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Annex 15: Reference Level Report

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ABBREVIATIONS

AD	Activity data
AE	Allometric Equation
AGB	Above Ground Biomass
BCEF	Biomass Conversion and Expansion Factors
BGB	Below Ground Biomass
BUR	Biannual Updated Report
CF	Carbon Fraction
DBH	Diameter at Breast Height
EF	Emission Factor
EBF-R	Evergreen Broadleaf Forests, Rich
EBF-M	Evergreen Broadleaf Forests, Medium
EBF-P	Evergreen Broadleaf Forests, Poor
FAO	Food and Agriculture Organization
FIPI	Forest Inventory and Planning Institute
FRL	Forest Reference Level
FREL	Forest Reference Emission Level
FPCF	Forest Carbon Fund Facility
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Change
INDC	Intended Nationally Determined Contribution
JICA	Japan International Cooperation Agency
LULUCF	Land use, Land Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
Mha	Millions hectare
Mt CO ₂ e	Million tonnes carbon dioxide equivalent
NCC	North Central Coast
NFIMAP	National Forest Inventory, Monitoring and Assessment Program
PSU	Primary Sample Unit
REDD+	Reducing Emission from Deforestation, forest Degradation, forest carbon conservation and enhancement and sustainable management of forests
RF	Removal Factors
SCC	South Central Coastal
tC	Tonne of carbon
UNFCCC	United Nation Framework in Climate Change
WD	Wood Density

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.

2. METHODOLOGICAL FRAME FOR FREL/FRL CONSTRUCTION

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)¹. This definition is in line with the definition of forests used for the national GHG inventory². 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 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 of at least three tree lines.

¹ Issued by Ministry of Agriculture and Rural Development in 2009.

² MONRE, 2014. First Biannual Updated Report (BUR) for 2010

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 2.1).

Table 2.1 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

2.3. 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 2.2.

Table 2.2 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.

2.4. 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 2.3 for details).

Table 2.3 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 CO₂. Non-CO₂ gases³ such as CH₄, CO, N₂O, NO_x etc. caused by burning of biomass (for example, forest fire) is not counted as such an emission is not significant. Non-CO₂ emissions resulted from burning biomass accounts for 0.04 % of total Viet Nam's emissions (MONRE, 2010).

³ In National GHG inventory, it only requires to estimate emission of CH₄, N₂O and NO_x if this is significant.

Table 2.4. Gases included in construction of FREL/REL

Greenhouse gases	Selected?	Justification / Explanation
CO₂	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 CH ₄ , CO, N ₂ O) 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-CO ₂ emissions are not significant and are excluded.

2.5. 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 2010⁴.

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 Panel 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.

2.6. 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

⁴ Forest inventories take multiple years we assume that time 1 = mid 2000 and time 2 – mid 2010, that is 10 years.

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).

2.7. Scope of REDD+ Activity Data included

Five (5) REDD+ activities are defined⁵. 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 2.5).

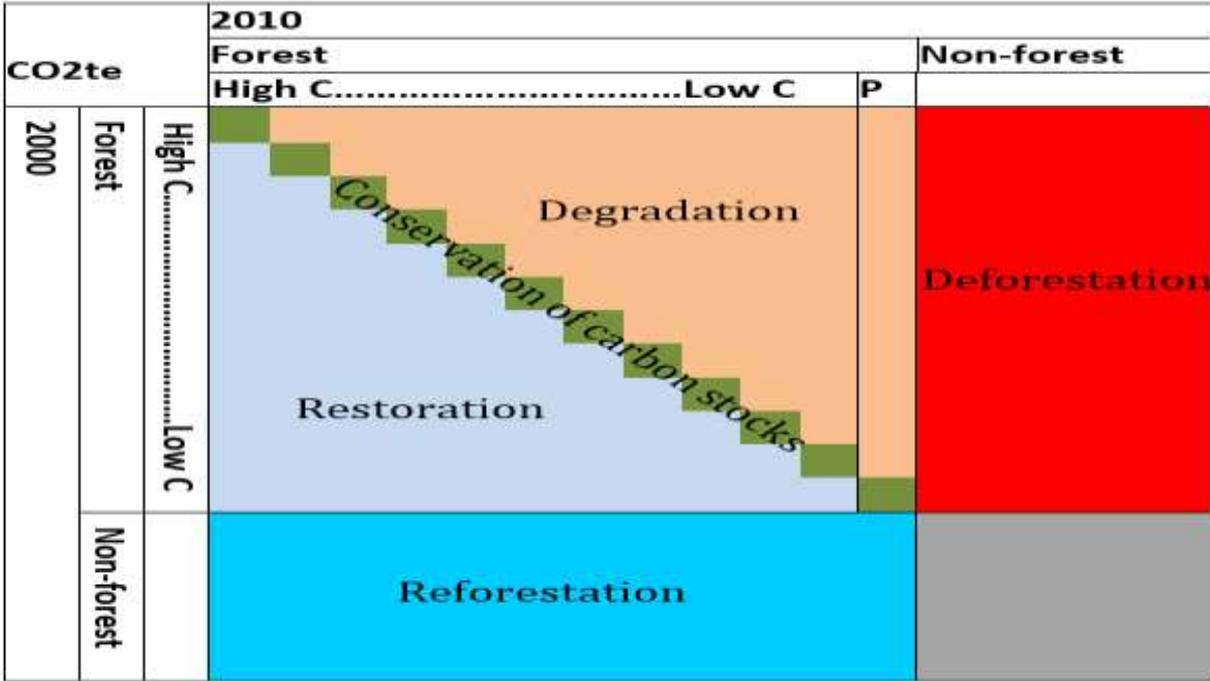
- **Reducing emissions from deforestation (“Deforestation”):** Activity of conversion of forests to non-forest land, as identified per NFIMAP⁶ results with modifications based on updates⁷. Where a series of activities including deforestation may have occurred within a single cycle of NFI, the deforestation 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 activity 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 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.

⁵ Decision 1/CP.16 of UNFCCC

⁶ Including both plot measurements and remotely sensed information.

⁷ 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.

Table 2.5 Matrix of land use change



2.8. 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 2.6 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 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).

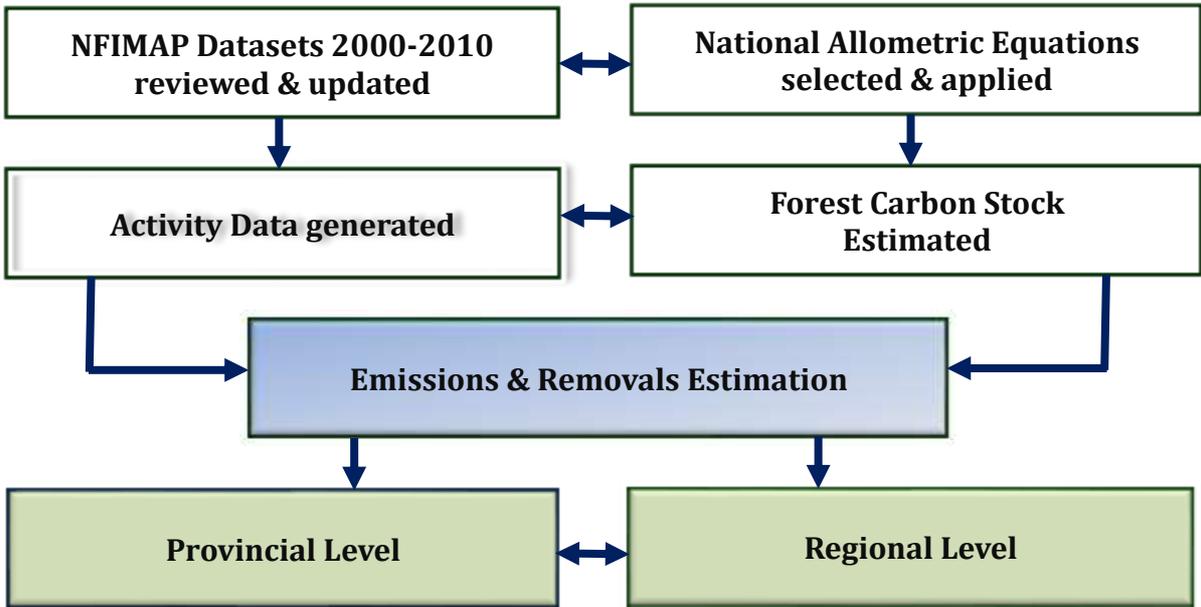
Table 2.7 Carbon stock used for construction of reference level

Land use and forest	Carbon stock (tCO ₂ e/ha)	STDEV (tCO ₂ e/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

2.9. 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 2.1).

Figure 2.1 Approach to Reference Level construction



Based on adjusted 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 follows⁸:

$$\text{Emissions or Removals} = \sum_{i=0}^n A_i \times \text{EF/RF}_i$$

Where:

E is emissions caused by deforestation and forest degradation;

R is removals resulted from reforestation and forest enhancement;

A_i is adjusted AD for land use change *i*;

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

2.10. Uncertainty analysis

2.10.1. 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 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 2.8 Potential causes of uncertainties in RL construction and 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. The components of forest emissions and removals are generally known in theory, significant unknown gaps are unlikely	Not applicable.
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 (CH ₄ , NO _x) 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.

⁸ The detailed spreadsheet on calculation of emissions and removals is available

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

2.10.2. 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

The results of accuracy assessment are used to correct the AD. Those AD will be used together emission and removal factors for construction of reference level.

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:

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

Where: U_{total} is percentage uncertainty in the products of parameters

U_i 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 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.

2.10.3. 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 2.9).

Table 2.9 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:

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

Where: $U_1, U_2, U_3, \dots, U_n$ is percentage of uncertainty associated with each of the parameters

X_1, X_2, \dots, X_n is the value of each parameters

U_{total} is percentage uncertainty in the sum of parameters

3. RESULTS OF REFERENCE LEVEL CONSTRUCTION

3.1. 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 adjusted 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 84.8 Mt CO₂e or the annually averaged emission is 8.4 Mt CO₂e/yr. The removals for this period are -100.1 Mt CO₂e or the annually averaged removal is -10.0 Mt CO₂e/yr. It indicates that for the period 2000-2005, a net emission for the NCC is 3.4 MtCO₂e, but it is -18.7 MtCO₂e for 2005-2010 (see Table 3.1).

Table 3.1 Reference emissions and removal for the NCC in 2000 – 2010

Activities	Emissions (+)/Removal (-) for 2000-2005 (tCO ₂ e)	Emissions (+)/Removal (-) for 2000-2005 (tCO ₂ e)	Total emissions (+)/Removals (-) for 2000-2010 (tCO ₂ e)
1. Deforestation	18,138,337	14,940,876	33,079,213
2. Forest degradation	27,346,395	24,436,968	51,783,363
3. Reforestation	-33,882,374	-43,770,811	-77,653,185
4. Forest restoration	-8,137,271	-14,388,328	-22,525,599
5. Total emissions	45,484,732	39,377,844	84,862,576
6. Total removals	-42,019,645	-58,159,139	-100,178,784
7. Net emissions	3,465,087	-18,781,295	-15,316,208

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 CO₂e, but Ha Tinh is lowest emitting province, with 7.9 Mt CO₂e. Removal amount is highest in Nghe An province, about -28 Mt CO₂e and lowest removal amount is found in Ha Tinh province (-10.9 Mt CO₂e). In term of net emissions, out of six provinces in the NCC region, only Quang Binh province that is carbon emitting and remaining provinces are carbon sequestration (see Table 3.2 and details in Annex 2-8 for emissions and removals matrices).

Table 3.2 Emissions and removals (tCO₂e) 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	9,849,752	7,035,561	2,566,652	3,711,821	4,792,101	5,123,156
2. Forest degradation	5,382,375	8,658,681	5,346,309	17,309,056	8,177,792	6,909,834
3. Reforestation	-16,412,104	-21,044,919	-9,693,930	-10,284,240	-9,816,637	-10,401,049
4. Forest restoration	-3,549,806	-7,560,695	-1,219,244	-3,591,169	-3,442,373	-3,162,406
5. Total emissions	15,232,127	15,694,242	7,912,962	21,020,878	12,969,893	12,032,990
6. Total removals	-19,961,910	-28,605,613	-10,913,174	-13,875,409	-13,259,011	-13,563,455
7. Net emissions	-4,729,783	-12,911,371	-3,000,212	7,145,469	-289,117	-1,530,465
8. Annually averaged emissions	1,523,213	1,569,424	791,296	2,102,088	1,296,989	1,203,299
9. Annually averaged removals	-1,996,191	-2,860,561	-1,091,317	-1,387,541	-1,325,901	-1,356,346

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 CO₂e/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 CO₂e/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.

3.2. Uncertainty assessment

Uncertainty of emissions estimated for 2000-2010 is from 26-29% and this is 28- 29 % for removals. The overall uncertainty of emissions associated with deforestation and forest degradation is 19% and this value for removals associated with reforestation and forest restoration is 20-22%⁹ (see details in Table 3.3).

Table 3.3 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	18,138,337	26%	14,940,876	26%	19%
2. Emissions caused by Forest degradation	27,346,395	26%	24,436,968	29%	19%
3. Removals resulting from reforestation	-33,882,374	28%	-43,770,811	28%	20%
4. Removal resulting from forest restoration	-8,137,271	29%	-14,388,328	29%	22%

3.3. Estimated reference level for 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 13 below summarizes the estimated reference level.

⁹ Details of uncertainty assessment is calculated in a separate spreadsheet

Table 3.4 The estimated ER Program Reference level 2000 - 2010

ERP A 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 (reforestation) over the Reference Period (tCO _{2-e} /yr)	If applicable, average annual historical removals by sinks (restoration) over the Reference Period (tCO _{2-e} /yr)	Reference Level	
					Emissions (tCO _{2-e} /yr)	Removals (tCO _{2-e} /yr)
2017	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2018	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2019	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2020	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2021	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2022	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2023	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2024	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2025	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
2026	3,307,921	5,178,336	-7,765,318	-2,252,560	8,486,258	-10,017,878
Total	33,079,213	51,783,363	-77,653,185	-22,525,599	84,862,576	-100,178,784

4. 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 8.4 Mt CO_{2e} and annual removal is -10.0 Mt CO_{2e}.

Uncertainty analysis of emissions and removals estimation for constructing reference level is calculated. The overall weighted uncertainty of emissions associated with deforestation and forest degradation is 19% and the uncertainty of removals estimation associated with reforestation and forest restoration is 20-22%.

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/VIE_TNAM'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.
- Tran Lam Dong, Vu Tan Phuong, Luu Canh Trung et al, 2016. Assessment report on success rate of the 5 million reforestation program. http://vietnam-redd.org/Upload/Download/File/661SuccessRateReport-240716_2206.pdf
- 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.

Annex 1. Emissions (+) and removals (-) matrices for 2000 - 2010 for the NCC (tCO₂e)

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	13,171,171	3,436,967	70,896	7,786	860,353
2. EGF - M	-2,999,314	0	10,077,492	168,232	51,387	2,552,400
3. EGF - P	-286,575	-4,283,497	0	287,690	84,743	9,542,346
4. Other forest	-16,936	-36,098	-507,243	0	-9,970	1,860,951
5. Plantation	0	-2,695	-6,562	1,649	0	3,322,287
6. Non-forest	-228,851	-558,916	-16,232,939	-1,655,468	-15,206,199	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	5,359,414	5,829,375	106,965	205,132	543,813
2. EGF - M	-6,785,191	0	11,404,249	335,675	359,578	2,182,571
3. EGF - P	-363,252	-6,297,056	0	573,568	272,403	7,993,294
4. Other forest	-14,453	-17,827	-875,525	0	-9,391	2,015,308
5. Plantation	-5,331	-3,900	-26,083	292	0	2,205,891
6. Non-forest	-74,199	-515,326	-22,507,602	-1,946,931	-18,726,753	0

Annex 2. Emissions (+) and removals (-) matrices for 2000-2010 for Thanh Hoa (tCO₂e)

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	672,578	296,411	26,839	0	37,584
2. EGF - M	-236,044	0	882,965	83,085	10,251	214,790
3. EGF - P	-31,676	-519,914	0	181,798	30,400	2,726,544
4. Other forest	-3,685	-15,836	-153,371	0	-3,620	1,046,310
5. Plantation	0	0	-586	1,374	0	173,201
6. Non-forest	-3,804	-41,323	-3,007,507	-845,021	-3,070,352	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	633,319	543,922	39,790	0	48,044
2. EGF - M	-1,272,440	0	1,417,890	190,288	25,586	542,678
3. EGF - P	-45,374	-743,836	0	340,762	15,062	3,351,428
4. Other forest	-5,067	-12,013	-500,411	0	-4,950	1,571,625
5. Plantation	0	-528	-10,629	229	0	137,548
6. Non-forest	-5,978	-55,891	-5,371,845	-1,145,584	-2,864,800	0

Annex 3. Emissions (+) and removals (-) matrices for 2000-2010 for Nghe An

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	849,245	668,483	44,285	0	66,242
2. EGF - M	-738,101	0	724,432	85,207	171	311,652
3. EGF - P	-88,179	-2,129,060	0	105,262	14,044	3,131,086
4. Other forest	-13,357	-20,204	-353,546	0	-6,346	797,806
5. Plantation	0	0	-2,668	264	0	426,773
6. Non-forest	-22,282	-125,822	-6,753,794	-794,635	-1,102,461	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	1,071,676	1,762,830	67,492	0	43,016
2. EGF - M	-2,180,953	0	2,827,770	144,109	25,009	197,139
3. EGF - P	-71,057	-1,573,372	0	228,538	50,910	1,579,564
4. Other forest	-9,212	-5,643	-374,620	0	-4,437	419,270
5. Plantation	0	0	-1,049	64	0	63,012
6. Non-forest	-18,478	-64,898	-7,520,084	-757,037	-3,885,429	0

Annex 4. Emissions (+) and removals (-) matrices for 2000-2010 for Ha Tinh

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	2,898,905	176,682	0	6,180	137,653
2. EGF - M	-387,743	0	1,023,787	0	19,477	294,478
3. EGF - P	-25,255	-325,278	0	632	21,850	1,127,630
4. Other forest	0	0	-325	0	0	16,834
5. Plantation	0	0	-29	14	0	465,535
6. Non-forest	-2,717	-21,986	-1,467,259	-15,809	-2,792,103	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	458,463	299,578	0	0	5,587
2. EGF - M	-389,238	0	397,545	1,194	6,733	63,172
3. EGF - P	-8,133	-80,394	0	4,270	31,020	154,575
4. Other forest	0	0	-476	0	-7	24,447
5. Plantation	0	0	-2,374	0	0	276,741
6. Non-forest	-2,174	-9,271	-2,379,076	-44,326	-2,959,210	0

Annex 5. Emissions (+) and removals (-) matrices for 2000-2010 for Quang Binh

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	7,192,747	451,475	0	0	152,217
2. EGF - M	-610,193	0	3,012,418	0	3,588	741,462
3. EGF - P	-34,672	-111,078	0	0	6,599	933,190
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-2,463	-1,525	0	0	223,577
6. Non-forest	-146,191	-167,674	-1,441,013	0	-1,991,469	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	1,799,734	1,884,534	0	188,860	250,275
2. EGF - M	-1,372,223	0	2,362,878	0	251,818	505,374
3. EGF - P	-29,964	-1,428,820	0	0	154,406	680,108
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-176	-55	0	0	225,618
6. Non-forest	-9,239	-122,113	-3,987,449	0	-2,419,092	0

Annex 6. Emissions (+) and removals (-) matrices for 2000-2010 for Quang Tri

2000 - 2005

2000	2005					
	1	2	3	4	5	6
1. EGF - R	0	1,039,980	1,073,397	0	1,766	153,626
2. EGF - M	-442,428	0	2,789,281	0	17,939	739,859
3. EGF - P	-41,521	-711,731	0	0	3,158	619,433
4. Other forest	0	0	0	0	0	0
5. Plantation	0	0	-1,290	0	0	801,016
6. Non-forest	-30,977	-139,331	-1,747,393	0	-3,286,981	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	545,586	432,048	0	994	99,998
2. EGF - M	-1,082,185	0	2,227,856	0	29,626	539,683
3. EGF - P	-33,388	-1,129,100	0	0	16,160	1,118,922
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-176	-552	0	0	719,564
6. Non-forest	-9,782	-126,352	-1,536,416	0	-2,939,405	0

Annex 7. 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	517,555	770,751	0	0	312,890
2. EGF - M	-584,858	0	1,644,563	0	0	250,054
3. EGF - P	-65,064	-486,590	0	0	8,704	1,004,521
4. Other forest	0	0	0	0	0	0
5. Plantation	0	-352	-440	0	0	1,232,172
6. Non-forest	-22,282	-63,043	-1,815,826	0	-2,962,832	0

2005 - 2010

2005	2010					
	1	2	3	4	5	6
1. EGF - R	0	850,517	906,224	0	15,407	97,205
2. EGF - M	-488,147	0	2,170,480	0	20,776	334,102
3. EGF - P	-175,503	-1,341,402	0	0	4,857	1,108,720
4. Other forest	0	0	0	0	0	0
5. Plantation	-5,454	-3,167	-11,430	0	0	783,491
6. Non-forest	-28,803	-136,682	-1,712,755	0	-3,658,826	0