

$t_{\alpha,l_i\text{-}1}$ is value of *t* distribution with l_i-1 free degree at confidence of 1-α. In this case, the confidence used is 95% (α = 0.05).

The error for emission/removal factor for land use change *ij* (conversion from land cover type *i* to land cover type *j*) is estimated as follows:

$$E\_EF\%_{ij} = \frac{\sqrt{(E\%_i \times \bar{C}_i)^2 + \left(E\%_j \times \bar{C}_j\right)^2}}{\left|\bar{C}_i + \bar{C}_j\right|} \quad (19)$$

Where:

$E\_EF\%_{ij}$ is the error for EF/RF for land use change *ij*;

$E\%_i$ and $E\%_j$ are errors for average carbon stocks of land cover *i* and *j*, respectively;

$\bar{C}_i$ and $\bar{C}_j$ are average carbon stocks of land cover *i* and *j*, respectively.

4.18 Uncertainty in emissions/ removal estimate

After assessing the uncertainties of AD and EF/RF, these uncertainties need to be combined to estimate the overall uncertainty of the total emissions/removals. According to the IPCC guidelines, there are two approaches for combination of uncertainties, including error propagation (IPCC Tier 1) and Monte Carlo simulation (IPCC Tier 2). The error propagation is carried out based on accumulation of all errors. In a Monte Carlo simulation, all different kinds of error are randomly selected within their thresholds for a large number of simulations.

The error propagation approach is selected because of easy implementation and it is consistent with Forest reference setting.

First of all, errors of emissions/removals for each land use change *ij* (conversion from land cover *i* to land cover *j*) are estimated as follows:

$$E\_EM\%_{ij} = \sqrt{E\_AD\%_{ij}{}^2 + E\_EF\%_{ij}{}^2} \quad (20)$$

Where:

$E\_EM\%_{ij}$ is the error of emissions/removals for land use change *ij*;

$E\_AD\%_{ij}$ is the error of AD for land use change *ij*;

$E\_EF\%_{ij}$ is the error of EF/RF for land use change *ij*.

Finally, error for total emissions/removals is calculated as follows:

$$E\_EM\%_{total} = \frac{\sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(E\_EM\%_{ij} \times AD_{ij} \times EF_{ij}\right)^2}}{\left|\sum_{i=1}^{n}\sum_{j=1}^{n} AD_{ij} \times EF_{ij}\right|} \quad (21)$$

Where:

$E\_EM\%_{total}$ is the error of the total emissions/removals;

AD_{ij} is the AD for land use change *ij*;

EF_{ij} is the EF/RF for land use change *ij*;

4.19 Data management

As part of the FMS, an information system will be established. This information system will have a GIS database that stores all the maps and data collected by the FMS as well as information about the methods, and a web-based information portal to provide information to stakeholders, users and reviewers. Detailed information on key data and methods to enable the reconstruction of the Reference Level, and the reported emissions/removals are documented and made publicly available online via this web-based portal. The following information will be made publicly available online:

- Forest definition;
- Definition of classes of forests;
- Choice of activity data, and pre-processing and processing methods;
- Choice of emission/removal factors and description of their development;
- Estimation of emissions/removals, including accounting approach;
- Disaggregation of emissions by sources and removal by sinks;
- Estimation of accuracy, precision, and/or confidence level, as applicable;
- Discussion of key uncertainties;
- Rationale for adjusting emissions, if applicable; and
- Methods and assumptions associated with adjustment, if applicable.

In addition, the following spatial information, maps and/or synthesized data will be displayed publicly:

- Accounting area;
- Activity data (e.g., forest-cover change or transitions between forest categories);
- Emission/Removal factors;
- Average annual emissions over the Reference Period;
- Adjusted emissions, if applicable; and
- Any spatial data used to adjust emissions, if applicable.

Information about multiple benefits such as biodiversity conservation or enhanced rural livelihoods, governance indicators, etc. will be collected and made available online through the information system.

In Vietnam, the Development of Management Information System for Forestry Sector – Phase I (FORMIS I) project (2009-2013) developed a system with adequate structure and capacity for integrating and sharing data through standard interfaces. The FORMIS system comprises of three sub-systems: (i) the databases for storing quantitative and qualitative data collected and managed by agencies inside and outside of the FORMIS system; (ii) the platform for providing capacity for integration of existing and new data and applications, security, exposing data and business functionalities in a standardized manner; and (iii) the content delivery layer for including different channels such as the portal for delivering the information to the target users and for accessing various applications. However, due to time limitations, only a limited amount of data has been put into the databases of the FORMIS system to date. The Development of Management Information System for Forestry Sector – Phase II (FORMIS II) project started in May 2013 and will last until 2018. This project aims to integrate most of forest resources data into the system developed by FORMIS I. If the proposed ER Program is approved, the Government of Vietnam will give priority to integrate forest-related data of the provinces in the Accounting Area into the FORMIS system and use FORMIS as the information system of the ER Program.

4.20 Reporting

The ER Program, when approved, will be nested into the national REDD+ implementation to avoid double accounting of emission reduction and/or removal enhancement at the national scale. This means that the forest reference emission level (FREL) and forest reference level (FRL) of the Accounting Area will be nested into the national FREL and FRL to be submitted to the UNFCCC. Similarly, the emission reduction and/or removal enhancement resulting from REDD+ activities in the Accounting Area will be nested into the national REDD+ performance to be reported to UNFCCC as a mitigation action in a technical annex of Biennial Report Updates.

Therefore, in addition to reporting the performance of the ER Program to FCPF Carbon Fund following required template (which is not available now), the ER Program also needs to report biennially its performance to the Vietnam REDD+ Office (VRO), which is the focal point for REDD+ implementation and has the mandate to oversee and coordinate all REDD+ projects/programs in Vietnam, to be included in the Biennial Report Updates and submitted to UNFCCC. Information to be reported to VRO includes:

- FREL and FRL of the Accounting Area, prepared on the basis of agreed guidelines (Decision 12/CP.17 and the FCPF Framework Document), IPCC methodologies (including the 2003 Good Practice Guidance for Land Use, Land Use Change and Forestry), and other relevant information (historical data, information on methods, approaches, models and assumptions used, pools/gases, and activities included in FREL and FRL and the reasons for any omission);
- Information on forest-related emissions/removals resulting from REDD+ activities in the Accounting Area (prepared following agreed guidelines in Decision 12/CP.17 and Decision 13/CP.19 and IPCC methodologies) and other relevant information (information on methods, approaches, models and assumptions used, pools/gases, and activities included and the reasons for any omission); and
- The information on how safeguards are respected and addressed (Decision 1/CP.16) in the ER Program.

The biennial reports on REDD+ performance in the Accounting Area to VRO needs to ensure that:

- There is consistency in methodologies, definitions, comprehensiveness, and information provided between the assessed reference level and the results of the implementation of the activities;
- The data and information provided in the report is transparent, consistent, complete and accurate, and consistent with the guidelines; and
- The results are accurate, to the extent possible.

4.21 Other functions of MRV

4.21.1 Actions to address Displacement

Domestic Displacement

There is some risk of domestic Displacement as a result of the ER Program as specified in the following Table 7.3.

Table 4.3 Identification and assessment of Risk of Displacement

Driver of deforestation or degradation	Risk of Displacement. (Categorize as High, Medium or Low)	Explanation / justification of risk assessment
Planned conversion to agricultural land	Low	Largely underutilised degraded and bare lands; possibility to displace rubber production to other regions if latex prices recover and rise (currently they are low) Planned conversion of forest to agriculture land also exists in other agro-ecological regions.
Unplanned forest conversion to agriculture (shifting cultivation)	Low	The differences in ecological conditions across agro-ecological regions limit displacement of conversion for agricultural purposes;
Planned and unplanned natural forest conversion to planted forest	Low	The area affected during 2000-2010 is not large (11,800 ha); A national logging ban covers most natural forests (an exception may be where the forest has a FSC).
Planned and unplanned conversion related to infrastructure	Low	Planned conversion related to infrastructure also exist in other agro-ecological regions and is comparatively small and tends to be localised. Unplanned conversion related to infrastructure is not significant.
Unsustainable legal and illegal selective logging for commercial and subsistence purposes	Low	Illegal logging could be displaced to other parts of Vietnam if proportional law enforcement efforts are not made The proposed ER Program is focused on sustainable development – through forestry-based livelihood support (through CFM and smallholder forestry), and, as such, will work to address the needs of communities in conjunction with enhanced forest protection responsibilities (through PFES); The proposed ER Program promotes alternative production sources for timber through allocation and certification of production forest in the context of a nationwide logging ban in natural forests;

International Displacement

The proposed ER Program may create international Displacement, especially in Laos, which shares forest across the border with the NCC region. Illegal logging could be displaced to Laos or other neighbour countries if no change in international measures to address illegal timber supply taken. Based on expert judgment, the risk of international Displacement is categorized as medium. However, the risk of international Displacement is decreasing over time as Vietnam and neighbouring countries are going to join the Voluntary Partnership Agreement (VPA) with the European Union on the Forest Law Enforcement, Governance and

Trade (FLEGT) Action Plan, a mechanism designed to combat the international trade of illegal timber.

4.21.2 Design features to prevent and minimize potential Displacement

Domestic Displacement

The potential risk of both domestic and international displacement of emissions from the proposed ER Program activities are summarised in the following Table 7.4 and elaborated further below. Residual domestic displacement will be measured and fully accounted for by a robust National Forest Monitoring System (NFMS) currently under development.

Table 4.4 Summary of possible risk mitigation design features

Driver of deforestation or degradation	Mitigation design feature
Planned forest conversion to agriculture	Allocation of, and investment in, production forests, particularly for households and communities, provides stable alternative income to shifting cultivation and market volatility of global commodity prices (particularly latex and cassava/ starch) Inclusive business value chain strengthening
Unplanned forest conversion to agriculture (shifting cultivation)	Allocation of, and investment in, production forests, particularly for households and communities, provides stable alternative income to shifting cultivation and market volatility of global commodity prices (particularly latex and cassava/ starch) PFES, with participatory forest monitoring, adopted to compensate forest owners and subcontracted local communities as an alternative income source High income generating cash crops planting to avoid unplanned deforestation and forest degradation with sustainable agriculture
Planned and unplanned forest conversion to forest plantation	Tightening regulations on conversion of natural forests to other land uses Systematic mapping and monitoring of biological diversity in both forest and non-forest ecosystems
Planned and unplanned related to infrastructure	Tightening regulations on conversion of natural forests to other land uses Support local authority to prepare proper forest conversion plan for infrastructure development
Unsustainable legal and illegal selective logging for commercial and subsistence purposes	Law enforcement interventions adopted as model to inform improved national policies and practices; integration with FLEGT and operationalising VPA components adopted as strategic response to both domestic and international leakage By certifying production forests in the Accounting Area, some supply can be maintained within the Accounting Area, reducing the risk of both domestic and international displacement

International Displacement

Vietnam does not have jurisdiction over other sovereign states, and consequently no requirement to address international leakage for national-level under the UNFCCC, it is therefore not possible to eliminate this risk. Nevertheless, the Government of Vietnam takes international illegal forest crime as a serious issue in the ASEAN region and is committed to reducing this broader reputational risk for the country. In addition to existing bilateral Memoranda of Understanding on trans-border timber trade with immediate neighbours, Laos and Cambodia, Vietnam has been negotiating FLEGT-VPA since 2010. Furthermore, Laos is preparing to negotiate FLEGT-VPA. The proposed ER Program will operationalise key elements of the VPA (Legality Definition and Timber Legality Assurance System) to limit risk of international displacement.

Relation and consistency with the design features of the (emerging) national REDD+ Action Plan (NRAP)

The Vietnam's NRAP does not articulate any specific provisions for addressing risks of displacement, either domestically or internationally. Consequently, the design features to address the risk of displacement in the ER Program will serve as a major influence informing the operationalisation of the evolving NRAP.

4.22 Actions to address Reversals

4.22.1 Identification of risk of Reversals

Reversal of GHG benefits could result from fire, disease, illegal logging, unplanned agricultural expansion (responding to global commodity price hikes), centrally planned infrastructure development, or climate change (particularly increased frequency and intensity of typhoons). Table 7.5 provides an assessment of the anthropogenic and natural risks of Reversals that might affects ERs during the Term of the ERPA.

Table 4.5 Identification and assessment of risk of Reversals

Risk	Level of risk
Anthropogenic risk	
Expansion of commercial and subsistence agriculture	Medium – commodity (latex, cassava/ starch) prices beyond the control of the ER Program
Infrastructure development	Low – historically a minor driver of Deforestation and Forest Degradation; large HEP dams now require PM approval
Illegal logging	Low – key strategy of the proposed ER Program is strengthened enforcement
Climate change	Medium – increased frequency of typhoons could impact coastal forests
Natural risk	
Fire	Low – historically a minor driver of Deforestation and Forest Degradation; could increasing with climate change

4.22.2 ER Program design features to prevent and mitigate Reversals

The overall risk mitigation strategy is to negotiate trade-offs between ER, economic, environmental and social objective of land-use options through the participatory PRAP processes. Vietnam's equivalent of a national REDD+ strategy, the NRAP does not offer any specific provisions for addressing the anthropogenic and natural risks of Reversals. Consequently, the ER Program will serve as a major influence informing the operationalisation of the evolving NRAP with regards to reversals management mechanisms.

Table 4.6 Mitigation strategies for risk of Reversals

Risk	Mitigation strategies
Anthropogenic risk	
Expansion of commercial and subsistence agriculture	Participatory land-use planning through PRAP; livelihood improvement through production forestland allocation and development coupled with PFES contracts for natural forest protection
Infrastructure development	Participatory land-use planning through PRAP; forestland allocation securing statutory tenure
Illegal logging	Prevention-based enforcement; strengthened criminal justice response; intelligence-based enforcement; participatory forest monitoring
Climate change	Appropriate selection of locations for future industrial tree crop plantations during PRAP to avoid exposure to typhoons; planting wind breaks in coastal areas (within 50 km from the coast)
Natural risk	
Fire	Monitored by FPD under VNFOREST; implementation of fire prevention measures and fire-fighting infrastructure (Vietnam has a well-established and functioning fire prevention and management system in the FPD)

4.22.3 Reversal management mechanism

Table 4.7Selection of Reversal management mechanism

Reversal management mechanism	**Selected (Yes/No)**
Option 2: ERs from the ER Program are deposited in an ER Program -specific buffer, managed by the Carbon Fund (ER Program CF Buffer), based on a Reversal risk assessment.	YES

4.22.4 Monitoring and reporting of major emissions that could lead to Reversals of ERs

In the course of ER Program implementation, any significant emissions in the Accounting Area or changes in ER program circumstances that the ER program considers could lead to reversals of previously transferred ERs by the next monitoring event, and will be reported to the Carbon Fund within the timeline prescribed in the Carbon Fund Methodological Framework. A percentage of the potential emissions under the proposed ER Program will be used as insurance against the occurrence of any reversals in the Accounting Area included in the Program. Vietnam will participate in the Carbon Fund buffer option. In addition to the buffer solution of reserving ERs, during the full ER Program's development, and integrated with national REDD+ fund design under the NRAP, other national non-permanence risk mitigation strategies - namely national/subnational compensation funds and formal insurance mechanisms - will be investigated.

4.22.5 Linking FMS with Benefit sharing mechanism system (BSM)

In principle, the FMS as described above can provide to the BSM the following information: (i) area of forests per forest owner, commune, district and province; (ii) forest carbon stocks per forest owner, commune, district and province; and (iii) emission reduction/removal enhancement per forest owner, commune, district and province. However, due to the limitation of the sampling method, the forest carbon stocks and emission reduction/removal enhancement are only accurate enough at the provincial level. Therefore, information on forest carbon stocks and emission reduction/removal enhancement provided by the FMS can be used as input parameters (together with other inputs) to distribute benefits at the provincial level. The information on forest area provided by the FMS can be used as an input parameter (together with other inputs) to distribute benefits to each forest owner.

4.23 Budget estimate

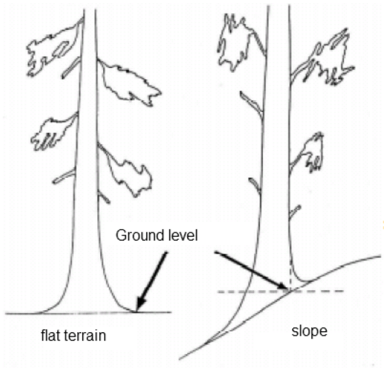
The cost estimate for operating the proposed MRV system for the NCC region in period 2016-2020 is 1,392,800 USD, as detailed in Table 7.8 below:

Table 4.8 Cost estimate for the MRV system in the NCC region during 2016-2020

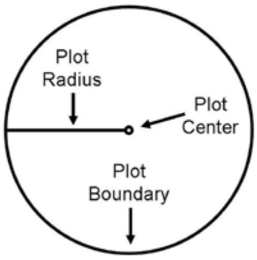
Activities	Unit	Quantity	Price (USD)	Total (USD)
Initial procurement of equipment and software	Province	6	10,000	60,000
Potential change detection using medium satellite imagery	Year	5	10,000	50,000
Field check of potential changes and update	Year	5	30,000	150,000
High resolution satellite images (e.g., SPOT-5 or equivalent) procurement	Scene	12	5,000	60,000
Accuracy assessment of land cover change map 2015-2020 using Open Foris Collect Earth	Point	1800	20	36,000
Field inventory	Cluster	789	1,000	789,000
QA/QC of field inventory (including training, assuming to be 20% of inventory cost)				157,800
Calculation of emission reduction and removals enhancement (National consultant)	Man-day	150	250	37,500
Uncertainty assessment (National consultant)	Man-day	30	250	7,500
Reporting and data management (National consultant)	Man-day	100	250	25,000
Verification of results (International consultant)	Man-day	40	500	20,000
Total				1,392,800

4.24 Glossary

Ground level: Ground level is described as in the following figure:



Plot radius, centre and boundary: as in the following figure.



Tree: A tree is at least 1.35 m perennial wooded plant with distinct stem capable of reaching 5 meters height *in situ*. Cactuses and palms are regarded as trees in the data collecting phase, but distinguished in the data analysis phase.

Undergrowth: Undergrowth includes small trees, bushes, herbs and grasses growing beneath taller trees in the forest.

Seeding point: Seeding point is usually at the ground level. Trees that grow on the top of a stone or old stump, the seeding point is the point where the seeds have started to grow.

Living tree: A live tree must have living branches. The tree must be able to survive at least to the next growing season/next year.

Dead tree: A tree is regarded as dead tree if it does not have any living branches. Trees that are alive but so badly damaged that cannot grow in the next growing season (e.g. trees felled by storm) are regarded as dead trees.

Forked tree: If the forking point is below the breast height (1.3 m), the tree is recorded by giving a unique tree number for each fork. If the forking point is above the breast height, a tree is recorded as one stem.

Tally tree: Live or dead standing tree in the sample plot with the DBH higher than the minimum DBH (≥ 6 cm).

Sample tree: A live tree selected for measurements of additional parameters. The first sample tree is the third three in each sample plot followed by the 8th, 13rd, 18th trees… (every 5th tree in the sample plot is selected as sample tree). Note, in case sample tree is dead, the next living tree is selected as sample tree but the counting of next sample tree continues from the original (dead) tree.

Tree height: Tree height is the distance along the stem axis between the seeding (base) point and the tree tip. If the seeding point is higher than the ground level (e.g. in case where a tree growing on the top of a stone), the tree height is measured from the seeding point.

Bole height: Bole height refers to merchantable height that is defined as the distance from the base of the tree to the first occurrence of the lowest point on the main stem, above the stump, where the stem form is changing or utilization of the stem is limited by branching or other defect.

Breast height: Breast height is the height from the ground level, or if the ground level cannot be defined to the point of 1.3 m high of the stem. See more explanations and special cases in the section *Tree diameter measurements.*

Stump height: Stump height is the level of the upper most root collar. If no root collars exist, stump height is expected to be 15 cm from the ground level.

Shrub: Shrubs are woody perennial plants, generally of more than 0.5 m and (usually) less than 5 m in height on maturity and with many stems and branches.

Biomass: Organic material both above ground and below ground, and both living and dead, e.g., trees, crops, grasses, tree litter, roots etc. Biomass includes the pool definition for above and below ground biomass.

Biomass of forests: The total amount of aboveground living organic matter in trees expressed as oven-dry tons per unit area (tree, hectare, region, or country). Forest biomass is classified into above ground biomass and below ground biomass.

Above ground biomass: All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.

Below ground biomass: All living biomass of live roots. Fine roots of less than (suggested) 2 mm diameter are sometimes excluded because these often cannot be distinguished empirically from soil organic matter or litter.

Basic wood density: Ratio between oven dry mass and fresh stem wood volume without bark. It allows the calculation of woody biomass in dry matter mass. Basic wood density is normally expressed in gram/cm3 or ton/m3.

Biomass Expansion Factor (BEF): A multiplication factor that expands growing stock, or commercial round wood volume, or growing stock volume increment data, to account for non-merchantable biomass components such as branches, foliages, and non-commercial trees.

Carbon fraction: A carbon content expressed in per cent (%) in dry oven mass of certain component of forests (stem, branches, foliage, root, etc).

Carbon pools: Reservoirs containing carbon. There 5 carbon pools in a forests considered for forest carbon estimation that are: carbon in live trees (above and below ground), carbon in dead trees and wood, carbon stock in under-storey vegetation (seedlings, shrubs, herbs, grasses), carbon stock in forest floor (woody debris, litter, humus) and soil organic carbon.

Carbon stock: The quantity of carbon in a pool.

Forest: A minimum area of land of 0.05 – 1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10 – 30 per cent with trees with the potential to reach a minimum height of 2 – 5 meters at maturity in situ (in place). A forest may consist either of closed forest formations where trees of various stories and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10 – 30 per cent or tree height of 2 – 5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily un-stocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.

FAO provides the definition of a forest which is land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

Vietnam now uses the forest definition given by FAO. However, in AR CDM, the forest is defined by Designated National Authority (DNA) as follows: forest is an area that meets the following criteria: i) has a minimum tree crown cover of 30%; ii) has a minimum tree height of 3 meter at maturity; and iii) has a minimum area of 0.5 hectare;

Quality Assurance (QA): QA activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process to verify that data quality objectives were met, ensure that the inventory represents the best possible estimation of emission and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the quality control program.

Quality Control (QC): QC is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to: i) provide routine and consistent checks to ensure data integrity, correctness, and completeness; ii) identify and address errors and omissions; and iii) document and archive inventory material and record all QC activities.

Root to shoot ratio (RS): The ratio of below ground biomass of trees to above ground biomass of trees. RS is normally used to estimate below ground biomass of trees if above ground biomass of trees is known.

Benefits Sharing mechanism (BMS): The principles, model and processes developed and applied to distribute benefits, both direct and indirect, of project activities, including project funding, between different participants and stakeholders.

Carbon Sink: A reservoir or location that sequesters or stores a greater amount of carbon dioxide than they release. Major carbon sinks include forests and oceans.

Carbon Source: A carbon pool (reservoir) can be a source of carbon to the atmosphere if less carbon is flowing into it than is flowing out of it. It is the opposite of a sink.

Conference of the Parties (COP): The term used to describe the regular meeting of state parties to the UN Framework Convention on Climate Change. This is the body with authority to take decisions under the Convention.

Crown Cover: The percentage of the surface of an ecosystem that is under the tree canopy. Also referred to as ‘canopy cover’ or just ‘tree cover’.

Dead Wood: The term used to describe all non-living woody biomass not contained in the litter, either standing, lying on the round, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the host country.

Greenhouse gases (GHGs): A group of gases that control energy flows in the Earth's atmosphere by absorbing infra-red radiation. Some GHGs occur naturally in the atmosphere (e.g. H2O), while others result from human activities or occur at greater concentrations because of human activities. There are six GHGs covered under the Kyoto Protocol carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) and sulphur hexafluoride (SF6). CO2 is the most important GHG released by human activities.

Litter: Forest carbon pool that includes the detritus, leaves, small dead biomass lying on the ground, and humus layers of the soil surface.

Monitoring: The collection and archiving of all relevant data necessary for determining the baseline and project-based measuring of anthropogenic emissions by sources (or sinks) of greenhouse gases (GHG) within the project boundary (and leakage of emissions).

Permanence: A key pre-requisite for the credibility of any carbon sequestration activity, particularly tree planting; that it have in place safeguards to cover the possibility that carbon removed from the atmosphere may be released in the future, for example, due to fire, disease or logging. In practice, ongoing verification of planted trees must take place where carbon offset credits have been generated for those carbon reductions.

Remote Sensing: A method of measuring deforestation and/or forest degradation by a recording device that is not in physical contact with the forest, such as a satellite.

Removals: This is the opposite of an emission of greenhouse gas and occurs when greenhouse gases are removed from the atmosphere, for example, by trees during the process of photosynthesis.

Soil organic carbon (SOC): The carbon pool that includes all organic material in soil, but excluding the coarse roots of the belowground biomass pool.

Stakeholder: An individual, group or body that has a legitimate stake or interest in the project and is either participating in or likely to be affected or influenced by the project.

Tier: The IPCC Good Practice Guidance tiers are levels of methodological complexity: Tier 1 is the most basic and uses global default values for carbon stocks; Tier 2 is intermediate and uses national values; and Tier 3 is most demanding in terms of complexity and data requirements, and uses site-specific values for carbon stocks.

4.25 References

1. Brown, S. (1997). *Estimating biomass and biomass change of tropical forests: a primer. In FAO Forestry Papers – 134*.

   (available at http://www.fao.org/icatalog/search/dett.asp?aries_id=7736.)

2. Card, D. H. (1982). *Using known map category marginal frequencies to improve estimates of thematic map accuracy*. Photogrammetric Engineering and Remote Sensing, vol. 48, Mar. 1982, p. 431-439.
3. Dahm S. (2006). *Auswertungsalgorithmen für die zweite Bundeswaldinventur.*
4. FCFP (2013). *FCPF Carbon Fund Methodological Framework*.
5. GFOI (2013). *Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative*: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.
6. IPCC (1996). *Revised 1996 IPCC Guidlines for National Greenhouse Gas Inventories.* Institute for Global Environmental Strategies (IGES). Japan.
7. IPCC (2003). *IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry*. Institute for Global Environmental Strategies (IGES). Japan.
8. IPCC (2006). *IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme*. Eggleston H.S., Buendia L., Miwa K., Ngara T., Tanabe K., (eds). Published: IGES, Japan.
9. MONRE, 2014. *The Initial Biannual Updated Report of Vietnam to the UNFCCC.*
10. JICA, 2012. *Potential forest and land related to "Climate change and forest" in the Socialist Republic of Vietnam*.
11. Nguyen Dinh Hung, Ngo Van Tu, Vu Tan Phuong, Do To Nhu, Vu Quang Hien, Pham Duc Cuong and Pham Tuan Anh. 2015. *Report on construction of national reference level for REDD+ implementation in Vietnam (unpublished)*. UN-REDD Vietnam, Hanoi.

12. Olofsson, P.; Foody, G.M.; Stehman, S.V.; Woodcock, C.E. *Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation*. Remote Sens. Environ. 2013, 129, 122–131.
13. Olofsson, P.; Foody, G.M.; Herold, M.; Stehman, S.V.; Woodcock, C.E.; Wulder, M.A. *Good practices for estimating area and assessing accuracy of land change*. Remote Sens. Environ. 2014, 148, 42–57.
14. UN-REDD Programme in Vietnam (2012). *MRV Framework Document*.
15. UN-REDD Programme in Vietnam (2015). *Allometric equations at national scale for estimating tree and forest biomass in Viet Nam.*
16. Việt Nam (2014). *Emisison Reduction Program Idea Note (ER-PIN) for the Forest Carbon Partnership Facility (FCPF).*
17. VNFOREST (2013). *Technical guidelines for forest inventory*. (in Vietnamese; used as training manuals for National Forest Inventory and Statistics Project).
18. VNFOREST (2013). *Technical guidelines for forest statistics*. (in Vietnamese; used as training manuals for National Forest Inventory and Statistics Project).
19. Vu Tien Dien, 2016. *Report on development of Activity Data for North Central Coastal for Development of reference level for FPCF program (unpublished)*. FPCF, Hanoi.
20. Vu Tan Phuong and Vu Tien Dien, 2016. *Report on development of emission and removal factors for North Central Coastal for FPCF program (unpublished)*. FPCF, Hanoi.

4.26 Annex 1

Vietnam context on MRV for REDD+

The Government of Vietnam has emphasized the basic principles for REDD+, including that participation of countries is voluntary, and the Program is designed for specific local contexts and respects national sovereignty. As REDD+ is considered a multi-sectoral and national Program, and requires the active participation of various parties, policy reforms are needed to improve collaboration between stakeholders and ensure an effective and transparent mechanism. REDD+ has been integrated into three major forestry policies in Vietnam: (1) the National Forest Development Strategy in period of 2006–2020; (2) National Forest Development and Protection Plan; and (3) Vietnam National REDD+ Strategy.

The Ministry of Natural Resources and Environment (MONRE) is the state agency responsible for climate change adaptation activities in Vietnam, and at the same time acts as the focal point for UNFCCC and the Biodiversity Convention. The Ministry of Agriculture and Rural Development (MARD), which incorporates VNFOREST, is the agency responsible for providing the strategic direction of REDD+.

To ensure effective coordination between MONRE and MARD in implementing climate change initiatives, including the REDD+ Program, the Prime Minister of Vietnam issued Guideline No. 282/VPCOQHQT (dated 13th January, 2011), which sets out the division of responsibilities between the two ministries, and their individual and joint duties in implementing REDD+ and related strategies. This decision stated that MARD would take the lead in developing the National REDD+ Program, strengthen institutional and organizational capacities, establish a National REDD+ Steering Committee, secure support from the international community, and strengthen collaboration among line ministries, economic sectors and local authorities. MONRE, on the other hand, was assigned to take the lead in preparing a proposal for the establishment of an inter-sectoral climate change negotiation delegation, in close collaboration with MARD and related agencies, to be submitted to the Prime Minister for consideration and approval.

The agency mandated with the primary responsibility for measuring and reporting forest metrics and forest change is MARD that pursuant to Decision No 799/QĐ–TTg issued by Prime Minister of Vietnam.

Building upon national requirements and institutional structures and in accordance with UNFCCC guidance, the principles for establishing and implementing the national forest monitoring system are:

- Consistent with recently adopted or recommended IPCC guidelines, and inform the UNFCCC implementation process;

- Appropriate with national context, capacity, abilities and information;

- Effective and multi-purpose in design;

- Following a phased-approach in its development and implementation;

- Allow for the monitoring of safeguards, policies and measures;

- Encourage the participation of relevant stakeholders and forest owners;

- Transparent, consistent over time and efficient for estimating forest-related anthropogenic emissions and removals;

- Institutional arrangements shall be based, whenever possible, on existing institutions, with the creation of new ones being the result only of necessity;

- GHG emissions will be reported once every four years and updated biennially;

- Vietnam has full and sole responsibility for implementing, monitoring and reporting on REDD+ in the country.

Currently there are three separate systems operational in Viet Nam designed to measuring and monitor forest change.

1. National Inventory and Statistic (NFIS) Project in period 2011-2016

Legal bases: The Prime Minister's Decision No. 144/2008/QD-TTg, dated 10th October, 2008, approved the National Inventory and Statistic programs, which includes the "National Forest Inventory and Statistic" program. On 27th April, 2009, the Minister of MARD signed Decision No 1169/QĐ-BNN-KH approving the project "National Forest Inventory and Statistic in period 2010 to 2015". On 5th May, 2009, MARD released Circular No. 25/2009/TT-BNN to guide the implementation of the forest inventory and statistics, and the establishment of the forest management dossiers. The Prime Minister's Decision No. 1698/2009/QD-TTg, dated 20th October, 2009, approved the establishment of the Steering Committee for the Project "National Forest Inventory and Statistic in period 2010 to 2015". The Prime Minister's Decision No. 1240/ QĐ-TTg, dated on 22nd July, 2011, approved the implementation of the pilot project "National Forest Inventory and Statistic" in Bac Kan and Ha Tinh provinces. While on 15th April, 2013, the Prime Minister signed Decision No.594/QĐ-TTg, which approved the project "National Forest Inventory and Statistic in period 2013 to 2016".

Executive Agency: Ministry of Agricultural and Rural Development (MARD)

Management Agency: Vietnam Forest Administration (VNFOREST)

Implementation Agencies: Forest Inventory and Planning Institute (FIPI), Vietnam Forestry University (VFU), Vietnam Academy of Forest Sciences (VAFS), Provincial People's Committees

Objectives:

+ To determine the exact total area of forests, forest quality and non-forest land planned for future forestry purposes associated with specific owners across the whole country. This information is to assist in forest management and protection, and forest protection and development planning, from national through to local levels.

+ To develop a forest management database for all forest management and administrative units to monitor forest land change annually, and to provide the information necessary to improve the efficiency of forest management and protection activities, and create a basis for the implementation of Payment for Forest Environmental Services (PFES), regulated in Decree No. 99/2010/NĐ-CP of the Prime Minister.

Implementation Progress: In 2012, the Project was successfully piloted in Bac Kan and Ha Tinh provinces. In 2013, NFIS was implemented in 13 provinces in the Central Highland and Mekong Delta regions; In 2014, it was implemented in a further 25 provinces; in 2015, it was implemented in another 20 provinces; and, in 2016, the data will be summarised and the results published.

Technologies: The technologies applied in the Project include ground inventory and Remote Sensing. Specifically:

+ High resolution satellite imagery, such as SPOT-5, SPOT-6 and VNREDSAT-1, have been used and automatically interpreted;

+ Rectangular sample plots have been established to measure forest stocks.

Disaggregation:

+ The total forest areas; total areas of very young plantation forest areas (i.e., the areas of bare land that have just been planted and not have become forest yet); non-forest land (the land without forest which are allocated for forestry purposes).

+ All forest owners who have been issued forest land tenure certificates to manage forests, forest utilisation and forest land leasing, including the Special Use Forest Management Boards, Protection Forest Management Boards, State forest enterprises, private enterprises, households, individuals, the armed forces (i.e., Army and public security), other organisations, local communities, overseas Vietnamese, and Commune People's Committee (that are managing forests and non-forest land).

Methods: The Project has 2 main phases, each having a different approach:

(i) *Inventory and survey to develop forest status map*: Interpreted satellite imagery is combined with a field inventory as a basis to develop forest status maps. This task is implemented by FIPI and VFU.

(ii) *Forest statistics*: Carry out forest statistics collection at the plot level of the forest owner, with the support of local and central forestry agencies. This step is conducted for two groups of forest owners: households, individuals, and village communities (Group 1); and, Protection Forest Boards, Special Use Forest Boards, and state and private forest enterprises (Group 2). After the completion of the statistical stage, the forest management dossier is established for each forest owner. The Provincial People's Committees will lead the implementation of this step.

Project achievements: (i) The forest status maps showing forest utilisation purposes and forest owners from the commune through to national level; (ii) Forest area database disaggregated by three forest functions, forest management owners and forest stocks, synthesized from the commune through to national level; (iii) Forest management dossier for each forest owners and administrative units; and, (iv) Project achievement report. The data will be published on the FORMIS platform (http://formis.vnforest.gov.vn/).

2. Annual Monitoring of Forest and Forestry Land Program

The “Annual Monitoring of Forest and Forestry Land” Program has been conducted by the Forest Protection Department (FPD) at the national scale since the issuing of Directive No. 32/2000/CT-BNN-KL by MARD in 2000. The Program provides annual data on forest cover and forestry land area for all forested provinces in Vietnam.

Objectives: To monitor the forest cover change annually, in order to support the identification of existing areas of forests by type, as well as unused non-forested land, in addition to the change in forests and forest land (i.e., land planned for the forestry sector), in the different administrative units (i.e., communes, districts and provinces). The outputs of the forest monitoring system will support provincial policy makers in making decisions relating to forest protection and development (pursuant to Decision No.78/2002/QĐ-BNN).

Methodology: Remote Sensing technology, combined with ground surveys and field inspections, are used to generate forestland cover maps that identify plot boundaries of forest types and non-forest land. Ground surveys for checking, updating the plot boundary, its status, as well as the area of specific plots on the map are conducted using GPS.

Maps showing forest and forestry land changes have to be updated in order to meet two different levels of requirements:

- Level 1: Any plot area over or equal to 0.5 ha (i.e., equal to 0.5 cm^2 on a map at a scale of 1/10.000) must be drawn on the map.
- Level 2: Any plot area below 0.5 ha with scattered trees will be recorded on the inventory sheet, but no need to be drawn on the map.

(Pursuant to Decision No. 78/2002/QĐ-BNN)

Implementation steps:

Data collection: Forest rangers or commune forestry staff collect information from various sources on forest plots that have experienced changes; forestry staff then carry out a survey every November in the changed plots, recording the changes, and synthesizing the data on the forest area and forestry land. At the end of each year, areas that have experienced change are recorded for each commune, and by forest type, with the reasons for change and total forest cover area summarized at the commune level and reported to the District FPD.

District FPD will analyze, process and verify the commune level data, before complementing and synthesizing it into district level data, and reporting the results (digitized data) to the Provincial FPD; The Provincial FPD has to then synthesize and verify the district-level data and report the results to Provincial Department of Agriculture and Rural Development (DARD) and the national FPD. Subsequently, the national FPD has to verify and synthesize forest statistics for both the regional and national levels, and submit to the Minister of MARD to announce at the end of each year on 31st December.

Forest database management and storage: The annual commune-level forest inventory data is managed and stored in the forest management dossier by the Commune People’s Committee and District FPD. The district-level data is managed and stored in the District FPD and DARD, while the provincial-level data is managed and stored by both DARD and MARD; with the central-level data managed by MARD (VNFOREST) and the General Statistics Office (GSO).

Achievements:

1. Forest status map:

a) Commune level: Map of a scale of 1/25.000 or 1/10.000;

b) District level: Map of a scale of 1/50.000 (urban use scale of 1/25.000);

c) Provincial level: Map of a scale of 1/100.000;

d) National level: map of a scale of 1/1.000.000.

2. Reporting tables that shows the results of the calculation and summary of the area of forests and forestry land of each forest stand and compartments. The reporting units follows administrative units – i.e., commune, district, province, and national levels.

Table 1. Forest and forestry land areas by forest types

Table 2. Forest and forestry land areas by functions.

Table 3. Forest and forestry land areas by forest owners.

Table 4. Plantation forest areas by species and age classification.

Table 5. Changes to forest and forestry land areas by drivers.

All of the above data is then entered into a specialized software program for synthesis, calculation and analysis. This database is also stored in a specialized computer network and a summary of the data is posted on the National FPD's website (http://www.kiemlam.org.vn/Desktop.aspx/List/So-lieu-dien-bien-rung-hang-nam/).

Achievements:

+ The Program provides annual data on forest and forestry land area. The database contributes to the development of forest protection and policy-making.

+ The monitoring of forest resource change at the plot, compartment and block levels, requires a huge amount of work to develop and update the database. However, the detailed database is without question highly useful to all levels and sectors to understand the changes in forest and forestry land area, and from this, to develop the most effective planning for forest and forestry land utilization.

Limitations:

The Program has been implemented for more than 10 years now. However, the results demonstrate that it still has some shortcomings as follows:

+ The Program's results only focus on the changes in forest area and forest status. Other forest parameters, such as forest stock, forest structure, silviculture characteristics, and biodiversity, etc., are not collected. Therefore, it can be said that the program only outlines the "forest's outer shell", but does not reveal the inner characters of forests.

+ The Program only focuses on forest area and applies out-dated methods that have significant limitations, so the accuracy of the data collected remains low. Despite the long duration for data collection, the database has also not yet been completed.

+ Human resources available consist primarily of forest rangers, with data collection at the local level mainly carried out by them and/or commune forestry staff, both of whom have limited capacity in relation to forest inventory issues. The database is collected and synthesized from a variety of different sources.

+ The Program data are updated based on baseline data and maps generated by the NFIS period 1997-2000. The data has subsequently been updated annually, however, it has been done so without the application of remote sensing, while fieldwork has also been limited, meaning that the accuracy of program data has been getting lower and lower over time.

+ There remains no adequate guidelines for the inspection, monitoring, evaluation and quality assessment of data collected, nor for data processing, thus, the accuracy and transparency of the data is not high.

+ The main responsibility of forest rangers is forest protection, thus, the reported data may not be transparent and may not reflect reality.

+ Forest rangers receive a fixed salary. Therefore, their motivation to undertake field collection, particular in difficult areas, is limited. This affects the quality of the results.

3. The National Forest Inventory, Monitoring and Assessment Program (NFIMAP)

The NFIMAP is a basic forest inventory Program with a 5-year rotation, which has been conducted by FIPI since 1991, with 4 cycles (Cycle I: 1991-1995; Cycle II: 1996-2000; Cycle III: 2001-2005; and Cycle IV: 2006-2010) completed thus far. The Program has not been continued in the 2011-2015 period due to the implementation of the NFIS project during this time.

The NFIMAP is implemented on the basis of a series of Decisions made by the Prime Minister. Specifically, Cycle I was implemented according to Decision No. 575 / TTg, dated 27th November, 1993; Cycle II under Decision No. 446/TTg, dated 21st June, 1997; Cycle III under Decision No. 10/2002/ QD-TTg, dated 14th February, 2002; while Cycle IV was carried out under Decision No. 258/2006/QD-TTg, dated 11th November, 2006.

Objectives:

Through comprehensive and continuous inventory at the national scale, the project has provided adequate information in relation to forest area and quality, as well as assessing trends in forest change and their relationships with social-economic activities. This information has subsequently formed the scientific foundation for the development of strategies and plans to properly utilize, protect and develop forest resources, and contribute to the nation's socio-economic development.

Each cycle has generated provincial forest cover maps at the scale of 1:100,000; regional forest cover maps of six forestry regions at the scale of 1:250,000 and a national forest cover map at the scale 1:1,000,000. Cycle IV has also generated commune-level (scale 1:25,000) and district-level (scale 1:50,000) forest cover maps.

Technology: the Program has been implemented by applying ground inventory and medium to high resolution satellite imagery. This combination has been used to assess and monitor forest area and forest land; assess and monitor forest quality using information collected from established primary sample plots and permanent plots.

Specific information about the satellite imagery, spatial resolution and interpretation method for each cycle:

- Cycle I (1991-1995): Landsat MSS and Landsat TM imagery with the spatial resolution of 30×30m were used. The images were in hardcopy at scale 1:250,000. Interpretation was done visually by drawing on the hardcopy images.
- Cycle II (1996-2000): SPOT-3 imagery with the spatial resolution of 15m×15m was used. The images were in complex colours in hardcopy at scale 1:100,000. Like Cycle I, interpretation was done by visual interpretation drawing on the hardcopy images.
- Cycle III (2001-2005): Landsat ETM+ imagery with the spatial resolution of 30m×30m was used. The images were in digital form and interpretation was undertaken with the assistance of the ERDAS software.
- Cycle IV (2006-2010): SPOT-5 imagery with the spatial resolution of 2.5m×2.5m or 5m×5m was used. The images were in digital form and interpretation was done with the assistance of the software ERDAS and ENVI.

Implementation Methods: Implementation methods can be divided into two main methods as follows:

+ *Inventory, assessment and monitoring forest area and forest land*: the main task in this step is to develop a new forest status map from previous cycles' forest status maps, which have been updated to reflect recent land use change, deforestation and new plantations, through the use satellite imagery, such as Landsat MSS and Landsat TM, SPOT-3, and SPOT-5. Field work was conducted to adjust and update the forest status maps generated using satellite images.

+ *Inventory, assessment and monitoring forest quality parameters:* this step involves collecting and processing the data for checking and carrying out supplementary revisions to the final forest cover maps through the primary and permanent plots system, specifically:

Layout of a primary sample plot (Figure A.1): the plot area is 1 km x 1 km. From the centre of each plot, two strips of the secondary sample plots were set up, one towards the North and another towards the East. Each strip contains 20 sub-plots of 500 m^2 (i.e., 20 m x 25 m) in size. The total area of the secondary sample plots is 2 x 20 x 500 m^2 or 2 ha.

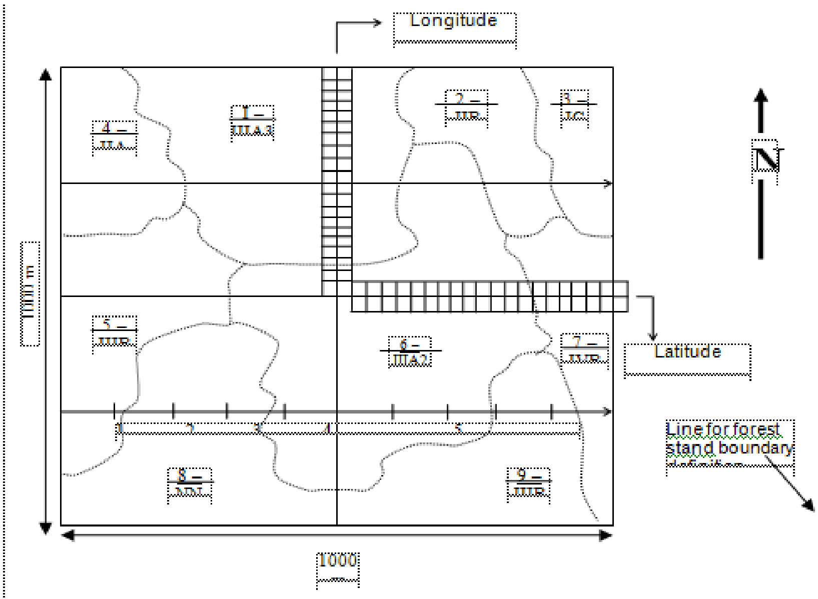


Figure A.4.6: Layout of a primary sample plot

Permanent sample plots for ecological research: the total plot area is 100 ha, containing three research plots, each 1 ha (100 x 100 m) in size. Each research plot is subsequently divided into 25 measurement plots of 400 m^2 (20 m x 20 m) in size.

Achievements:

+ Through four cycles (1991-2010), over a period of 20 years, the Program has provided information and data about forest resources to inform the development of the national forestry development strategy, as well as forest development planning in each of the country's provinces. A database of Vietnam's forest resources, established and stored using specialized software provides long-term value and has contributed important data to the FAO's Global Forest Resource Assessment (FRA). FIPI has received FAO capacity building support in relation to information collection contributing to the national forest resource management system, and reporting to the FAO on national forest resource change over 5 year periods.

+ With significant experience in forest inventory and the use of advanced technology, the results of the NFIMAPs are diversified. The program has not only provided information on fluctuations in forest area and land, but also data on forest structure and ecological parameters that can be used in more in-depth researches.

Limitations:

- Under the guidance of the UNFCCC, Vietnam must submit GHG National Communication every 4 years and provide biennial update reports. However, the NFIMAP is implemented over a period of five years, with forest area and quality results only collected and synthesised at the end of this period – i.e., only once every five years.

- The technical verification of the results of the NFIMAP have not been conducted frequently, with it only occurring during the last cycle (cycle IV). The statistical data on forest area and land was collected from annual reports at the local level. However, these data were not assessed, and its accuracy not high.
- The NFIMAP database has been developed and, while abundant, the data is scattered and, thus, very difficult to use. Therefore, the efficient utilisation of data to inform the development of policy, strategies and plans, and in management, is still limited.
- The quality of supervision, monitoring activities and technician expertise is limited. This, in turn, places limitations on data collection, particularly data required for thematic reports. In addition, material facilities, technical equipment, base maps, and satellite imagery quality are not up to standards, further negatively influencing the results of the program.
- Human resources for implementing the NFIMAP, from sub–FIPIs up to FIPI headquarter, have not been adequate, which is exacerbated by the large area over which the Program is implemented. Consequently, the results do not fully meet requirements.
- Limitations on plot design and data collection methods:
    - Measurement of highly correlated neighbouring plots: from a statistical point of view, this does not make sense. Variation is a good thing in forest inventory. Sampling should be designed to maximize the variation in the sample.
    - All trees over 6 cm are measured, although, the large number of small trees measured represented a small part of the total volume. Two-thirds of the time spent in the field is used for measuring small sized trees, which represents less than one-third of the total volume.
    - Rectangular plot measurement in the field are difficult due to the challenging terrain. The correct locations of neighbouring rectangular plots (i.e., L-shape lines of 40 sub-plots), with no gaps between them, are difficult to identify in the field using just maps, compasses and measuring tapes. In mountainous areas, the measurement of such plots can be almost impossible.
    - Cost and time taken for implementation in the field: historical data reveals that it can take up to one month to measure one L-shape plot with 40 sub-plots.
    - Plots were established only in forested areas. No reliable estimates of land use classes or their changes were taken. Similarly, no information on trees outside of forests has been collected.
    - The number of sample plots would not meet statistical requirements in areas which have high diversity and topography divided into climatic micro regions.