Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	**Emission Reduction Program in North Central Coast, VIET NAM**
Reporting Period covered in this report:	**01-02-2018 To 31-12-2019**
Number of FCPF ERs:	**13,811,121 tCO_2-e**
Quantity of ERs allocated to the Uncertainty Buffer:	**2,383,968 tCO_2-e**
Quantity of ERs allocated to the Reversal Buffer:	**2,797,189 tCO_2-e**
Quantity of ERs allocated to the Reversal Pooled Reversal buffer:	**874,122 tCO_2-e**
Date of Submission:	**18-05-2021**

Notice

This ER Monitoring Report is made public for validation and verification purposes. Annex 1, 2, and 3 are not included in this version since they are being completed by the Program Entity. The full Report will be made available as soon as Annex 1, 2, and 3 are completed and the validation/verification are concluded as outlined in the FCPF Process Guidelines.

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LIST OF ANNEXES

LIST OF ABBREVIATIONS

AD	Activity Data
AGB	Above Ground Biomass
CPMU	Central Program Management Unit
DARD	Department of Agriculture and Rural Development (provincial level)
DONRE	Department if Natural Resources and Environment (provincial level)
EF	Emission Factor
EMPF	Ethnic Minority Planning Framework
ER	Emission Reduction
ERP	Emission Reduction Program
ERPD	Emission Reduction Program Document
ERPA	Emission Reduction Purchase Agreement
ESMF	Environment and Social Management Framework
FCPF	Forest Carbon Partnership Fund
FGRM	Feedback Grievance Redress Mechanism
FIPI	Forest Inventory and Planning and Institute
FMCR	Project of Forestry Sector Modernization and Coastal Resilience Strengthening
FORMIS	Forestry management Information System
FPD	Forest Protection Department
GHG	Green House Gas
LUP	Land Use Planning
MARD	Ministry of Agriculture and Rural Development
MOF	Ministry of Finance
MONRE	Ministry of Natural Resources and Environment
MOLISA	Ministry of Labour, Invalids and Social Affairs
MPI	Ministry if Planning and Investment
MMR	Measurement, Monitoring and Reporting
MRV	Measurement, Reporting and Verification
NDC	Nationally Determined Contribution
NRAP	National REDD+ Action Plan
PPC	Province People Committee
PPMU	Provincial Program Management Unit
PRAP	Provincial REDD+ Action Plan
PSC	Program Steering Committee
QA	Quality Assurance
QC	Quality Control
RPF	Resettlement Policy Framework
SESA	Strategic Environment and Social Assessment
SFCs	State Forest Companies
VNFOREST	Vietnam Administration of Forestry

1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

The planned interventions for ERP implementation include 4 components that are: (1) *Component 1*: Strengthening enabling conditions for emissions reduction; (2) *Component 2:* Promoting sustainable management of forests and carbon stock enhancement; (3) *Component 3*: Promotion of climate smart agriculture and sustainable livelihoods for forest dependent people; and (4) *Component 4*: Program management and emission monitoring. The program is on track and there are no changes in the implementation of the planned components and activities compared to the ERPD. The following describes the implementation status of ERP for 2018-2019.

Component 1: The activities implemented include law enforcement to control deforestation and forest degradation; development of legal documents for forest management; review of forest planning and review of hydropower plants list for construction and other project on forest conversion. The national budget for implementing activities in component 1 in 6 provinces over 2018-2019 was 32 billion VND (or **1.4 million USD**).

Component 2: The activities implemented focus on investment in forest protection and management; reforestation, forest enhancement. Total forest area for protection is 4M ha with total budget of 27 million USD, of which 57% is from payment for forest environmental services. Total estimated budget invested in component 2 is **36 million USD over 2 years 2018-2019** in six provinces of the ERP area.

Table 1. Key results and investment for component 2 for 2018-2019

ID	Investment activities	Intervention area (ha)	Investment (USD)
1	Forest protection	4,055,470	27,811,359
2	Resolution of forest and land conflict	445	5,000
3	Allocation of forests and forest contract for protection to communities	427,504	617,689
4	Support development of sustainable forest management plan after allocation	452,570	244,821
5	Natural forest area applied sustainable forest management	290,995	332,688
6	Shifting short-term plantation to long term plantations for sawlogs	19,594	177,898
7	New plantation for saw logs	14,330	2,135,082
8	Natural assisted forest regeneration and enrichment planting	5,150	576,869
9	Afforestation of protection and special use forests	2,076	2,672,222
10	Compensation forest planting for converted forests	1,282	1,597,810
Total (2018 - 2019)		5,269,416	36,171,438

Source: Reports of DARDs in NCC (2020)

Component 3: The implemented activities focus on supporting livelihood generation and improve income for forest dependency. Over 2 years implementation, the provinces invested in bamboo development (77 ha), 98 ha for non timber forest products in forest areas, several free-deforestation agriculture cultivation models and 65 good practice model (Vietgap) for rice production. Those activities are implemented mainly in Quang Binh and Quang Tri provinces and the total budget for this component is **about 686,051 USD**.

Component 4: The important activity implemented is emission monitoring. The government provides budget for implementation of national forest monitoring which provide data for monitoring emission in the ERP area and preparing this ER monitoring report and other technical guidelines. Ministry of Agriculture and Rural Develop leads the implementation of this ERP and coordinates relevant programs and budget for ERP implementation. The estimated budget used over 2018-2019 is **about 1.5 million USD**.

1.2 Update on major drivers and lessons learned

The analysis of drivers causing deforestation and forest degradation in the reference period indicated that the main identified drivers in the accounting area are: (1) Planned conversion of mainly poor natural forests to rubber and other agricultural land uses; (2) Planned conversion of mostly poor natural forests to tree plantations; (3) Unplanned conversion of forests due to encroachment; (4) Impacts from hydropower and infrastructure development; (4) Illegal and legal logging; and (5) Other minor causes.

The implementation of ERP has addressed and reduced drivers and causes for deforestation and forest conversion and degradation compared to that in the period of 2016-2017. Most drivers and causes associated with deforestation, forest conversion and degradation are effectively controlled. However, the conversion of forests to infrastructure development (road, power lines, etc.) has increased making a total forest loss of 1,777 ha for 2018-2019. As regulations[1], such converted area is required to replant the forests to compensate the loss area. **The key lessons learned for effective control of deforestation and forest conversion are strong legal framework directed by highest legal level (government and prime minister) and the effective collaboration of line ministries and departments across levels**.

Table 2. Changes in deforestation, forest conversion and degradation 2016-2019 in ERP

TT	Deforestation and forest degradation	2016-2017	2018- 2019
1	Converted forest for hydro power plants (ha)	168	55
2	Forest conversion for infrastructure construction (ha)	842	1,777
3	Burned and damaged forests by forest fire (ha)	250	1,140
4	Damaged forests caused by typhoons and disease (ha)	34,296	156
5	Forest loss by rubber plantation development (ha)	0	0
6	Forest loss caused by coffee, fruit trees development (ha)	1	196
7	Forest conversion for crop agriculture (ha)	12	5
8	Illegal logging area (ha)	1,606	963
9	Illegal timbers (m^3)	61,962	3,044
10	Number of cases recorded for forest conversion, illegal logging and encroachment (cases)	1,078	456

Source: Reports of DARDs in NCC (2020)

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

Organizational structure, responsibilities and competencies, linking these to the diagram shown in the next section

Organizational structure of agencies associated with MMR is provided in

[1] Circular 23/2017/TT-BNNPTNT dated 15 November 2017; and Forestry Law 2017

Figure 1. The MMR is an integral part of the overall M&E system for the ER-P, other issues, for example, monitoring of safeguards is covered separately and is integrated into the M&E system.

Figure 1: Responsibility of the relevant Ministries, agencies and localities

1) Ministry of Agriculture and Rural Development (MARD)

MARD acts as manager of the ER P and organizes a central PMU to manage the implementation of the ER-P

2) Vietnam Administration of Forestry (VNFOREST)

The VNFOREST will supervise the forest monitoring process in the Accounting Area, including:

*Cooperate with the CPMU in selecting suitable national and international consultants;
*Connect with People's Committees, branches and agencies of provinces in MMR implementation at provincial level;
*Organize annual and final quantity and quality checks of the MMR system and receive outcomes and register carbon certificates for the Accounting Area
*Updates the central forest database annually.

3) Program Management Unit (CPMU)

Provide support to MARD in activities such as

*Approval of the MRV implementation plans in six provinces, and review technical issues, procedures and guidance on field measurement, field data collection, quality control, biomass estimation methods, and technical guidelines of each specific work step
*Supports MARD in for the approval of cost estimates and in identification of financial resources
*Selects national service providers and national consultant teams for implementing change detection using satellite imagery for the ER-P, field verification and update of forest cover maps, accuracy assessment of the land cover change map, calculation of emission reduction, uncertainty assessment of emission reduction results
*Selects 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 the PPCs in establishing provincial MMR teams to verify the potential changes identified by remote sensing and update the confirmed changes to the provincial forest database
*Cooperate with the PMU to develop resource plans (human resource and financial resources) for MRV implementation at the provincial level

5) Forest Inventory and Planning Institute (FIPI)

FIPI has been implementing the NFIMAP and this data was used to develop the FREL/FRL for the ER-P. FIPI is also the main agency to implement the forest inventory step of the National Forest Inventory and Statistics (NFIS) for the period 2011-2016 and has a mandate to implement the improved NFIMAP in the future, it is therefore expected that FIPI will implement the following work:

*Develop standard technical guidelines including a field data collection and survey manual; satellite imagery processing manual; QA/QC guidelines and forms; field data management and processing manual
*Conduct of forest change detection using remote sensing
*Organize field inventory and quality control
*Conduct training and support knowledge transfer to provincial MMR teams on forest monitoring, measurement, field verification and update of activity data and forest cover maps;
*Provide guidance to national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission reductions

6) Support from central specialized agencies

The central specialized agencies such as Vietnam Academy of Forest Science (VAFS) and Vietnam National University of Forestry will act as 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

Local communities are expected to participate in the monitoring, pilots are now in place in three provinces in the NCC and they are planned for all provinces to introduce the commune PFMS to mobile and electronic equipment such as tablets for forest monitoring system that will link with FORMIS

Article 34.4 of the current Forestry Law (2017), which specifies that "Forest owners shall have to conduct forest statistics and submit to the inspection by, specialized forestry agencies at provincial level for forest owners being organizations, at district level for forest owners being households, individuals or village comunities…". Therefore, local communities can participate in the monitoring system either:

- Directly, as forest owners (individual households or collectively as village communities under community forest management); or

- Indirectly as subcontracted service providers to larger state-managed forest owners (e.g. state forest companies or protected area management boards).

The selection and management of GHG related data and information

Currently, Vietnam's national forest monitoring system consists of three elements as follows:

(1) National Forest Inventory, Monitoring and Assessment Program (NFIMAP)

Based on a series of Prime Minister's Decisions, NFIMAP has been implemented by FIPI since 1991, with a 5 year inventory cycle. So far, four 5-year cycles (Cycle I: 1991-1995; Cycle II: 1996-2000; Cycle III: 2001-2005; and Cycle IV: 2006-2010) have been completed. It was not, however, implemented for the period 2011-2015. This is because a NFIS (see below) is being implemented during this period. The NFIMAP period 2016-2020 has been completed at the end of 2020 and the results are awaiting appraisal and approval by MARD. The Program uses remote sensing in combination with ground surveys to monitor forest resources changes. Each cycle has generated provincial forest cover maps at the scale of 1:100,000; regional forest cover maps at the scale of 1:250,000; and a national forest cover map at the scale 1:1,000,000. Data from a systematic sample plot system were also collected in each cycle. The forest cover maps and sample plot data of NFIMAP Cycle III and IV are used for FREL/FRL setting in the Accounting Area. The MMR of the ER-P is based mainly on the NFIMAP. The sample plot data are used for EFs calculation and the forest cover maps of NFIMAP are used for AD generation in the Accounting Area.

(2) National Forest Inventory and Statistics (NFIS) Projects

Based on Prime Minister's Decisions, several NFIS Projects have been carried out in the past and the latest NFIS Project was being implemented during 2011-2016. In the latest NFIS Project, there are two stages in generating the forest cover maps: (i) "Forest survey stage" - interpretation of RS imagery will be used in combination with ground surveys to generate non-cadastral-dossier-based forest cover maps (which are called the "forest inventory maps"); (ii) "Forest statistics stage" - the forest inventory maps will be used as inputs to overlay with the cadastral-based forest owner boundary maps to generate the cadastral dossier-based forest cover maps (which are called the "forest statistics maps"). The forest statistics maps will be printed out as a deliverable to each forest owner for verification and revised as necessary. As the generation of forest statistics maps employs a participatory method, higher accuracy is expected compared to the forest inventory maps.

The scales of forest cover maps are 1:10,000 or 1:25,000 for the commune level, 1:50,000 for the district level, and 1:100,000 for the provincial level. During the forest inventory stage, a system of sample plots is inventoried to estimate the mean volume stocks for each forest type. These sample plot data can also be used to estimate the mean carbon densities in AGB pool for each forest type. The main agency to implement the forest inventory stage is FIPI under MARD. For the forest statistics stage, the main actors are provincial authorities and local forest owners with the technical support from national institutions such as FIPI, Vietnam National Forest University and Vietnam Academy of Forest Sciences.

Due to the coarse frequency (almost every ten years) and the different approach on generating the FCMs, the FCMs of NFIS will not be used to generate the AD the ER-P. However, these FCMs can be used as a reference layer for AD verification and improvement.

(3) Annual Forest and Forestry Land Resources Monitoring and Reporting Program (Program No. 32 or FRMS)

This Program has been conducted by FPD under VNFOREST since 2001 following the Directive No. 32/2000/CT-BNN-KL dated 27/03/2000 by MARD. Based on forest baseline maps of the latest NFIS Project, forest rangers collect information on changes in the communes under their responsibility, and then update these changes in a database. These updates are usually based on reports from forest owners and do not requires remote sensing imagery or field surveys. Data are then aggregated through the FPD system from commune to district to province up to the central level. The Program has generated a dataset on area of forest and forestry land, broken down by drivers, forest owners, forest functions, and administrative units. However, this dataset still has some limitations, including: (i) the data are just for forest area; there is no data on forest stocks; (ii) the data on area changes cannot be tracked spatially as they are not associated with maps; and (iii) recently, with support from JICA, this element has been improved by addressing limitations on accuracy, credibility, transparency and quality assurance of Program no. 32. Where forests are allocated to villages a Village Based Forest Patrolling Team will be established and undertake forest patrols and report to commune-based forest rangers. The team will conduct field measurements of forest change and submit the collected data to a data server. Satellite images and photographs are used to verify forest changes, and the resulting information is used to update forest cover maps and the use of a tablet-based approach will allow update information to be sent to a data server.

Among the three systems above, NFIMAP is the main source of information to construct FREL/FRL and calculate REDD+ emission reductions. FRMS is not integrated yet to the MRV for REDD+ but contributes alongside NFIMAP to the monitoring of the National REDD+ Action Program, and its provincial plans.

The FRMS is the main data source for official forest area in Vietnam however it is not used for the REDD+ MRV for the following reasons:

- FRMS data was not used for the FREL/FRL construction. Therefore, it couldn’t be used for the calculation of REDD+ results for the sake of consistency.
- FRMS mainly provides updates on deforestation and reforestation; it is challenging to obtain timely updates on changes in forest conditions using FRMS system (due to its forest stratification of 98 forest types). Therefore, this prevents calculating reduced emissions from forest degradation and enhanced removals from forest restoration based on FRMS data.
- FRMS doesn’t include the measurement of forest plots for monitoring timber volumes and forest carbon stocks as a basis to update EF/RF.

However, FRMS contains invaluable information on forest ownership and especially on new forest plantations which cannot be easily interpreted using medium resolution satellite images. Thus, Vietnam is working on integrating this system into the safeguards information system for REDD+.

The management of GHG related data and information

All the GHG related data and information are managed by VNFOREST using an information system. This information system has a GIS database that store all the maps and data collected by the MMR 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 factors
- Average annual emissions over the Reference Period
- Adjusted emissions, if applicable; and
- Any spatial data used to adjust emissions, if applicable.

Processes for collecting, processing, consolidating and reporting GHG data and information

For the ER-P to be performance-based, a MMR is needed to estimate ERs generated by the ER-P. To be consistent with Decision 11/COP19, the MMR will be built based on existing forest monitoring systems.

As mentioned above, to estimate the emission reductions, the MMR of the ER-P is based on the regional forest cover map of the NCC region developed by NFIMAP 2016-2020 to generated AD for period 2015-2019. It also uses the sample plot data located in the NCC region and measured by NFIMAP 2016-2020 to calculate the latest EFs.

The ER-P will be nested into the national REDD+ implementation to avoid double accounting of emission reduction and/or removal enhancement at the national level. This means that the FREL and/or FRL of the Accounting Area was 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-P to FCPF Carbon Fund following required template, the ER-P also needs to report biennially its performance to the Vietnam REDD+ Office (VRO), which is the focal point for national REDD+ implementation and has the mandate to oversee and coordinate all REDD+ projects/programs in Vietnam, to be included in Biennial Report Updates and submitted to UNFCCC. Information to be reported to VRO includes:

- FREL and/or FRL of the Accounting Area, prepared on the basis of agreed guidelines (Decision 12/CP.17 and the FCPF Methodological 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/or 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
- Information on how safeguards are respected and addressed (Decision 1/CP.16) in the ER-P.

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 adherence to the guidelines; and
- The results are accurate, to the extent possible.

Systems and processes that ensure the accuracy of the data and information

The accuracy of field measurement data is ensured and controlled by a quality assurance/quality control (QA/QC) protocol.

The accuracy of AD is ensured by conducting an accuracy assessment of the forest cover map following the method of Olofsson (2014). In the case the overall accuracy of the forest cover map is below a threshold (70%), more ground truthing is conducted to enhance the accuracy of the forest cover map above this threshold.

The accuracy of EF and emission reduction is ensured by organized a scientific committee of 5-7 experts having deep knowledge on REDD+ and GHG inventories to appraise the results.

Design and maintenance of the Forest Monitoring System

In Viet Nam, the Development of Management Information System for Forestry Sector – Phase I (FORMIS I) Project (2009-2013) has 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 standardized manners; 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 limitation, only a limited amount of data has been put into the databases of the FORMIS system under FORMIS I Project. The Development of Management Information System for Forestry Sector – Phase II (FORMIS II) Project (2013-2018)has integrated most of forest resources data including the results of the NFIS 2011-2016 into the system developed by FORMIS I Project. The Government of Viet Nam has given priority to integrate forest-related data of the provinces in the Accounting Area into the FORMIS system to be used as the information system of the ER-P.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

There are standard operating procedures for: (1) conducting plot measurement in the field, (2) inputting the field data into a database using a software developed based on FAO's Open Foris Collect, (3) Field data processing, calculation and reporting, (4) Forest cover mapping. These SOPs are available in Vietnamese as NFIMAP's technical guidelines.

A QA/QC protocol for field measurement data is also available. The QA/QC team controls the quality of measurements of the plots measured by other field teams. 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 controlling measurements are conducted within 1–2 weeks after the measurements by the initial team. 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. 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 oversees 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 considered 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.

Role of communities in the forest monitoring system

The role of local communities in the implementation of the proposed ER-P forest monitoring system is as follows:

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

Participatory forest monitoring under the proposed ER-P has been integrated into a modified annual monitoring of forest and forestry land program to be implemented by the FPD, which has the mandate and human resource capacity (at all levels of administration from commune to national level), to engage with forest owners and local communities[2].

[2] Consistent with the Criterion 16 of the FCPF Carbon Fund Methodological Framework.

Use of and consistency with standard technical procedures in the country and the National Forest Monitoring System

Use of and Consistency with National Forest Monitoring System:

A measurement, monitoring and reporting (MMR) system for implementation of Vietnam's REDD+ has been developed based on the above programs/projects. The NFIMAP has been used to generate the AD and EFs while the NFIS in combination with the Program no. 32 (see section 2.1.2 above) have been used to verify and improve the AD generated by NFIMAP as well as providing safeguards information. This system allows sub-national forest monitoring at the provincial level. Provincial forest cover maps will be generated every 5 years, based on medium resolution satellite imagery with the previous map as a base for generating AD. Since the Accounting Area of the ER-P consists of six provinces, the AD of the ER-P are aggregated from all data generated by the sub-national forest monitoring operating in each of the six provinces so the AD are fully consistent with the national measurement, monitoring and reporting system for REDD+. The MMR relied on an approach which relies on the use of medium resolution satellite imagery and the base FCM year X-5 to generate the AD.

The plot measurement data of NFIMAP are used to generate EFs for the MMR of the ER-P. The NFIMAP will generate the EFs at the regional level every 5 years, and the latest EFs were generated in 2019 based on the NFIMAP period 2016-2020 (all the sample plots have been inventoried by the end of 2019). Since the Accounting Area of the ER-P covers fully one region (the NCC region) of Vietnam, the method for calculation of EFs in 2019 is consistent with methods used in calculation of EFs for 2005 and 2010.

Use of and consistency with standard technical procedures in the country:

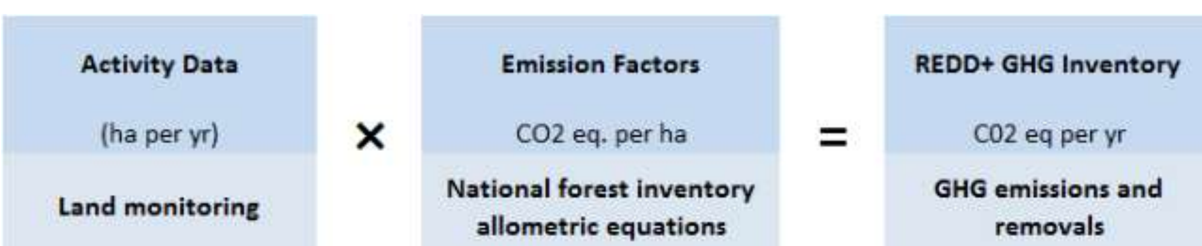
Since the NFIMAP is a national program, its technical procedures are all standard technical procedures for Vietnam. Therefore, the ER-P MMR, which is based on data generated by the NFIMAP, will also follows these standard technical procedures in Vietnam. Currently, the existing SOPs are being reviewed for improvement to be used in the next cycle of NFIMAP. The SAE's SOP of AD has been developed for the MMR 1st report.

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram

The approach for estimating emissions and removals follows the IPCC guidelines, multiplying the activity data (AD) with the emission factors (EF) (Figure A4)[3].

Figure 2: Approach for estimation of emissions and removals



[3] The forest definitions, stratifications, REDD+ activities, carbon pools and gases to be monitored, change matrix are all standardized and follow those already described in Section 8 of ERPD.

2.2.2 Calculation

The estimates of emissions and removals in monitoring period (4 years, 2016-2019) are consistent with that used in estimating emissions and removals in reference period (2005-2015). The key steps are as follows:

(1) Estimation of AGB at tree level

The estimation of AGB at tree level is based on plot measurement data of NFIMAP cycle 4 (tree species name, DBH, tree height and wood density) and allometric equations developed for the NCC (UN-REDD 2015). The tree level AGB is estimated for all SSP.

(2) Calculation of forest biomass

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

$$AGB_i = \sum_{j=1}^{n_i} AGB_{ij}$$

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*;

Forest BGB: To estimate BGB of forests, it is estimated 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 values are adopted from IPCC 2006 as conservative estimation for BGB as follows. RS is 0.205 if AGB is less than 125 t.d.m/ha and is 0.235 if AGB is larger than 125 t.d.m/ha.

$$BGB \quad = AGB \quad \times RS$$

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

TB = AGB + BGB

(3) Calculation of forest carbon stock:

Forest carbon stock estimation is calculated based on biomass and carbon fraction (CF). Default value of CF (0.47) is used (IPCC 2006). The formula for calculation is as follows:

$$C \quad = TB \quad \times CF$$

After the carbon stock of all measurement plots is estimated, based on area of measurement plot, the carbon density (i.e., carbon stock per ha) of forest type is calculated as follows:

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

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 densities of all plots are estimated, the average value of carbon density for forest type *i* is calculated as follows:

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

Where:

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

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

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

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

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

Ab is the area of bamboo forest (ha)

Cm is the average carbon density (tC/ha) of mangrove forests.

Am is the area of mangrove forests (ha).

Regarding the mangrove forests, there are no measurement plots in the PSU in mangrove forests, however there are a number of studies on biomass of mangroves. A review report on biomass and carbon density suggests that the average weighted carbon density 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 at the national level is 58.0 tC/ha (Phuong et al 2015).

(4) Estimation of emission factors (EFs):

Based on carbon densities estimated for all forest types (tC/ha) at different points of time (2005, 2010 and 2015), the EFs are calculated as follows:

EFs (tCO_2e/ha) = (*Ci* – *Cj*) x 44/12
Where:

C_i and C_j are carbon densities of forest type/land use *i* and *j* corresponding to the changes; and

If C*i* > C*j*, such a change is considered to be emissions (higher carbon density land use changed to lower carbon density land use, for example deforestation, forest degradation), otherwise it is considered removals or enhancement (lower carbon stock land use changed to higher carbon stock land uses, including reforestation).

(5) Estimation of uncertainty of forest carbon:

Uncertainty of the FREL/FRL is calculated using the Monte Carlo method with the following parameters and their associated uncertainties: AGB, CF coefficient, RS ratio, AD. The uncertainties araised from measurement error and biomass equation are not integrated into the combined uncertainty of FREL/FRL. For parameter CF, the value applied is 0.47 and the default error at 95% CI is 2.7% *(*IPCC 2006, Volume 4*).* For the RS ratio, the value applied is 0.205 for AGB < 125 t.d.m/ha or 0.235 otherwise and the error at 95% CI is 20% *(*GOFC-GOLD sourcebook 2015, Table 2.3.3, page 72*).*

(6) Estimation of emissions and removals:

The calculation is consistent with that used in construction of reference level. Based on developed AD and EF, a spread sheet is used to calculate the emissions and removals for monitoring period using Stock Change Method. For land cover changes which result in Emissions, the entire expected emission is assumed to occur over the time period in question. For land cover changes which result in Removals (e.g. forest which increases from poor to medium or medium to rich quality), we apply an Adjustment Factor (AF) ranging from 20% to 40% per 4-year monitoring period to reduce the expected Removals in the year they are first observed. This recognizes that forest accretion occurs more slowly over time than do forest removals (IPCC 2006). The Adjustment Factors is consistent with that is applied in reference period, but this is applicable to 4 years monitoring. The adjustment factors applied are:

- 20% per 4-year monitoring period for forest land or plantations which change to a higher biomass forest type, and for non forest to forest conversion.
- 40% per 4-year monitoring period for non-forest land which becomes forest plantation.

The emissions and removals are then estimated for 2 years of reporting period (2018 -2019) based on annually averaged emissions and removals estimated in monitoring period.

(7) Uncertainty assessment and sensitivity analysis of emissions and removals estimates
Monte Carlo method is applied with 10,000 runs for simulation. The simulation is run for 4 parameters that are AGB, AD, RS and CF. Sensitivity analysis is conducted for every single parameter and its standard error is assumed to be very small value (set at 0.0001).

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	$C_{t,6}$ (*t* = 2005, 2010, 2015 or 2019) for non forest;
Description:	• Carbon density of non-forested land includes agricultural crops (i.e. annual crops, perennial crops), water area and settlement for year *t*. •
Data unit:	• Carbon density of non forest expressed in tone of Carbon per hectare (tC/ha) •
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	• When developing FREL/FRL for the ERPD, the carbon density of non-forest land was assumed to be zero. To be consistent with methodology of FREL/FRL establishment, the carbon density of non-forest land is also assumed to be zero in the monitoring period. •
Value applied:	• Carbon stock of non forest is 0 (zero)
QA/QC procedures applied	*N/A*
Uncertainty associated with this parameter:	*N/A*

Any comment:	This assumption is consistent with its value used in construction of reference level for ERP. This could lead to higher emissions resulted from deforestation in both Reference Period and Crediting Period. Therefore, if the emission reduction from deforestation has the positive sign, it will be a conservative estimate.

Parameter:	$C_{t,i}$ (*t* = 2005, 2010; 1 ≤ *i* ≤ 5)
Description:	Carbon densities of forest type *i* for year *t (t* = 2005 or 2010).
Data unit:	Tone of Carbon per hectare (tC/ha)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Source of data: The carbon densities of forest types in the NCC region for 2005 and 2010 were calculated using sample plot data inventoried in NFIMAP Cycle 3 (2001-2005) and Cycle 4 (2006-2010), respectively. Spatial level of the data: regional
Value applied:	See table below
QA/QC procedures applied	The controlling measurements are conducted by QA/QC teams within 1–2 weeks after the measurements by the initial team. 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. 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. The data processing and carbon density calculation process is verified by a scientific committee comprising of 5-7 experts.
Uncertainty associated with this parameter:	See the table in the "Value applied" field.
Any comment:	The uncertainty here is a combined uncertainty of the uncertainty from sampling error, the uncertainty of the CF coefficient and the uncertainty of the RS ratio.

Value applied:

Forest types	**2005 AGB**		**2010 AGB**	
	Value (t.d.m/ha)	Uncertainty (%)	Value (t.d.m/ha)	Uncertainty (%)
1.EBF_R	295.00	12.92	255.84	8.68
2. EBF_M	126.47	1.63	122.70	2.27
3. EBF_P	55.97	3.88	51.60	5.16
4. Other forests	23.10	8.85	26.06	14.97
5. Plantations	37.03	29.75	41.64	21.50

Remark: uncertainty estimated for sampling

Parameter:	$AD1_{ij}$ ($1 \le i \le 6$; $1 \le j \le 6$)
Description:	Area of land use and land cover conversion from type i in 2005 to type j in 2010. Types i and j run from 1 to 6 and mean as follows: 1. EBF_R; 2. EBF_M; 3. EBF_P; 4. Other forests; 5. Plantation; and 6. Non-forested land. *Spatial analysis of 4 parameters: deforestation, forest degradation, reforestation and forest enhancement is conducted for periods 2005 – 2010. The definition of those parameters are as follows:* ***Deforestation:*** *The activity of conversion of forests to non-forest land, as identified following the NFIMAP (Including both plot measurements and remotely sensed information) and updates . Where a series of activities including deforestation may have occurred within a single cycle of the National Forest Inventory (NFI).* ***Forest degradation:*** *Any activity resulting in a downward shift in terms of carbon density 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. In the case that the deforestation activity occurring as a transitional activity not captured by the NFI, and thus will be reported as degradation.* The conversion from plantation to Non forest is considered as degradation. ***Reforestation:*** *Any activity resulting in land use change from non-forest land to forest land. The conversion of forestland into plantations is not considered "reforestation";* ***Forest enhancement:*** *Any activity resulting in an upward shift of carbon density 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;* *Emissions associated with deforestation and forest degradation are considered sources.* *Removals generated by increment of forest biomass through forest enhancement and reforestation are considered sinks.*
Data unit:	Hectare (ha)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Source of data: AD Annex of Vietnam ERPD for the NCC region Spatial level of the data: regional
Value applied:	(see table below)

REDD+ activities	AD 2005-2010 (ha)
Enhancement	**268,684**
2. EBF_M to 1. EBF_R	18,331
3. EBF_P to 2. EBF_M	41,588
4. Other forest to 3. EBF_P	21,628
4. Other forest to 5. Plantation	2,580
5. Plantation to 1. EBF_P	0
6. Non forest to 2. EBF_P	164,905
6. Non forest to 3. Other forest	19,653
Stable forest	**2,180,106**
1. EBF_R to 1. EBF_R	199,187
2. EBF_M to 2. EBF_M	394,297
3. EBF_P to 3. EBF_P	1,045,355

4. Other Forest to 4. Other Forest	104,906
5. Plantation to 5. Plantation	436,361
Deforestation	**106,105**
1. EBF_R to 6. Non-Forest	628
2. EBF_M to 6. Non-Forest	5,676
3. EBF_P to 6. Non-Forest	74,792
4. Other Forest to 6. Non-Forest	25,009
Degradation	**174,452**
1. EBF_R to 2. EBF_M	32,422
1. EBF_R to 3. EBF_P	8,188
1. EBF_R to 4. Other Forest	51
1. EBF_R to 5. Plantation	395
2. EBF_M to 3. EBF_P	78,251
2. EBF_M to 4. Other Forest	830
2. EBF_M to 5. Plantation	1,495
3. EBF_P to 4. Other Forest	13,057
3. EBF_P to 5. Plantation	7,712
5. Plantation to 4. Other forest	7
5. Plantation to 6. Non forest	32,045
Reforestation	**186,921**
6. Non-forest to 5. Plantation	186,921
Stable non forest	**2,228,250**
Total	**5,144,519**

Remarks: AD is adjusted based on SAE ratio at 90% CI.

QA/QC procedures applied

The accuracy assessment of the forest cover maps for 2005, 2010 are made on the basis of existing data at more or less the same year, using the methods of Olofsson 2014.

- Landsat images covering NCC region for 2005, 2010 was used for visual interpretation.
- *At each of the evaluation sample points, the forest changes were independently evaluated by three experts in the field of remote sensing and forest change monitoring and assessment by* applying visual interpretation method.
- 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
- *Accuracy calculating* and Uncertainty by applying Olofsson's method.

Uncertainty associated with this parameter:

Type of change	Uncertainty (90% CI)
Deforestation	23.38%
Forest degradation	8.14%
Reforestation	8.34%
Forest enhancement	5.67%
Stable Forest	3.53%

Any comment:

The uncertainty associated with this parameter has been recalculated using the 90% CI instead of using 95% CI as in the ERPD.

Parameter:	$AD2_{ij}$ ($1 \leq i \leq 6$; $1 \leq j \leq 6$)
Description:	Area of land use and land cover conversion from type i in 2010 to type j in 2015. Types i and j run from 1 to 6 and mean as follows: 1. EBF_R; 2. EBF_M; 3. EBF_P; 4. Other forests; 5. Plantation; and 6. Non-forested land. Spatial analysis of 4 parameters: deforestation, forest degradation, reforestation and forest enhancement is conducted for periods 2010 – 2015. The definition of those parameters are as follows: **Deforestation:** The activity of conversion of forests to non-forest land, as identified following the NFIMAP (Including both plot measurements and remotely sensed information) and updates . Where a series of activities including deforestation may have occurred within a single cycle of the National Forest Inventory (NFI). **Forest degradation:** Any activity resulting in a downward shift in terms of carbon density 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. In the case that the deforestation activity occurring as a transitional activity not captured by the NFI, and thus will be reported as degradation. The conversion from plantation to Non forest is considered as degradation. **Reforestation:** Any activity resulting in land use change from non-forest land to forest land. The conversion of forestland into plantations is not considered "reforestation"; **Forest enhancement:** Any activity resulting in an upward shift of carbon density 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; Emissions associated with deforestation and forest degradation are considered sources. Removals generated by increment of forest biomass through forest enhancement and reforestation are considered sinks.
Data unit:	Hectare (ha)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Source of data: AD Annex of Vietnam ERPD for the NCC region Spatial level of the data: regional
Value applied:	

REDD+ activities	**AD 2010-2015 (ha)**
Enhancement	**312,077**
2. EBF_M to 1. EBF_R	8,115
3. EBF_P to 2. EBF_M	58,716
4. Other forest to 3. EBF_P	6,585
4. Other forest to 5. Plantation	10,022
5. Plantation to 1. EBF_P	3,092
6. Non forest to 2. EBF_P	184,196
6. Non forest to 3. Other forest	41,350
Stable forest	**2,297,483**
1. EBF_R to 1. EBF_R	156,207
2. EBF_M to 2. EBF_M	411,986
3. EBF_P to 3. EBF_P	1,090,672

	4. Other Forest to 4. Other Forest	100,768
	5. Plantation to 5. Plantation	537,849
	Deforestation	**137,436**
	1. EBF_R to 6. Non-Forest	848
	2. EBF_M to 6. Non-Forest	3,224
	3. EBF_P to 6. Non-Forest	111,468
	4. Other Forest to 6. Non-Forest	21,896
	Degradation	**219,969**
	1. EBF_R to 2. EBF_M	52,590
	1. EBF_R to 3. EBF_P	1,968
	1. EBF_R to 4. Other Forest	7
	1. EBF_R to 5. Plantation	0
	2. EBF_M to 3. EBF_P	31,813
	2. EBF_M to 4. Other Forest	101
	2. EBF_M to 5. Plantation	49
	3. EBF_P to 4. Other Forest	10,005
	3. EBF_P to 5. Plantation	32,727
	5. Plantation to 4. Other forest	64
	5. Plantation to 6. Non forest	90,646
	Reforestation	**162,255**
	6. Non-forest to 5. Plantation	162,255
	Stable non forest	**2,015,294**
	Total	**5,144,514**
	Remarks: AD is adjusted based on SAE ratio.	
QA/QC procedures applied	The accuracy assessment of the forest cover maps for 2005, 2010 are made on the basis of existing data at more or less the same year, using the methods of Olofsson 2014. - Landsat images covering NCC region for 2005, 2010 was used for visual interpretation. - At each of the evaluation sample points, the forest changes were independently evaluated by three experts in the field of remote sensing and forest change monitoring and assessment by applying visual interpretation method. - 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 Accuracy calculating and Uncertainty by applying Olofsson's method.	
Uncertainty associated with this parameter:	see table below	
Any comment:	The uncertainty associated with this parameter has been recalculated using the 90% CI instead of using 95% CI as in the ERPD.	

Type of change	Uncertainty (90% CI)
Deforestation	15.83%
Forest degradation	13.99%
Reforestation	8.82%
Forest enhancement	24.96%
Stable Forest	3.52%

3.2 Monitored Data and Parameters

Parameter:	$AD3_{ij}$ ($1 \le i \le 6$; $1 \le j \le 6$)
Description:	Area of land use and land cover conversion from type i in 2015 to type j in 2019. Types i and j run from 1 to 6 and mean as follows: 1. EBF_R; 2. EBF_M; 3. EBF_P; 4. Other forests; 5. Plantation; and 6. Non-forested land. Spatial analysis of 4 parameters: deforestation, forest degradation, reforestation and forest enhancement is conducted for periods 2015 – 2019. The definition of those parameters are as follows: **Deforestation:** The activity of conversion of forests to non-forest land, as identified following the NFIMAP (Including both plot measurements and remotely sensed information) and updates . Where a series of activities including deforestation may have occurred within a single cycle of the National Forest Inventory (NFI). **Forest degradation:** Any activity resulting in a downward shift in terms of carbon density 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. In the case that the deforestation activity occurring as a transitional activity not captured by the NFI, and thus will be reported as degradation. The conversion from plantation to Non forest is considered as degradation. **Reforestation:** Any activity resulting in land use change from non-forest land to forest land. The conversion of forestland into plantations is not considered "reforestation"; **Forest enhancement:** Any activity resulting in an upward shift of carbon density 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; Emissions associated with deforestation and forest degradation are considered sources. Removals generated by increment of forest biomass through forest enhancement and reforestation are considered sinks.
Data unit:	Hectare (ha).
Value monitored during this Monitoring / Reporting Period:	(see table below)

REDD+ activities	AD 2015-2019 (ha)
Enhancement	**102,266**
2. EBF_M to 1. EBF_R	848
3. EBF_P to 2. EBF_M	8,380
4. Other forest to 3. EBF_P	288
4. Other forest to 5. Plantation	5,431
5. Plantation to 1. EBF_P	272
6. Non forest to 2. EBF_P	53,043
6. Non forest to 3. Other forest	23,581
5. Plantation to 4. Other forest	10,423
Stable forest	**2,721,879**
1. EBF_R to 1. EBF_R	161,909
2. EBF_M to 2. EBF_M	517,945
3. EBF_P to 3. EBF_P	1,245,396
4. Other Forest to 4. Other Forest	143,531
5. Plantation to 5. Plantation	653,098
Deforestation	**27,727**

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>1. EBF_R to 6. Non-Forest</td><td>89</td></tr>
<tr><td>2. EBF_M to 6. Non-Forest</td><td>1,425</td></tr>
<tr><td>3. EBF_P to 6. Non-Forest</td><td>22,952</td></tr>
<tr><td>4. Other Forest to 6. Non-Forest</td><td>3,260</td></tr>
<tr><td>Degradation</td><td>146,441</td></tr>
<tr><td>1. EBF_R to 2. EBF_M</td><td>1,302</td></tr>
<tr><td>1. EBF_R to 3. EBF_P</td><td>2,436</td></tr>
<tr><td>1. EBF_R to 4. Other Forest</td><td>1,842</td></tr>
<tr><td>1. EBF_R to 5. Plantation</td><td>66</td></tr>
<tr><td>2. EBF_M to 3. EBF_P</td><td>845</td></tr>
<tr><td>2. EBF_M to 4. Other Forest</td><td>1,028</td></tr>
<tr><td>2. EBF_M to 5. Plantation</td><td>895</td></tr>
<tr><td>3. EBF_P to 4. Other Forest</td><td>25,588</td></tr>
<tr><td>3. EBF_P to 5. Plantation</td><td>34,935</td></tr>
<tr><td>5. Plantation to 6. Non forest</td><td>77,503</td></tr>
<tr><td>Reforestation</td><td>212,193</td></tr>
<tr><td>6. Non-forest to 5. Plantation</td><td>212,193</td></tr>
<tr><td>Stable non forest</td><td>1,934,016</td></tr>
<tr><td>Total</td><td>5,144,521</td></tr>
<tr><td colspan="2">Remarks: AD is adjusted based on SAE ratio at 90% CI</td></tr>
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</tr>
<tr>
<td>Source of data and description of measurement/calculation methods and procedures applied:</td>
<td>
• Object-based classification annual median Sentinel 2 composite image (Based on Google Earth Engine platform).
• Provincial forest and land cover map year 2019 for the six provinces in the NCC region.
• Combine provincial forest and land use maps of six NCC provinces to generate the regional forest and land cover map for the NCC region.
• Generate the matrix of area from the regional forest and land cover map.
• Illogical conversion in 2015-2019 check and update.
• Generate REDD+ activities map base-on combination with EF.
</td>
</tr>
<tr>
<td>QA/QC procedures applied:</td>
<td>
• Standard procedure for generating the forest cover map was applied QA/QC at some main step checking as: image data collection, Data pre-processing, Objet-based classification, illogical conversion checking.
• SOP for Accuracy assessments of the forest cover maps year 2015 and year 2019 are based on interpretation of high-resolution satellite images (Planet) and Google Earth image Google earth engine time series. The 5% sample was used for crosscheck (re-interpretation of independent expert) at sample respond step, using stratified sampling and applies the method described in Olofsson et al. (2014) to calculate the overall accuracies and area adjusted at CI 90%.
</td>
</tr>
<tr>
<td>Uncertainty for this parameter:</td>
<td>
Cover change are grouped into four REDD+ activities (deforestation, forest degradation, forest enhancement and reforestation) and allocated a degree of uncertainty, calculated by means of an assessment of accuracy based on SAE (Oloffson et al., 2014).
Margin of Error (MoE) of Deforestation (forest 2015 converted to non-forest land 2019) is 27.1% at CI of 90%. MoE of Forest degradation (high carbon density forest in 2015 converted to other low carbon density forest-land in 2019) is 15.0 % at CI of 90%. MoE of Reforestation (non-forest land in 2015 converted to forest land in 2019) is 5.7 % at CI of 90%; and MoE of Forest enhancement (low carbon density forest in 2015 converted to other high carbon density forest-land in 2019) is 13.5% at CI of 90%.
</td>
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</table>

	<table><tr><th>Type of change</th><th>Uncertainty (90% CI)</th></tr><tr><td>Deforestation</td><td>15.0%</td></tr><tr><td>Forest degradation</td><td>27.1%</td></tr><tr><td>Reforestation</td><td>13.5%</td></tr><tr><td>Forest enhancement</td><td>5.7%</td></tr><tr><td>Stable Forest</td><td>2.4%</td></tr></table>
Any comment:	• Following standard procedure for classification • Using high accuracy GPS or tablet • Conducting accuracy assessment. If the overall accuracy of forest cover map is below 70%, conduct additional field drawing to increase the accuracy of the maps.

Monitoring emission factors:

Parameter:	C(t,i) (t = 2015 or 2019; 1 ≤ *i* ≤ 5)
Description:	Carbon densities of forest type *i* in year *t*. The values of *i* mean: 1. EBF_R; 2. EBF_M; 3. EBF_P; 4. Other forests; and 5. Plantation.
Data unit:	Tone of carbon per hectare (tC/ha)
Value monitored during this Monitoring / Reporting Period:	<table><tr><th rowspan="2">Forest types</th><th colspan="2">2019 AGB</th><th colspan="2">2015 AGB</th></tr><tr><th>Value (t.d.m/ha)</th><th>Uncertainty (%)</th><th>Value (t.d.m/ha)</th><th>Uncertainty (%)</th></tr><tr><td>1.EBF_R</td><td>231.01</td><td>3.88</td><td>242.05</td><td>4.57</td></tr><tr><td>2. EBF_M</td><td>127.85</td><td>2.46</td><td>125.56</td><td>1.70</td></tr><tr><td>3. EBF_P</td><td>69.83</td><td>5.50</td><td>61.73</td><td>3.95</td></tr><tr><td>4. Other forests</td><td>45.29</td><td>17.93</td><td>36.80</td><td>13.16</td></tr><tr><td>5. Plantations</td><td>46.40</td><td>9.27</td><td>44.28</td><td>10.48</td></tr></table>*Remark: Uncertainty estimated for sampling*
Source of data and description of measurement/calculation methods and procedures applied:	Dataset of NFIMAP cycle 5 (2016-2020) is used for the construction of emission factors. The use of this dataset is consistent with the national reference level and the datasets include measurement data of secondary sample units (SSUs) in primary sample units (PSUs)[4]. **Sampling design:** After the completion of Cycle 4, of NFIMAP, Vietnam 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 be implemented in the 2016-2020 and subsequent cycles. The NFA Project has successfully developed an improved sample plot system that maintains the consistency with the old sample system but is more efficient. This improved sampling design was reviewed by international experts from United States Forest Service and the World Bank and was highly regarded. This sampling design was chosen in the recently approved National Forest Inventory, Monitoring and

[4] The datasets are available at FIPI. The access of the data needs to be authorized by VNFOREST

Assessment Project period 2016-2020 (under the National Target Programme for Sustainable Forest Development period 2016-2020).

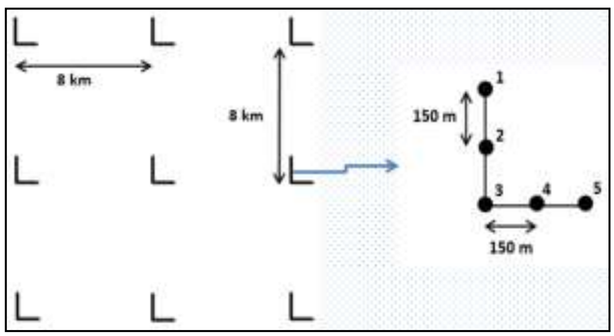
Since this is a systematic sample across the landscape, it will capture any changes in carbon removals occurring due to the ER program interventions and other forest management activities, in proportion to the area of the activities across the landscape. This improved sample plot system is also function as part of the national Measurement, Reporting and Verification (MRV) system for REDD+. Therefore, in order for the MMR system in the NCC region be consistent with the emerging national MRV system, the improved sample plot system proposed by the NFA Project is selected for generating the EFs for the MMR system in the NCC region.

The sample plots system is designed by the systematic method covering whole six provinces (Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue). On each intersection (grid point) one cluster is established (see **Error! Reference source not found.**).

Main parameters of the 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, and
- The distance between the sample plots is 150m.

Figure 1: Shape and distance between clusters sample plots



There are 453 clusters with 2,265 plots in the NCC region. The numbers of clusters and plots per provinces are provided in Table 3. The precise locations of the sample plots will be kept confidential to avoid possible manipulation of the results over time.

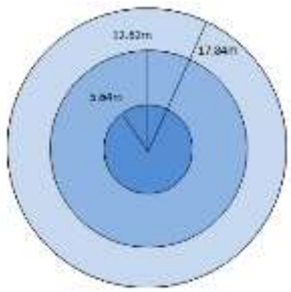
Table 3: The number of clusters and plots by provinces in the NCC region

No	Province	Number of clusters	Number of plots
1	Thanh Hoa	84	420
2	Nghe An	160	800
3	Ha Tinh	42	210
4	Quang Binh	75	375
5	Quang Tri	45	225
6	Thua Thien Hue	47	235
Total		**453**	**2,265**

Plot design:

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 (**Error! Reference source not found.**). The distance mentioned here refers to horizontal distance.

Figure 2: Sample plot design for year 2017



- Sub-plot with the area of 100 m^2 and radius of 5.64m (SP3): Measuring trees with DBH ≥ 6 cm; measuring bamboos with DBH ≥ 2 cm
- Sub-plot with area of 500m^2 and radius of 12.62m (SP2) to measure): trees with DBH ≥ 15 cm
- Sub-plot with area of 1,000m^2 and radius of 17.84m (SP1) to measure): trees with the DBH > 25cm

Estimation of biomass and carbon densities for forest types in 2019:

The aboveground biomass (AGB) of individual trees in the SSUs are estimated using AEs developed by UN-REDD Vietnam for NCC (Gael Sola et al, 2014). Under the UN-REDD Vietnam, a number of AEs for tree level biomass estimation are developed for national and major eco-regions (northeast, NCC, central highland and southeast). A single equation is also developed for national scale application. The equations are prepared for evergreen broadleaf forests, deciduous forests and bamboo forests that cover most forest area in Vietnam, particularly evergreen broadleaf forests. There are several choices available for using the developed AEs depending on data availability measured such as DBH only; DBH and tree height; and DBH, tree height and wood density (WD). The AEs using different predictors have different accuracies. Of these three predictors, DBH can be measured quite accurately. The NFIMAP data can only estimate the tree heights and WD of woody trees indirectly via height curves and species identification, which can generate additional but often unknown uncertainty. Therefore, tree height and WD are not used as predictors for forest carbon density estimation in this work.

Calculation of aboveground biomass (AGB) for individual trees and bamboos:

1) AGB estimation of trees in evergreen broadleaf forests (including plantations): the following AE is used (Huy, 2014):

$$AGB = 0.121155 \times DBH^{2.415395}$$

(observation = 311; MAE% = 33.6%; adjusted R^2 = 0.854)

Where:

AGB is above ground biomass expressed in kg

DBH is diameter at breast height expressed in cm

2) Aboveground biomass estimations for bamboo forests, the equations used are based on bamboo species. The equations are as follows (Phuong *et al*, 2014).

- *Bambusa balcooa*:

$$AGB = 0.0612 \times DBH^{2.0848} \times H^{0.2778}$$

(observation = 120; MAE% = n.a; adjusted R^2 = 0.875)

- *Dendrocalamus membranaceus*:

$$AGB = 0.1012 \times DBH^{1.9667} \times H^{0.2778}$$

(observation = 100; MAE% = 16%; adjusted R^2 = 0.875)

- *Bambusa chirostachyoides*:

$$AGB = 0.3558 \times DBH^{1.2154} \times H^{0.2778}$$

(observation = 120; MAE% = n.a; adjusted R^2 = 0.875)

- *Indosasa angustata*:

$$AGB = 0.2829 \times DBH^{1.4306} \times H^{0.2778}$$

(observation = 70; MAE% = n.a; adjusted R^2 = 0.875)

Where:

AGB is above ground biomass expressed in kg

DBH is diameter at breast height expressed in cm

H is the height expressed in m.

Calculation of carbon stock for each SSU

Step 1: Estimating AGB of SSU.

Total AGB of trees in each SSU is estimated as the sum of all individual tree AGBs in this SSU.

$$AGB\_T_i = \sum_{j=1}^{n_i} AGB\_T_{ij}$$

Where: AGB_T_i is the total AGB of trees in SSU *i*, n_i is the number of trees in SSU *i*, and AGB_T_{ij} is the AGB of the *j*th tree in SSU *i*.

Total AGB of bamboos in each SSU is estimated as the sum of all individual bamboo AGBs in this SSU.

$$AGB\_B_i = \sum_{j=1}^{m_i} AGB\_B_{ij}$$

Where AGB_B_i is the total AGB of bamboos in SSU *i*, m_i is the number of bamboos in SSU *i*, and AGB_B_{ij} is the AGB of the *j*th in SSU *i*.

Since the area of tree measurement in each SSU is 1000 m^2 but the area of bamboo measurement in each SSU is only 100 m^2, the total AGB of both trees and bamboos in SSU *i*, AGB_i, is:

$$AGB_i = AGB\_T_i + 10 \times AGB\_B_i$$

The AGB for each SSU is in the unit of kg per 1000 m^2. Apply the following formula to convert to the unit of ton dry matter (tdm) per ha:

$$AGB/ha_i = AGB_i \times \frac{10000}{1000 \times 1000} = AGB_i/100$$

Step 2: Estimating below-ground biomass (BGB) of SSU.

BGB is be estimated for each SSU as follows:

$$BGB/ha_i = AGB/ha_i \times R$$

Where: BGB/ha_i is the BGB of SSU *i* in the unit of ton per ha; *R* is the root-to-shoot ratio. As Vietnam has no specific data on R and the development of such factor is very costly, therefore, the default values of *R* of 0.20 for forest type with AGB < 125 tdm/ha and *R* of 0.24 for forests with AGB ≥ 125 tdm/ha (IPCC 2006) are used for calculation of BGB.

Step 3: Estimate total living biomass (including AGB and BGB) for each SSU.

Total living biomass in SSU *i* is the sum of AGB and BGB of this SSU:

$$B/ha_i = AGB/ha_i + BGB/ha_i$$

Step 4: Estimating carbon density of each SSU.

Carbon density of SSU *i* in the unit of ton carbon per ha, C/ha_i, is calculated as follows:

$$C/ha_i = B/ha_i \times CF$$

Where B/ha_i is total living biomass of SSU *i* in unit of tdm per ha; *CF* is the carbon fraction coefficient. This work applied the IPCC default value for CF, which is 0.47 (IPCC, 2006).

Calculation of mean carbon density for each forest type

The mean carbon density of forest type *i* is calculated as the mean of the carbon densities of all SSUs in this forest type.

$$\overline{C/ha}_i = \frac{1}{np_i}\sum_{j=1}^{np_i} C/ha_{ij}$$

Where np_i is the number of SSUs in forest type *i*; tC/ha_{ij} is the carbon density of SSU *j* in forest type *i*.

Regarding the other forest category (bamboo and mangrove forests are combined), its carbon density is calculated using weighted value as follows:

$$\overline{C/ha}_i = \frac{Cb * Ab + Cm * Am}{Ab + Am}$$

Where: *Cb* is the carbon density (tC/ha) of other forest (excluding mangrove forest) calculated from its biomass using equations and plot data

Ab is the area of other forest excluding mangrove forest (ha) derived from a forest cover map

Cm is the carbon density (tC/ha) of mangrove forest

Am is the area of mangrove forest (ha) derived from a forest cover map.

Regarding the mangrove forests, there are no measurement plots in PSU in mangrove forests, however there are a number of studies on biomass of mangroves. A review report on biomass and carbon density suggests that the average weighted carbon density for mangrove forest in the North (Northeast, NCC and South Central Coast) is 35.2 tC/ha and in the South (Southeast and Southwest) is 64.4 tC/ha and at the national level is 58.0 tC/ha (Phuong *et al*, 2015).

Estimation of carbon densities for forest types in 2015

Carbon density for one forest type in 2015, $\overline{C/ha}_{2015}$, is interpolated from carbon densities for that forest type in 2010 and 2019 using the following formula.

$$\overline{C/ha}_{2015} = \overline{C/ha}_{2010} + 5 \times \frac{\overline{C/ha}_{2019} - \overline{C/ha}_{2010}}{9}$$

	Where: $\overline{C/ha}_{2010}$ is the carbon density in 2010, which is taken from the EF Annex of the ERPD; $\overline{C/ha}_{2019}$ is the carbon density in 2019, which is calculated as described in the previous section.
QA/QC procedures applied:	The QA/QC protocol for field inventory developed for the NFIMAP period 2016-2020 were applied. The controlling measurements are conducted by QA/QC teams within 1–2 weeks after the measurements by the initial team. 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. 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. The data processing and carbon density calculation process is verified by a scientific committee comprising of 5-7 experts.
Uncertainty for this parameter:	• The uncertainties for this parameter are provided in the table in the "Value monitored during this Monitoring / Reporting Period" field. • The potential sources of uncertainty considered include: (1) error from sampling and field data measurement; (2) error from estimating AGB using allometric equations; (3) error of applying root to shoot ratio; and (4) error of using carbon fractions. • Reducing uncertainty plan: Following QA/QC protocol for field inventory; Using equipment with high accuracy.
Any comment:	Equipment used for measurement are GPS, tree diameter measurement tape, tree height measurement equipment, distance measurement equipment. The uncertainty for this parameter is a combined uncertainty of the uncertainty from sampling error, the uncertainty of the CF coefficient and the uncertainty of the RS ratio.

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring / Reporting Period covered in this report

The reference level is separated for emissions and removals and is updated with newly calculated forest carbon for 2015 and the activity data are updated using the adjusted activity data based on SAE ratio at 90% CI[5]. As the results, the annual emission reference level is 12.1 million tCO_2-e (old annual emission level was 10.8 million tCO_2-e) and the annual removal reference is -6.8 million tCO_2-e (old estimated

[5] The spreadsheet of reference level calculation is available on request

annual removal was -6.3 million tCO_2-e). The net updated annual emission is 5.3 million tCO_2-e (old net annual emission was 4.6 million tCO_2-e.

Table 4. Updated reference level for monitoring/reporting period

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 (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2016	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2017	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2018	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2019	2,624,811	9,516,700	-6,861,250	NA	5,280,261
Total	**10,499,244**	**38,066,800**	**-27,445,000**	**NA**	**21,121,044**

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

The estimates of emission and removals enhancement are calculated for a period of 2016-2019.

Table 5. Estimates of emissions and removals in reporting period (2018 -2019)

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, emissions from forest degradation (tCO_{2-e}/yr)*	If applicable, removals by sinks (tCO_{2-e}/yr)	Net emissions and removals (tCO_{2-e}/yr)
2016	904,523	3,843,565	-9,841,555	-5,093,467
2017	904,523	3,843,565	-9,841,555	-5,093,467
2018	904,523	3,843,565	-9,841,555	-5,093,467
2019	904,523	3,843,565	-9,841,555	-5,093,467
Total	**3,618,092**	**15,374,260**	**-39,366,220**	**-20,373,868**

4.3 Calculation of emission reductions

Emissions and removals are estimated separately in monitoring period (2016-2019) in the same way that they were estimated in the Reference period. The annual averaged emissions and removals are then calculated and are used to estimate emission reduction and removal enhancement comparing to annual reference emissions/removal level for reporting period. As the results, total net emissions and removals in monitoring period is -20,373,868 tCO2. Total ERs credits (Emission reductions and removal enhancement) for monitoring period (4 years, 2016-2019) is **41,494,912 tCO2-e.**

Table 6. Estimated emissions and removals for monitoring period

Total Reference Level emissions during the Monitoring Period (tCO_2-e)	21,121,044
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	-20,373,868
Emission Reductions during the Monitoring Period (tCO_2-e)	41,494,912
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	699 days/1,440 days
Emission Reductions during the Reporting Period (tCO_2-e)	19,866,400

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

Identification and assessment of sources of uncertainties possibly incurred during the development of activity data and emission factors are described as follows:

Table 7. Uncertainties sources and assessment

Sources of uncertainty[6]	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty (High / Low)**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
Activity Data						
Measurement	☒	☒	The sources of uncertainty associated with the use of satellite imagery: 1) the quality and suitability of the satellite data in terms of spatial and temporal resolutions, 2) the consistency and quality of radiometric and geometric preprocessing of annual images data, 3) the thematic and cartographic standards such as the land cover type and the minimum mapping unit, and 4) the interpretation procedure from either automatic classification of the imagery or the visual interpretation, 5) the error for visual interpretation of sampling in SAE.	H (bias/ random)	YES	NO
Representativeness	☒	☐	This source of uncertainty is related to the representativeness of the estimate which is related to the sampling design. If the sample is not representative for the area of interest or the time of interest (e.g. not all elements of the population or region of interest are included in the sampling frame; . deforestation is not measured for the period of interest), the estimate given by the sample will not be representative and this can be a cause of bias. Biases must be	L (bias)	YES	NO

[6] At minimum, the sources listed in the table should be analyzed, others can be added as identified by the ER Program

			avoided as far as practical and this can be avoided through a correct sample design which can be ensured through adequate QA/QC processes. This source of uncertainty might be High or Low depending on the circumstances and REDD Countries may assess the magnitude. Vietnam assesses this source of uncertainty is low.			
Sampling	☐	☒	SRS (Stratified random sampling) method was applied for AD sampling desgin.	H (random)	YES	YES
Extrapolation	☒	☐	The SAE of AD was carried out at the forest/nonforest level, then the resulting estimates of AD were allocated back to the 5 strata proportionally to mapped area. AD estimates at the stratum level are needed in order to combine with stratum-specific EFs to estimate emissions and removals. However, evolving understanding has raised the concern that this may be biased: for example it assumes that deforestation and degradation happen equally across all forest types in proportion to the mapped forest type area, but in reality, deforestation and degradation rates may not be constant for all forest types.	L (bias)	YES	NO
Approach 3	☒	☐	IPCC Approach 3 was used to develop spatially disaggregated AD using updated forest cover maps for 2005, 2010, 2015 and 2019 based on remote sensing images (Landsat, Sentinnel 2). Successive maps are overlaid to detect the land use changes for each periods. Land use changes for the periods are then aggregated by time series (2005-2010-2015 -2019) for NCC.	L (bias)	YES	NO
Emission factor						
DBH measurement	☒	☒	Measurement of DBH and plot delineation are subject to errors. Errors may be caused by multiple factors such as poor training, poor measurement protocols, etc. While measurement errors are significant at the tree level, they usually average out at plot level and inventory level (Chave et al. 2004). Picard et al. (2015) also found the measurement error to be small when compared to the other errors. The FMT conducted an assessment of the contribution of this source of error (c.f. Annex) and found that this source of error should be negligible for Emission Reduction estimation, provided minimal QA/QC	H (bias) & L (random)	YES	NO

			procedures are in place. Vietnam applied QA/QC procedures to avoid both random error and systematic error caused by DBH measurement and plot delination. Therefore, the contribution of this source of error to random error is expected to be low.			
H measurement error	☒	☒	H parameter is not used in the estimation of EF	NA	NA	NA
Plot delineation	☒	☒	See analysis in column "DBH measurement" above.	H (bias) & L (random)	YES	NO
Wood density estimation	☒	☒	Wood density is not used in the estimation of EF	NA	NA	NA
Biomass allometric model	☐	☐	The error of biomass allometric equations (tree level) are 10-18% for natural timber forest, plantation and bamboo forest, respectively. Since these equations are used to estimate AGB at the individual tree/bamboo level, the contribution of allometric equation errors to ramdom carbon stock errors at forest type level are assumed to be low. However, since these equations are developed based on a non-representative sample, the contribution of allometric equation errors to systematic errors (bias) at forest type level are assumed to be high.	H (bias) & L (random)	YES	NO
Sampling	☐	☒	This source of error is applicable for Vietnam case when the carbon densities of forest used to derive emission factors are based on a terrestrial inventory based on a systematic sampling design with the grid size of 8 km. Sampling uncertainty is the statistical variance of the estimate of aboveground biomass. This source of uncertainty is random and is expected to be high.	H (random)	YES	YES
Other parameters (e.g. Carbon fraction, Root-to-shoot ratios)	☒	☒	In Vietnam case, some other parameters are used to estimate emission factors, such as aboveground biomass in non-forest land, carbon fraction and root-to-shoot ratios. These are not measured but sourced from the 2006 IPCC Guidelines. This can lead to both random and systematic errors. The random error of each individual parameter might be low but the aggregated effect might be high. Moreover, the lack of QA/QC procedures for the selection of the values may lead to high systematic errors.	H (bias/ random)	YES	YES

Representativeness	☒	☐	Vietnam applied a systematic sampling design to estimate AGB of forest types, which in turn are used to estimate the emission factors. Therefore, the sample is expected to be representative for the accounting area, and this source of error is bias and is expected to be low.	L (bias)	YES	NO
Integration						
Model	☒	☐	Sources of both random and systematic error are the calculations themselves (e.g. mistakes made in spreadsheets) and the process of data preparation (e.g. pre-processing, data cleansing, data transfer, etc). In Vietnam case, the assumption on the adjustment factors for calculating removals could be a source of bias to emission reductions. All these sources are addressed with adequate QA/QC processes.	L (bias)	YES	NO
Integration	☒	☐	This source of uncertainty is related to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. For Vietnam, Activity Data is estimated through remote-sensing observations, whereas Emission Factors for a specific forest type are based on ground-based observations of the forest type. These may not be comparable, and it may represent a source of low bias.	L (bias)	YES	NO

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

The Monte Carlo Method was applied to assess uncertainties of emissions and removals estimates in reference level and the reporting period. In this analysis, all parameters associated with emissions and removals estimates are simulated with assumption of normal probability distribution. Four (4) parameters analyzed are as follows:

- Above ground biomass of 5 forest types for 2005, 2010, 2015 and 2019
- Activity data of all forest and land use change (6 types) for 2005-2010; 2010-2015 and 2015-2019.
- Root to shoot ratio (RS)
- Carbon fraction (all types of forest biomass)

The details of description on parameters, parameters values, standard errors and probability distribution function are provided in separate spreadsheet[7].

[7] The spreadsheet for MC analysis is available for sharing upon the request

Quantification of the uncertainty of the estimate of Emission Reductions

The uncertainty analysis of the defined parameters for 10,000 runs in excel spreadsheet for emissions and removals estimates as well as annual emission reduction and removal enhancement. The uncertainty for total emission is 62% and 80% for emissions from forest degradation (see Table 8).

Table 6. Results of uncertainty analysis of emission reduction and removal enhancement in tCO_2-e for reporting period

		Total Emission Reductions
A	Median	14,755,263
B	Upper bound 90% CI (Percentile 0.95)	23,799,261
C	Lower bound 90% CI (Percentile 0.05)	5,648,495
D	Half Width Confidence Interval at 90% ((B – C) / 2)	9,004,401
E	Relative margin (D / A)	62%
F	**Uncertainty discount**	12%

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

Sensitivity analysis was conducted independently for 4 parameters: (1) root to shoot ratio (RS); (2) carbon fraction (CF); (3) above ground biomass (AGB) of all forest types; and (4) activity data (AD). The value of these parameters was set to very small value (0.00001) to remove from simulation. The results of sensitivity analysis indicated that the uncertainty associated with AGB has the largest overall contribution to the uncertainty of total emission reductions, to degradation, and to estimates of removals from enhancement and reforestation. The uncertainty associated with AD has the largest overall contribution to the uncertainty of emissions associated with deforestation. The uncertainty associated with RS and CF terms contributes relatively little to the overall uncertainty.

Table 9. Sensitivity analysis of uncertainties for emission reduction and removal enhancement in reporting period.

Analysis type	**Total Emission Reductions***	**Emissions - Deforestation**	**Emissions - Degradation**	**Total removal**	**Removal - Enhancement**	**Removal - Reforestation**
With All Uncertainty Terms	62%	30%	80%	252%	302%	149%
Dropping AGB Uncertainty	16%	30%	19%	23%	17%	113%
Dropping AD Uncertainty	60%	10%	78%	260%	304%	89%
Dropping RS Uncertainty	60%	31%	78%	260%	306%	148%
Dropping CF Uncertainty	61%	31%	79%	261%	304%	148%

It suggests that in the future, the greatest potential for reducing uncertainty in estimates of emission reductions would be through reducing uncertainty in estimates of AGB, perhaps through increasing sample sizes in the NFI.

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

The ability of Program Entity to transfer the titles to ERs under the ERPA shall not be affected by any considerable legal and trade challenges in context of the current situation of forest and environmental protection I Vietnam. Physically, the Program Entity is in full control of ER activities due to the following factors: (1) The major part of forests, especially natural forests belong to the State-owned enterprises that are under management of the MARD which shall be acting as the Program Entity; (2) all other forest owners in the ER Program Area are committed to participate in the ER Program and subject to its activities and ERPA; (3) currently in the ER Program Area, there is no and will not be in the near future significant ER market that challenges the volume of ERs committed by the Entity under ERPA; (4) the non-state forest owners in the ER Program Area are unable to measure and register their ERs for any transactions outside ER Program; (5) MARD and provincial governments in Vietnam are carrying out different activities provided in the National Program for Sustainable Forestry Development. This means would ER Program and ERPA not be available, forest owners will reduce ERs. Otherwise speaking, ERPA only strengthens the Program Entity's ability to transfer ER titles.

The Program Entity's ability for transfer ER titles shall not challenge the land and resource tenure rights of the potential rights-holders, including Indigenous Peoples since ER Program implementation does not lead to any confiscation, withdrawal or restriction of such rights of such holders. In issuing regulations on ER right transfer, the Program Entity shall ensure implementation of the provisions of the 2017 Law on Forestry on forests of communities, including ethnic minority/indigenous ones. Besides, implementation of ER Program shall bring benefits to ethnic minority peoples. The regulations of ER transfer will be approved by the Government that ensure ER titles free of contest.

The details of legal regulation on transferring title to ERs is lacking. Over the 2018-2019, Vietnam has developed a specific legal document on carbon title for ERP and it is now in the final stage for approval that is expected to be ready this year. The main contents of this legal arrangement include:

- Application and scope of transfer title to ERs
- Confirmation of transfer title to ERs
- Transfer title to ERs within ERPA and outside ERPA
- Benefit sharing among the beneficiaries in ERP area
- Monitoring and management of transfer title to ERs.

Ministry of Agriculture and Rural Development (MARD) is responsible agency to transfer title of ERs to the carbon fund under the agreement between MARD and the World Bank (ERPA). MARD will secure the agreed transferable amount of ERs set in the ERPA.

The payment for ERs generated by the ERP will be made to Vietnam Forest Protection Fund (VNFF). VNFF will then share payment to the forest owners in ERP area through its branches at provincial level that complies with the benefit sharing plan.

Vietnam Administration of Forestry (VNFOREST) takes overall responsibility for monitoring and managing the transfer of ER title. This includes: (1) monitoring the emissions and removals; (2) data management and registration of carbon title linking to existing platform, for example, land registration system, Forestry management Information System (FORMIS) or REDD+ registration; and (3) monitoring of benefit sharing and implementing safeguard measures.

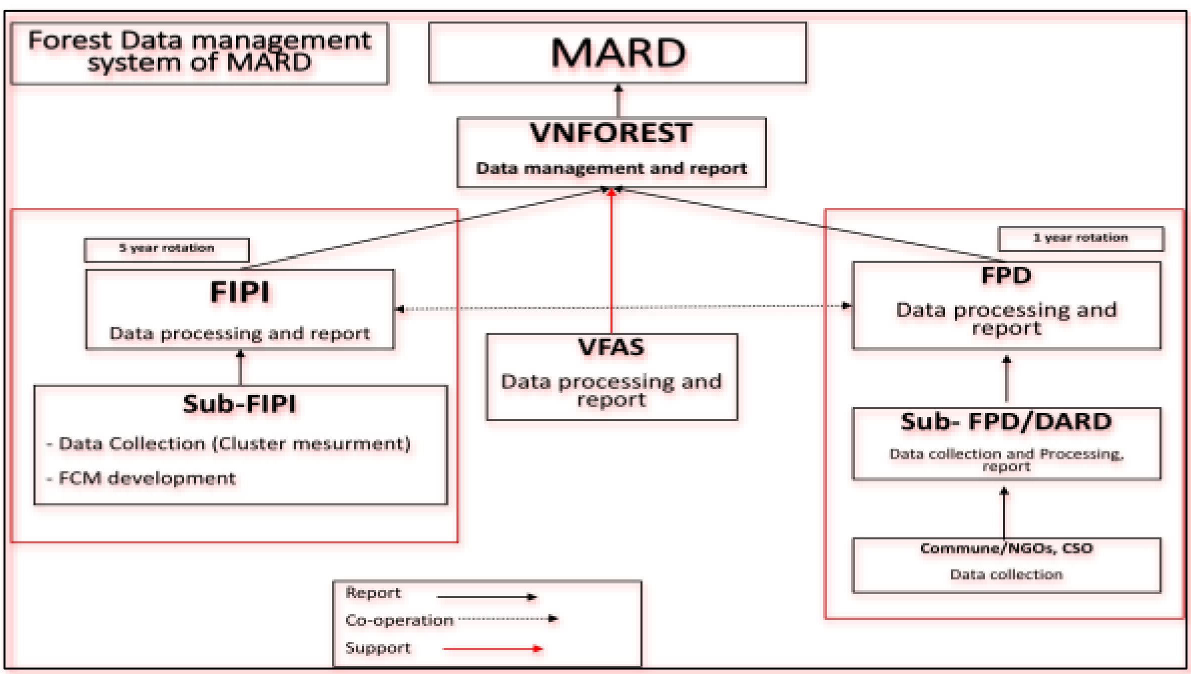
Vietnam is now preparing a policy to promote domestic carbon market which is expected to promote the carbon trading in different sectors, including private sector. The operation of transferring title to ERs in ERPA will provide significant lessons for future operation of domestic carbon market in Vietnam. This also allows the monitor of emission reduction resulted from forestry development program as contribution to the nationally determined contribution (NDC) of the country.

6.2 Implementation and operation of Program and Projects Data Management System

Basically, the organizational structure of the database management system has not changed in comparision to the proposal of the Program approved by the FCPF Council, some work has been done for the preparation work. These include tasks allocation to steering committee and provincial levels, legal framework development, guidelines for program operation and financial management etc.

The Ministry of Agriculture and Rural Development assigned the management of this database system to the Vietnam Administration on Forestry (VNFOREST)/the Administration Office of VNFOREST and Forest Protection Department (FPD). Overall arrangement for operation of ERP and data management is shown in following figure.

Figure 3. Overall arrangement for ERP operation and database management



In addition to implementation of ERP, the preparation, collection and management of forest related data is coordinated and implemented. This database supports the monitoring of implementation of ERP and other related outputs.

- From 2015, after the forest inventory and statistic data are published and VNFOREST assigned Formis project and FPD to store this data they were responsibility to manage this system and when the FORMIS project ended, the database system was be transferred to the VNFOREST by the IT team of the Administration Office. The database includes data on forest area for each Province, including the North Central Coast region with 6 provinces from Thua Thien Hue, Quang Tri, Quang Binh, Ha Tinh, Nghe An and Thanh Hoa.
- Updating forest information is carried out from the localities every year. Information on forest area is updated by the FPDs from commune to district level and to province level. Provincial FPD reports FPD/VNFOREST on-line data and maps (if it is not possible to transfer files online, so they can transfer direct the file to the Forest Protection Department/VNFOREST to ensure regular updates from local level. In recent years, with the support of the FCPF2 and UNREDD + phase II projects, together with the EU-supported domestic NGOs projects, each province has organized 10-15 training courses on using GPS and tablet for monitoring of forest changing in communal level with support of CFMS software to updat forest changes from local to districts and provinces.
- The VNFOREST/FPD coordinates with consulting agencies such as the Forest Inventory and Planning Institute, the Vietnam Academy of Forest Science (VAFS), and the Vietnam Forestry University (VFU) to advise the Ministry of Agriculture and Rural Development (MARD) to publish data on forest area in nationwide and for the region yearly in April. Information on forest areas, by forest types, forest managers, forest user etc. are publiced and are available on the General Department Webs website and through press conferences. Numbers of illegal cases, areas of forest lost, area of converting forest to other land use form, and more detailed information on forest are reported in the VNFOREST summary, if required, will also be provided. To support Provincial Forest Protection Department (Sub-FPD), FIPI has developed a local information-updating tool for collection of forest changing data by using GPS and tablet, guidance on the investigation of sample plots. Vietnam Academy of Forest Science (VAFS) to develops a guidance on calculation of forest carbon stocks and for reports.
- In parallel with VNFOREST data system, based on the updated local map, the Forest Inventory and Planning Institute uses satellite images of Sentinel provided free of charge to update and supplement the area, coordinate with the inventory system (sample cluster plots system) in the North Central region to determine the average volume of forest types, thereby determining the forest volume of the whole region and coordinate with the results of the study of conversion coefficients from tree volume to biomass and carbon volume of the VAFS and VFU for calculating of the RELs for the period 2015 and updated it for 2019. (Institute used the survey plots from 565 cluster of plots in the North Central region with 2290 plots with an area of 1 ha. On this basis of those data, the RELs have been calculated and adjusted and completed the monitoring system for localities).

VNFOREST takes a leading role in coordinating operation and implementation of ERP, in collaboration with line ministries and departments across levels, with the support of National Steering Board for Sustainable Forestry Development and REDD+. The key forestry development programs are coordinated to achieve the objectives of ERP includes:

- Sustainable forestry development program (also called Program 886): Currently the program has ended, the Vietnam Administration of Forestry has been developing a new program on forest protection and development to replace Program 886, the Financial Planning Department of the VNFOREST is the governing body they manage information on afforestation and reforestation. Every year, the provinces make statistics on the implementation of the Program to report to the VNFOREST.
- National policy on payment for forest environmental services (regulated by the Decree 156/2018/ND-CP. This policy provides significant financial investment for forest protection (about 7 million USD per year).

- National target program on sustainable poverty reduction 2016 - 2020 proposed with a total budget of more than USD 2 billion, and of this a significant share is allocated to the ER-P accounting area (Decision no. 1722/QD-TTg of PM dated September 2, 2016). By the end of 2020, the Government commits to continue this program, the Ministry of Labor, Invalids and Social Affairs and the Ministry of Planning and Investment are currently drafting a proposal for the Program.
- Project for protection and development of coastal forests: The project supports the implementation of the plan for coastal forest protection and development to cope with climate change (Decision on 120/QD-TTG dated 22 January 2015). Currently, the project provinces are preparing to summarize the project and the next MARD has proposed FMCR projects for 8 provinces including 6 provinces in the North Central region;
- The Project of Forestry Sector Modernization and Coastal Resilience Strengthening (FMCR) includes the North Central provinces of Thua Thien Hue, Quang Tri, Quang Binh, Ha Tinh, Nghe An, and Thanh Hoa.

In addition to the ongoing program, there are numbers of planned investment programs that support the ERP implementation using state and local budget. These planned programs to be funded and implemented in the ERP area are:

- The project Investment of High-tech in forest management and monitoring of biodiversity and forest changes by using of remote sensing images at the nearest time, establishing a center data management at the VNFOREST for the period 2021-2025, including 6 provinces in the North Central region.
- Prepare to deploy forest inventory and statistic data collection every 10 years using satellite images for forest inventory (area and volume of wood, forest biomass ... biodiversity) nationwide.
- Develop guidelines for MRV implementation for large timber reforestation and REDD+ implementation in forestry sector.

- Assessment of effective management and protection of existing forests to reduce deforestation and forest degradation (Assess forest status, develop plans to implement Directive 13-CT/TU)
- The Forest and Delta Project in Thanh Hoa, Quang Binh and Quang Tri Thua Thien Hue provinces (VFD 2)
- Project of Sustainable Forest Management, Restoration and Promotion of Forest Certification in Vietnam including Quang Binh, Quang Tri, and Thua Thien Hue provinces. (KFW 12)
- Project on Sustainable Management and Forest Certification Granted by GIZ for Quang Binh, Quang Tri, and Thua Thien Hue provinces.

6.3 Implementation and operation of ER transaction registry

In the ERP, the plan for development of REDD+ registry system will be linked to available land registration platform. Technically, it is possible, but it will be very costly to monitor and certify emissions reduction and removal enhancement for every forest owner in the accounting area. The current monitoring system for emissions and removals cover provincial level. Therefore, the REDD+ registry system should be simple and cost-effective.

In order to avoid double counting, as per Criterion 38, the Program Entity has decided to use the FCPF ER Transaction Registry. Consequently, the responsibilities of the Registry Administration as well as the buffer management will fall on the Trustee of the Carbon Fund.

As for ERP, MARD is responsible agency to transfer title of ERs to the carbon fund under the agreement between MARD and the World Bank (ERPA). MARD will secure the agreed transferable amount of ERs set in the ERPA.
VNFOREST takes overall responsibility for monitoring and managing the transfer of ER title. This includes: (1) monitoring the emissions and removals; (2) data management and registration of carbon title for provinces in the accounting area; and (3) monitoring of benefit sharing and implementing safeguard measures.

The measurement, registration of ER shall be made in compliance the ER Program's mechanisms and regulation adopted by the MARD under authorization of the Prime Minister right after the ERPA is signed. The Registry shall have responsibility to ensure, by using ER registration data, that no any amount of the ERs transferred to the Carbon Fund, set aside to meet Reversal Management requirements under other GHG accounting schemes be sold, transferred or accounted for whatever transactions. The Program entity is responsible to ensure all ER transactions under ERPA and transactions possibly made by the forest owners in the ER Program Area not affect performance of the ERPA.

All information on counting and transferring emissions reduction rights will be posted on the following portal of Vietnam Forest Protection and Development Fund[8]: http://vnff.vn. The information to be posted include:

- ERP related documents (ERPD, ERPA etc.)
- Legal documents (carbon title, BSP, etc.)
- Spatial maps used for construction of reference level and reporting period
- Plot data used for estimation of emission factors
- Spreadsheet of calculation of emissions and removals for reference level and reporting period
- Spreadsheet on sensitivity analysis of emissions and removals for emission reduction and reference level
- Etc.

6.4 ERs transferred to other entities or other schemes

As calculated, the total carbon credit (emission reduction and removal enhancement) generated in the reporting period (2018 and 2019) by the ER program is about **20.7 million tons of CO_2-e** (emission reduction amount is 14.7 million tons of CO_2-e and removal enhancement is -5.9 million tons of CO_2-e).
As far, only agreement between Vietnam (MARD) and the Carbon Fund (WB) is made to transfer the emission reduction credits through the ERPAs. The transfer of ERs of the ER program will follow the agreement and conditions set in the ERPAs.

7 REVERSALS

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

Not applicable

[8] A new window will be set up to provide all information on ERP implementation and emission reduction transfer

7.2 Quantification of Reversals during the Reporting Period

Not applicable

7.3 Reversal risk assessment

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	The ERP is fully aligned with strategies and policies on sustainable forest management and poverty reduction (i.e. national program on sustainable forest management, sustainable poverty reduction, technical support by agriculture extension centre etc.). The ERP is effectively supported by numbers of forest development programs, including livelihood development, focusing on forest dependent communities. In addition, the government supports The settlement of land disputes and complaints as regulated by the provisions of the Land Law and other relevant legal provisions.	**10%**	*10%*	*0%*
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	The ERP engages multi stakeholders and sectors in implementation across levels under the close coordination of State Steering Committee and Ministry of Agriculture and Rural Development. Integration of REDD+ issues and climate change mitigation and adaptation is being promoted. In addition, there is a strong vertical integration, with the Central State having a strong influence on provincial, district and commune matters. With current administration system, the institutional framework for forest governance is extended from national to sub-national level. However, the collaboration and integration of investment programs in forestry sector are not well coordinated as the different management regulations. The planning law 2017 requires cross-sector engagement in planning processes that promote cross-sectors coordination.	**10%**	*5%*	*5%*
Lack of long term effectiveness in addressing underlying drivers	The Government has invested numbers of investment programs on forest development and management and implemented law enforcement to control forest conversion (hydro-power plant development etc.). Protection of existing forest area and strict control of forest conversion are the policy priority (i.e. Forestry Law 2017 and Forestry Development strategy 2021-2030 and vision to	**5%**	*2%*	*3%*

	2030). Comparing to reference period and the results presented in Section 1 , the law enforcement is strengthened with positive achievement in addressing the underlying drivers for deforestation and forest degradation.			
Exposure and vulnerability to natural disturbances	Climate change impacts are considerable challenges for Vietnam and its forestry sector. The risks include forest fires, impacts of typhoons (landslide, flash flood). As the records (table 1, section 1) on forests damaged by natural disasters (typhoons, fires) it seems those damages are increasing. Therefore, the natural risks to the forests remain unpredictable.	**5%**	*2%*	*3%*
Total reversal risk set-aside percentage				**21%**
Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)				**21%**

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	19,866,400	
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**		**0**	
C.	**Number of Emission Reductions estimated using measurement approaches (A-B), (tCO_2-e)**		19,866,400	
D.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	12%	
E.	**Calculate (0.15 * B) + (C * D), (tCO_2-e)**		**2,383,968**	–
F.	**Emission Reductions after uncertainty set-aside (A – E), (tCO_2-e)**		**17,482,432**	
G.	**Number of ERs for which the ability to transfer Title to ERs is still unclear or contested at the time of transfer of ERs**	*from section 6.1*	**0**	
H.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*From section 6.4*	**0**	–
I.	**Potential ERs that can be transferred to the Carbon Fund before reversal risk set-aside (F – G – H), (tCO_2-e)**		**17,482,432**	
J.	**Total reversal risk set-aside percentage applied to the ER program**	*From section 7.3*	**21%**	
K.	**Quantity of ERs to allocated to the Reversal Buffer and the Pooled Reversal Buffer (multiply I and J), (tCO_2-e)**		**3,671,311**	–
L.	**Number of FCPF ERs (I – L), (tCO_2-e)**		**13,811,121**	

The following annexes are being completed and will be made public as soon as they are available:

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

During the communication with FMT and through its training on preparation of monitoring report, it was noted that the technical correction is encouraged in case the new data is available. Therefore, Vietnam decided to make the technical correction for reference level.

Summary of technical corrections

Two parameters are technically corrected for reference level that are carbon density estimated for 2015 and activity data. In the original Reference Level, due to the data unavailability, the carbon densities in 2015 were assumed to be equal to the carbon densities in 2010. In the MMR, the carbon densities in 2019 have been estimated based on plot measurement data of NFIMAP period 2016-2020 and the carbon densities in 2015 have been interpolated from carbon densities in 2010 and 2019 (assuming the carbon densities change uniformly during 2010-2019). The emission factors for the Crediting period have been estimated based on carbon densities in 2015 and 2019. Therefore, a technical correction has been made to the Reference Level using the new derived carbon densities in 2015. In the original Reference Level, the combined uncertainty was estimated using error-propagation method with the confidence interval (CI) of 95%. In line with the *Guideline on the application of the Methodological Framework Number 3 – Uncertainty Analysis*, the combined uncertainty has been re-calculated using the Monte Carlo method with the CI of 90%. The activity data used for reference level is based on map and is not adjusted according to the accuracy assessment. This correction revised activity data based on sample base accuracy assessment.

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

The deforestation and forest degradation sources contribute significant emissions in the ER Program. However, there also exist significant removals by sinks from forest enhancement and reforestation. The sources and sinks of the program are presented in the Table below.

Table A4-1. Selection of sources and sinks for emissions and removal accounting

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	Yes	Deforestation has mainly taken place in natural forests such as conversion of forests to agricultural cultivation, infrastructure development etc. In the program area, the spatial analysis of deforestation shows significant area of deforestation. The annual average forest loss is 31,822 ha for the period 2005 - 2015.
Emissions from forest degradation	Yes	Forest degradation is the gradual reduction in density of biomass due to anthropogenic variables such as illegal logging. The annual average forest area of 28,003 ha was degraded during the period 2005 – 2015 and is a significant source of emissions.

Sources/Sinks	Included?	Justification/Explanation
Removals from forest enhancement	Yes	Forest enhancement is accelerated through natural regeneration and forest enrichment. Over the past 20 years, several programs were implemented to restore forest vegetation. It is estimated that the annual average area of 16,345 ha of forests has been regenerated and enhanced during the period of 2005-2015.
Removals from reforestation	Yes	Vietnam has made great efforts in implementing reforestation programs to convert non-forests area to forested area. These programs contributed considerably to the increase of forest cover, particularly from 2000 onward. It is estimated that the annual average area of reforestation in the program area during 2005 – 2015 was about 75,822 ha.
Emissions and/or removals from conservation of carbon stock	No	The national REDD+ activities are not clearly defined for the conservation of carbon stock. Therefore, conservation of carbon stock is not accounted as it is conservatively assumed that 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 assumed to be included in the above REDD+ activities.

7.2 Description of carbon pools and greenhouse gases selected

The selection of carbon pools and greenhouse gases for the construction of FREL/FRL in the NCC is presented the tables below:

Table A4-2. Selection of carbon pools

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	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	Phuong et al (2009)[9] 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 submission of reference level to UNFCCC have not included this pool. In the future, a stepwise approach is proposed to be applied in MMR to improve the measurement of this carbon 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. 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. In the future, a stepwise approach is proposed to be applied in MMR to improve the measurement of this carbon pool.
Soil Organic Carbon (SOC)	No	IPCC 2006 (Ch. 4, Section 4.2.3.1) indicates that the Tier 1 approach accepting there is no change in forest soil carbon with management or soil carbon

[9] Phuong, V.T, 2008.Final report on studying forest valuation in Vietnam. Ministerial level Research Project. Research Center for Forest Ecology and Environment, Hanoi.

		change is zero for mineral soils. In Vietnam, most of the NCC area are covered by mineral soils (Sam et al 2000). Additionally, as per the "Tool for estimation of change in soil organic carbon in the implementation of A/R CDM activities", estimation is required for afforestation/reforestation activities in which site disturbance is more than 10 percent of the area (Clean Development Mechanism Executive Board 55, Annex 21). As the site disturbance in afforestation/reforestation activities is likely to be less than 10 percent of the area, it is not implemented in Reference Scenario. In the future, a stepwise approach is proposed to be applied in MMR to improve the measurement of this carbon pool.
Harvested Wood Products	No	Not required by the Methodological Framework and is thus excluded.

Regarding the GHG gases, the following gases are included in the monitoring of emissions and removals.

Table A4-3. Selection of green house gases

GHG	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.
CH4	No	Non-CO_2 gases (such as CH_4, N_2O etc.) are emitted only through incidents of biomass burning. The BUR (MONRE, 2014) indicated that total non-CO_2 gases emissions caused by burning of biomass (for example, forest fire) accounted for 0.04% of the total of Vietnam's emissions. In the NCC, the non-CO_2 emissions are estimated to be less than 1% of total emissions of the region and are not significant. Therefore, non-CO_2 gases are not selected.
N2O	No	See the explanation for CH_4 above

8 REFERENCE LEVEL

8.1 Reference Period

The reference period for the ER-Program conformed to the requirements of the Carbon Fund Methodological Framework (2013), which stipulated that the reference period should be a minimum of 10 years from the latest data available prior to 2013. The newly adopted requirements of the FCPF Methodological Framework (2016) for reference period requires that the end of the reference period end date should be no later than 2 years before the first mission of the TAP (i.e. 2016 – 2 years = 2014). Vietnam has a long history of national forest inventory, monitoring and assessment program (NFIMAP) from 1990 and it is implemented through a 5-year cycle. To date, data from the national forest inventories are only available for 1990 – 2010. Vietnam is now implementing NFIMAP period 2016-2020 and the results are now awaiting MARD appraisal and approval.

Based on consultations with the TAP and CFP, it was proposed and agreed that Vietnam would update the Reference Period to 2005-2015, to meet the requirements of the Methodological Framework (2016). The year 2015 is proposed because it is consistent with Vietnam's national forest planning cycles (5 year increments beginning in 1990), and because it provides the most up to date baseline for planning future REDD+ activities and measuring the future changes in emissions and removals. To develop this Reference

Level, Vietnam generated a forest cover map for 2015 following the consistent methodologies used in NFIMAP for generating the previous 2005 and 2010 forest cover maps, and applied Emission and Removal Factors also based on consistent NFIMAP inventory data to estimate total Emissions and Removals over the Reference Period.

The forest cover map for 2010 is defined as the base map for forest type boundaries that are present across years. The 2005 forest cover map has been rectified to match 2010 cover class boundaries where such exist, and the 2010 map was used as the baseline for producing the 2015 map where the same boundaries also existed. To address the concerns raised by the TAP regarding independence of maps and introduction of errors arising when 'differencing' maps. This will also facilitate tracking the time series of change over time for individual parcels, to enable better classification of activities impacting forest cover change and to enable detection of indirect conversion of natural forest to plantation.

Vietnam is choosing to work with the 2005 and 2010 forest cover maps (rather than re-analysing the underlying imagery) because of the significant effort made by multiple international projects in developing and checking those maps, and because the forest cover maps provide the linkage to the estimates of biomass and carbon that can be assessed from the historical forest inventory programs.

8.2 Forest definition used in the construction of the Reference Level

The definition of forests used for Forest Reference Emission Level/Forest Reference Level (FREL/FRL) for Vietnam, follows the definitions provided in Circular 34 (2009)[10]. This definition is in line with the definition of forests used for the national GHG inventory[11]. It is also consistent with the definition of UNFCCC Decision 12/CP.17, categorizes an area as a forest when it meets the following three criteria:

- An ecosystem where the major component is perennial timber trees, bamboos and palms of all kinds of a minimum height of 5m (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 forest plantations are identified as forests if they reach the average height of over 1.5m for slow-growing species, and over 3.0m for fast-growing species and have a density of at least 1,000 trees per hectare.
- Having a minimum tree cover of 10% for trees that constitute the major component of the forest.
- Having a minimum plot area of 0.5 ha or forest tree strips of at least 20m in width with at least three tree lines.

Forest classification is consistent with the government forest classification regulation (Circular 34). The forest stratification used for the construction of the ER-P reference level includes the following five types of forestland and non-forest land as shown in table below.

Table A4-4: Forest stratification

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
6	Non-forest lands	NOF	Non-forest

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

[11] MONRE, 2014. First Biennial Updated Report (BUR) for 2010.

8.3 Average annual historical emissions over the Reference Period

Description of method used for calculating the average annual historical emissions over the Reference Period

Vietnam considers it more transparent to present historical emissions and removals 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. Therefore, the emission and removals are presented separately in the ER-P.

The approach for estimation of historical emissions and removals is based on Activity Data (AD) and Emission Factors (EF). AD is generated spatially using remote sensing information. To detect land use change, land use change maps are generated by overlaying land cover maps between the inventory cycles. Areas are totaled up by change class (changes between cover classes or land remaining the same) across the three map periods, and summarized in tabular form showing the total area represented as sequence of time series change.

Forest carbon densities are estimated by applying allometric equations to measurement data of National Forest Inventory, Monitoring and Assessment Program (NFIMAP). NFIMAP data exist for 2005 (Cycle 3) and 2010 (Cycle 4); there are at present no NFIMAP data available for 2015, so forest carbon densities for 2015 must be estimated through some other means. Vietnam considered several alternatives including (1) averaging Cycle 3 and Cycle 4; (2) projecting the difference between Cycle 3 and Cycle 4 to project an estimate for 2015; and (3) simply using the 2010 estimates, which are considered to be the most reliable, as preliminary estimates of forest carbon densities for 2015. It was decided that the third option, using 2010 forest carbon densities as proxies for 2015, is the simplest and most conservative means for estimating forest carbon densities for 2015. For most forest types, the differences between 2005 and 2010 are very small. The proposed MMR system assumes the continuation of the NFIMAP program in the future and will eventually result in updated EFs. If those figures are substantially different from the figures assumed in the RL, then Vietnam can consider whether the RL should be recalculated using updated data.

The steps for the development of emission and removal factors are as follows:

1) Estimation of AGB at tree level

The estimation of AGB at tree level is based on plot measurement data of NFIMAP cycle 4 (tree species name, DBH, tree height and wood density) and allometric equations developed for the NCC (UN-REDD 2015). The tree level AGB is estimated for all SSP and the following equations are applied as follows:

Table A4-5: Allometric equations applied in AGB estimates

Forest types	Equations	Indicators
1. Evergreen broadleaved forests (including plantations)	1.1. AGB = 0.1245*DBH^2.4163	n = 110; SE = 18.37%; R^2 = 0.99
	1.2. AGB = 0.0421* (DBH^2 * Hmt)^0.9440	n = 110; SE = 16.23%; R^2 = 0.99
	1.3. AGB = 0.699*(DBH^2 * Hmt * WD/10)^0.940	n = 110; SE = 13.73%; R^2 = 0.99
2. Bamboo forests		
B. balcooa	2.1. AGB = 0.1021*DBH^2.2100*H^0.0612	n = 120; SE = 15.2%; R^2 = 0.92
Dendrocalamus membranaceus	2.2. AGB= 0.1527*DBH^2.1044*H^0.1013	n = 80; SE = 18.2%; R^2 = 0.91
B. chirostachyoides	2.3. AGB= 0.4514*DBH^1.5022*H^0.3558	n = 120; SE = 18.2%; R^2 = 0.92
Indosasa angustata	2.4. AGB= 0.3704*DBH^1.6460*H^0.2829	n = 70; SE = 18.2%; R^2 = 0.92

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[12].

2) Calculation of forest biomass

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

$$AGB_i = \sum_{j=1}^{n_i} AGB_{ij}$$

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*;

Forest BGB: To estimate BGB of forests, it is estimated 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 values are adopted from IPCC 2006 as conservative estimation for BGB as follows. RS is 0.205 if AGB is less than 125 t.d.m/ha and is 0.235 if AGB is larger than 125 t.d.m/ha.

$$BGB \quad = AGB \quad \times RS$$

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

TB = AGB + BGB

3) Calculation of forest carbon stock:

Forest carbon stock estimation is calculated based on biomass and carbon fraction (CF). Default value of CF (0.47) is used (IPCC 2006). The formula for calculation is as follows:

$$C \quad = TB \quad \times CF$$

After the carbon stock of all measurement plots is estimated, based on area of measurement plot, the carbon density (i.e., carbon stock per ha) of forest type is calculated as follows:

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[12] 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.

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

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 densities of all plots are estimated, the average value of carbon density for forest type *i* is calculated as follows:

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

Where:

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

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

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

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

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

Ab is the area of bamboo forest (ha);

Cm is the average carbon density (tC/ha) of mangrove forests.

Am is the area of mangrove forests (ha).

Regarding the mangrove forests, there are no measurement plots in the PSU in mangrove forests, however there are a number of studies on biomass of mangroves. A review report on biomass and carbon density suggests that the average weighted carbon density 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 at the national level is 58.0 tC/ha (Phuong et al 2015).

4) Estimation of emission factors (EFs):

Based on carbon densities estimated for all forest types (tC/ha) at different points of time (2005, 2010 and 2015), the EFs are calculated as follows:

EFs (tCO_2e/ha) = (*Ci* – *Cj*) x 44/12
Where:

C_i and C_j are carbon densities of forest type/land use *i* and *j* corresponding to the changes; and

If C*i* > C*j*, such a change is considered to be emissions (higher carbon density land use changed to lower carbon density land use, for example deforestation, forest degradation), otherwise it is considered removals or enhancement (lower carbon stock land use changed to higher carbon stock land uses, including reforestation).

5) Estimation of uncertainty of forest carbon:

Uncertainty of the FREL/FRL is calculated using the Monte Carlo method with the following parameters and their associated uncertainties: AGB, CF coefficient, RS ratio, AD. The uncertainties arose from measurement error and biomass equation are not integrated into the combined uncertainty of FREL/FRL. For parameter CF, the value applied is 0.47 and the default error at 95% CI is 2.7% *(*IPCC 2006, Volume 4*).* For the RS ratio, the value applied is 0.205 for AGB < 125 t.d.m/ha or 0.235 otherwise and the error at 95% CI is 20% *(*GOFC-GOLD sourcebook 2015, Table 2.3.3, page 72*).*

6) Estimation of emissions and removals:

The calculation is consistent with that used in construction of reference level. Based on developed AD and EF, a spread sheet is used to calculate the emissions and removals for monitoring period using Stock Change Method. For land cover changes which result in Emissions, the entire expected emission is assumed to occur over the time period in question. For land cover changes which result in Removals (e.g. forest which increases from poor to medium or medium to rich quality), we apply an Adjustment Factor (AF) ranging from 25% to 50% to reduce the expected Removals in the year they are first observed. This recognizes that forest accretion occurs more slowly over time than do forest removals (IPCC 2006). The Adjustment Factors consist of:

- 25% per 5-year inventory cycle for forest land or plantations which change to a higher biomass forest type, and for non forest to forest conversion. A 25% AF implies an expectation that 4 inventory cycles (20 years) are required for the full accretion of biomass to occur.
- 50% per 5-year inventory cycle for non-forest land which becomes forest plantation. At 50% AF implies 2 inventory cycles (10 years) required for full biomass accretion to occur.

7) Uncertainty assessment and sensitivity analysis of emissions and removals estimates

Monte Carlo method is applied with 10,000 runs for simulation. The simulation is run for 4 parameters that are AGB, AD, RS and CF. Sensitivity analysis is conducted for every single parameter and its standard error is assumed to be very small value (set at 0.0001).

Activity data and emission factors used for calculating the average annual historical emissions over the Reference Period

Activity data

Parameter:	AD(j,i)
Description:	Spatial analysis of 4 parameters: deforestation, forest degradation, reforestation and forest enhancement is conducted for separate periods 2005 – 2010 and 2010 – 2015. The definition of those parameters are as follows: **Deforestation**: The activity of conversion of forests to non-forest land, as identified following the NFIMAP (Including both plot measurements and remotely sensed information) and updates[13]. Where a series of activities including deforestation may have occurred within a single cycle of the National Forest Inventory (NFI). **Forest degradation**: Any activity resulting in a downward shift in terms of carbon density 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. In the case that the deforestation activity occurring as a transitional activity not captured by the NFI, and thus will be reported as degradation. **Reforestation**: Any activity resulting in land use change from non-forest land to forest land. The conversion of forestland into plantations is not considered "reforestation";

[13] Updates were made to the original results of the NFIMAP Cycles 1-4 by the same implementing body the 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.

	Forest enhancement: Any activity resulting in an upward shift of carbon density 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; Emissions associated with deforestation and forest degradation are considered sources. Removals generated by increment of forest biomass through forest enhancement and reforestation are considered sinks.
Data unit:	Hectare (*ha*)
Source of data and description of measurement /calculation methods and procedures applied:	Primary data sources used for construction of reference level are NFIMAP. To date, Vietnam has completed four cycles of the NFIMAP (1991-1995; 1996-2000; 2000 – 2005; and 2006-2010) and has generated a forest cover map for 2015. All forest cover maps of the four inventory cycles plus the 2015 map have been updated using remote sensing images with automated (eCognition) and manual classification and a consistent forest definition has been prepared with the work programs supported by Finland (Karsten Raae et al., 2010), JICA (2012), MARD (Dien 2015) and UN-REDD (2015). During these updates, all forest changes within these inventory cycles are checked for errors in classification and suitable corrections are made to the forest cover maps by reviewing the satellite imagery taken near the time of map creation. Under the ER-P, the updated forest cover maps of Cycle 3 (2000-2005) and Cycle 4 (2006-2010) for NCC and six provinces of NCC were again updated. The 2005 cover class boundaries were matched to the same boundaries where they existed in 2010. The 2010 cover map was used as the baseline, where identical boundaries existed, for establishing the 2015 map. IPCC Approach 3 was used to develop spatially disaggregated AD using updated forest cover maps for 2005, 2010, and 2015 based on remote sensing images (Landsat, Spot 5). Successive maps are overlaid to detect the land use changes for 2 sub-periods 2005 – 2010 and 2010 – 2015. Land use changes for the periods are then aggregated by time series (2005-2010-2015) for NCC.

Value applied

REDD+ activities	2005-2010 (ha)	2010-2015 (ha)
Enhancement	**268,684**	**312,077**
2. EBF_M to 1. EBF_R	18,331	8,115
3. EBF_P to 2. EBF_M	41,588	58,716
4. Other forest to 3. EBF_P	21,628	6,585
4. Other forest to 5. Plantation	2,580	10,022
5. Plantation to 1. EBF_P	0	3,092
6. Non forest to 2. EBF_P	164,905	184,196
6. Non forest to 3. Other forest	19,653	41,350
Stable forest	**2,180,106**	**2,297,483**
1. EBF_R to 1. EBF_R	199,187	156,207
2. EBF_M to 2. EBF_M	394,297	411,986
3. EBF_P to 3. EBF_P	1,045,355	1,090,672
4. Other Forest to 4. Other Forest	104,906	100,768
5. Plantation to 5. Plantation	436,361	537,849
Deforestation	**106,105**	**137,436**
1. EBF_R to 6. Non-Forest	628	848
2. EBF_M to 6. Non-Forest	5,676	3,224
3. EBF_P to 6. Non-Forest	74,792	111,468
4. Other Forest to 6. Non-Forest	25,009	21,896
Degradation	**174,452**	**219,969**
1. EBF_R to 2. EBF_M	32,422	52,590
1. EBF_R to 3. EBF_P	8,188	1,968
1. EBF_R to 4. Other Forest	51	7
1. EBF_R to 5. Plantation	395	0
2. EBF_M to 3. EBF_P	78,251	31,813
2. EBF_M to 4. Other Forest	830	101
2. EBF_M to 5. Plantation	1,495	49
3. EBF_P to 4. Other Forest	13,057	10,005
3. EBF_P to 5. Plantation	7,712	32,727

<table>
<tr><td></td><td>
<table>
<tr><td>5. Plantation to 4. Other forest</td><td>7</td><td>64</td></tr>
<tr><td>5. Plantation to 6. Non forest</td><td>32,045</td><td>90,646</td></tr>
<tr><td>Reforestation</td><td>186,921</td><td>162,255</td></tr>
<tr><td>Non-forest_Plantation</td><td>186,921</td><td>162,255</td></tr>
<tr><td>Stable non forest</td><td>2,228,250</td><td>2,015,294</td></tr>
<tr><td>Total</td><td>5,144,519</td><td>5,144,514</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures applied:</td><td>The accuracy assessment of the forest cover maps for 2005, 2010 and 2015 are made on the basis of existing data at more or less the same year, using the methods of Olofsson 2014.
- Landsat images covering NCC region for 2005, 2010, and 2015 was used for visual interpretation.
- At each of the evaluation sample points, the forest changes were independently evaluated by three experts in the field of remote sensing and forest change monitoring and assessment by applying visual interpretation method.
- 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
Accuracy calculating and Uncertainty by applying Olofsson's method.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>Key uncertainties for determining the above parameters are misclassification of forest types, particularly the changes in forest types to detect forest degradation and forest enhancement. In addition to the use of remote sensing information, such detection also requires ground survey data and information, therefore errors of ground survey including measurement and sampling errors are considered the key sources of uncertainties for identifying forest degradation and forest enhancement.

A total of 541 points are sampled and checked for analysis for 6 mentioned land use categories for 2005 – 2010 and 541 points for 2010-2015. Olofsson's Method[14] is used to estimate accuracy. The accuracy assessment results show that at 95 % confidence level, the overall accuracy of land use change detection is 95.4% for the changes in 2005 – 2010 and 94.5% for changes in 2010-2015.</td></tr>
<tr><td>Any comment:</td><td>None</td></tr>
</table>

Emission factors

Parameter:	$C_{t,i}$ (t = 2005, 2010 or 2015; $1 \le i \le 5$)
Description:	Forest carbon density of forest type i at year t.
Data unit:	Tonne of carbon per ha (tC/ha)
Source of data or description of the method for developing the data including the	Forest carbon densities are estimated using national allometric equations and plot measurement data (DBH) of NFIMAP cycle 3 (for 2005), cycle 4 (for 2010), and cycle 5 (for 2019). Carbon densities for 2015 are interpolated from carbon densities for 2010 and 2019 using the assumption that carbon density change in period 2010-2019 is uniform. The Cycles 3 and 4 inventory data came from a systematic sample across all forest lands. All forest conditions (including REDD+ Activities) are sampled in proportion to the area in which they occur, and are thus reflected in the estimates of AGB. This includes all examples of forest plantation in existence during 2001-2010 (the period of NFIMAP Cycle 3 and 4),

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

spatial level of the data (local, regional, national, international):	The biomass equations are available for evergreen broadleaved forests (including plantations) and bamboo forest. Belowground Biomass is estimated using IPCC default value of 0.24 for forest classes with AGB > 125 t/ha, and 0.20 for forest classes with AGB < 125 t/ha[15]. The total forest carbon is estimated using carbon faction (CF = 0.47). The carbon density of post – deforestation non-forest land is assumed to be zero tC/ha. The carbon density of non-forested land (such as rocky mountain, resident and water areas and other land) is assumed to be zero tC/ha (IPCC 2006 default values). The sources of data used for development of emission factors (EF) are dataset of plot measurement of Secondary Sample Unit (SSU) under NFIMAP cycle 3 (2001-2005, for 2005 EF), cycle 4 (2006-2010 for 2010 EF), cycle 5 (2016-2020 for 2019 EF). The EF for 2015 is interpolated from the EF for 2010 and 2019. The area of SSU is 500 m2 (20 x 25 m). This dataset has been reviewed ad 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. There are 23,680 SSUs of 592 Primary Sample Units (PSUs - 1 ha each) for cycle 3 and 16,080 SSUs of 402 PSUs for cycle 4 in the NCC region and this dataset includes information in tree species name, DBH, tree height. That information is used to apply in national allometric equations[16] to estimate AGB for evergreen broadleaf forests, bamboo forests and plantation. The AGB is estimated at tree level, then scale up to plot level and to a hectare of forests. Based on estimated AGB and IPCC default value of root to shoot ratio and carbon fraction, the forest carbon densities of forests are calculated. Only the other forests which include bamboo and mangrove forests, the carbon density of mangroves is estimated based on scientific literature review report (Phuong et al 2016). Based on carbon densities estimated for forest types, the EF is calculated
Value applied:	(see table below)

Forest types	2005		2010		2015	
	Value (tC/ha)	U (%)	Value (tC/ha)	U (%)	Value (tC/ha)	U (%)
1.EBF_R	171.23	26.00	148.50	9.55	140.50	5.36
2. EBF_M	73.41	9.60	71.22	4.63	72.88	3.35
3. EBF_P	31.70	9.63	29.22	6.36	34.96	4.82
4. Other forests	13.08	18.00	14.76	15.45	20.84	13.61
5. Plantations	20.97	10.60	23.58	21.87	25.08	10.86

QA/QC procedures applied	The data processing and carbon densities calculation process was appraised by a scientific committee before approval.
Uncertainty associated with this parameter:	The significant uncertainties for estimating emission and removal factors are associated with uncertainties of forest carbon density estimation and AD of land use changes. The key uncertainty of forest carbon density estimation is a propagation uncertainty of parameters used for the estimation. Such uncertainties include models for estimating forest above biomass, plots measurement error, and sampling error as mentioned above. However, of those potential uncertainty sources, the error of statistical random sampling and measurement error are not applicable to uncertainties analysis for the parameters as there is no data and information.

[15] Table 4.4. of IPCC 2006. AGB of forests values in Vietnam are less than 125 tones per ha except for Evergreen Rich forest, which has AGB > 125 tones per ha

[16] Under the support of UNREDD, Vietnam has developed allometric equations for aboveground biomass estimation for several forest types such as evergreen broadleaf forests, bamboo forests and deciduous forests. Those equations are also available to use for national level and eco-region (northeast, north central coast, central highland, southeast).

	A propagation error of forest carbon is assessed based on uncertainties of above forest carbon estimates generated from national equations and plot measurement data, errors of carbon fraction and root to shoot ratio.
Any comment:	None

8.4 Estimated Reference Level

ER Program Reference level (updated)

The updated annual reference level for ERP for 2018-2025 is 12.1 million tCO_2-e of emissions and -6.8 million tCO_2-e of removals. Comparing to the reference level presented in ERPD, the updated annual emission and removal reference levels are higher than that of ERPD. Annual emission reference level is 1.8 million tCO_2-e higher (in ERPD it was 10.8 million tCO_2-e) and it is -0.5 million tCO_2-e higher in the updated removal reference (-6.3 million tCO2-e for removal reference in ERPD). The revised reference level (net emissions) is 5,280,261 tCO_2-e per year.

Table A4-6. Estimated emissions and removal reference level for ERP

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 (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2018	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2019	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2020	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2021	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2022	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2023	2,624,811	9,516,700	-6,861,250	NA	5,280,261
2024	2,624,811	9,516,700	-6,861,250	NA	5,280,261

Calculation of the average annual historical emissions over the Reference Period

The average annual historical emissions (resulted from deforestation and forest degradation) and removals (generated by reforestation and forest enhancement) are estimated separately over the reference period 2005 – 2015. The estimation is based on AD and EF/RF and the steps implemented are as follows:

1) Develop emissions and removal matrices of provinces

Using the AD (land use change matrix) of the provinces (for 2005 -2010 and 2010 – 2015) and EF/RF, emissions and removal matrices are prepared for provinces for 2005 – 2010 and 2010 - 2015. Those matrices indicate emissions associated with deforestation and forest degradation and removals resulted from reforestation and forest enhancement[17]. The EF used in this analysis represent the average tCO2e/ha for each forest type, based on a statistical sample across the landscape.

For land cover changes which result in emissions, the entire expected emission is assumed to occur over the time period in question. For land cover changes which result in removals (e.g., forest which increases from poor to medium or medium to rich quality), we apply an Adjustment Factor (AF) ranging from 25% to 50% to reduce the expected removals in the year they are first observed. This recognizes that forest accretion occurs more slowly over time than do forest removals (IPCC 2006).

The Adjustment Factors consist of:

- 25% per 5-year inventory cycle for forest land or plantations which change to a higher biomass forest type, and for non forest-forest conversion. A 25% AF implies an expectation that 4 inventory cycles (20 years) are required for the full accretion of biomass to occur.
- 50% per 5-year inventory cycle for non-forest land which becomes forest plantation. At 50% AF implies 2 inventory cycles (10 years) required for full biomass accretion to occur.

2) Calculate emissions and removals for provinces:

Emissions and removals are accounted for all provinces in NCC based AD and EF using speadsheet, then aggregated to the provincial scale for the period of 2005 – 2015[18].

3) Estimate emissions and removals for NCC

After the emissions and removals of provinces are estimated, they are aggregated for NCC for 2005 – 2010, 2010-2015, and then 2005 – 2015. Based on the adjusted AD resulted from accuracy assessment of forest cover maps, the emissions and removals are re-estimated for NCC. The final emissions and removals for 2005 – 2015 for NCC.

4) Uncertainty analysis

Apply Monte Carlo method to assess uncertainties of emissions and removals estimates for reference level. This analysis is designed in excel. The spreadsheet is available for sharing.

8.5 Upward or downward adjustments to the average annual historical emissions over the Reference Period (if applicable)

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8.6 Relation between the Reference Level, the development of a FREL/FRL for the UNFCCC and the country's existing or emerging greenhouse gas inventory

The Reference Level prepared for the NCC is consistent with Vietnam's Submission on Reference Level for REDD+ Results Based Payment to the UNFCCC. The consistencies include the methodology for RL/REL construction such as forest definition, regional stratification, carbon pools, gases, generation of Emission Factors and Activity Data, and use of NFIMAP dataset etc. The construction of Vietnam's Reference Level for the UNFCCC is based on aggregated emissions and removals estimated for eight agro-ecoregions. However, the Reference Level for the NCC is based on a sum of emissions and removals of six provinces in the NCC region. The Reference Level for the NCC can be considered as a part of Vietnam's Reference Level for the UNFCCC. The difference between such Reference Levels is the reference period. The Vietnam's Reference Level for UNFCCC is from 1995 – 2010, however, for the NCC region it is 2005 – 2015.

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[17] The detailed calculations are available in a separate spread sheet.

[18] As footnote above. The detailed calculations are available in a separate spread sheet.

Such difference is derived from the different requirements for the Reference Level of the UNFCCC and FCPF. One additional difference is that the area estimates for Activity Data produced under the FCPF have been adjusted for bias (following the methods of Olofsson et al 2014); such adjustment was not made to the UNFCCC FREL/FRL.

With regards to the National Greenhouse Gases Inventory (GHGI), the Reference Level relates to the GHG inventory in LULUCF, particularly the Initial Biennial Updated Report (BUR1) of Vietnam for 2010 and the Second Biennial Updated Report (BUR2) for 2014. To date, Vietnam has prepared national GHG inventory for 1994, 2000 and 2010. The estimation of emissions and removals in Reference Level for NCC is more consistent with BUR in terms of forest definition, carbon pools and gases. However, the AD used in the BUR is mainly based on national statistics. Vietnam is in the process of preparing the third BUR and the preparation of Reference Level can contribute to an improvement of estimating the emissions and removals in LULUCF by using the best available forest data generated from remote sensing information and allometric equations for biomass estimation.

Vietnam will consider the improved FCPF methodology of AD and EF estimation for future national GHG inventory updates for LULUCF, which will increase the consistency in reporting. Specifically, Vietnam will continue periodic forest cover mapping under the proposed MMR program, and this consistent mapping will be used for future GHG inventory updates as well as ER reporting. Similarly, Vietnam will update the Emission Factors through the NFIMAP, and will use those data for future national GHG inventory and ER reporting. Finally, Vietnam will explore the utility in including additional carbon pools (soil carbon, dead wood, litter) and any pools which are quantified will be included in both GHG inventory and ER reporting.

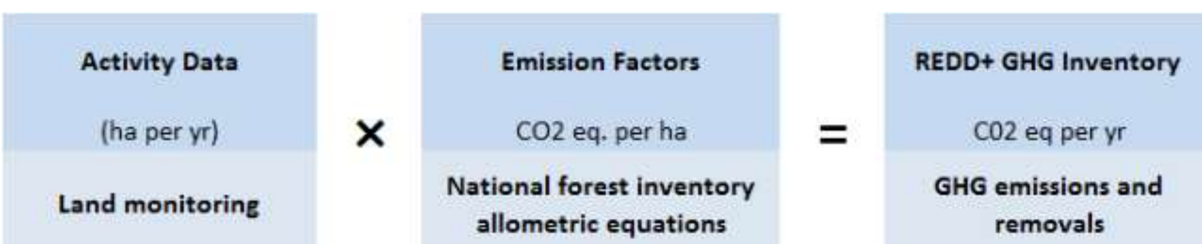
9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

9.1 Measurement, monitoring and reporting approach for estimating emissions occurring under the ER Program within the Accounting Area

Line diagrams

The approach for estimating emissions and removals follows the IPCC guidelines, multiplying the activity data (AD) with the emission factors (EF) (Figure A4)[19].

Figure A4-1: Approach for estimation of emissions and removals



Calculation steps

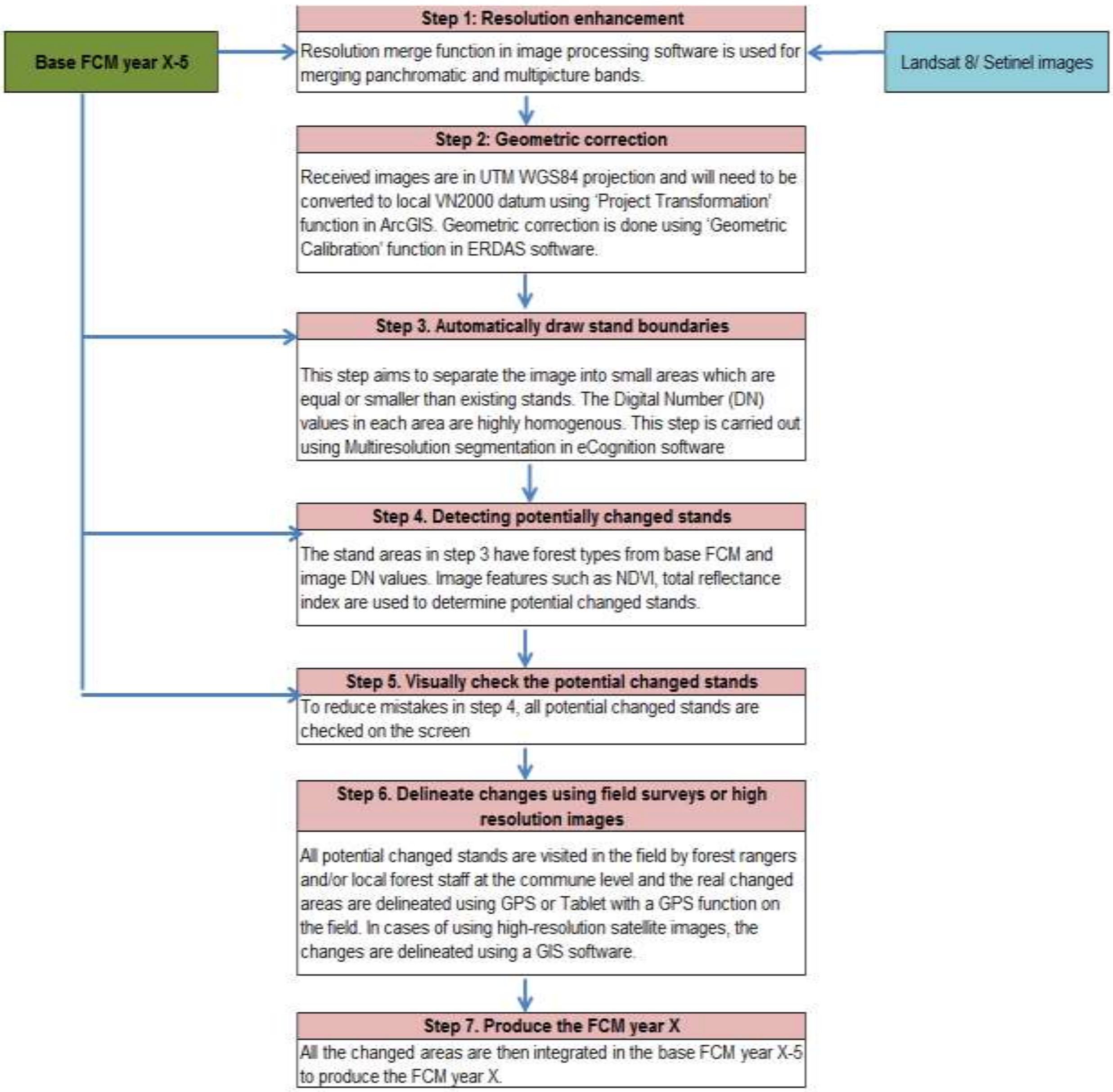
Monitoring activity data for forests using remote sensing:

To maintain the consistency with historical forest cover maps (FCMs) used in FREL/FRL setting, the approach under the measurement, monitoring and reporting (MMR) of the ER-P to generate FCM year X

[19] The forest definitions, stratifications, REDD+ activities, carbon pools and gases to be monitored, change matrix are all standardized and follow those already described in Section 8.

is proposed as follows: (1) using medium resolution remote sensing imagery to identify the potential forest change areas compared to the base FCM year X-n, where n is either 4 or 5; (2) using ground surveys and/or high resolution remote sensing imagery to delineate all identified areas of changes; (3) reference all final forest strata boundaries to the boundaries existing in the base FCM year X-n, with the forest cover map year X-n as the original basis, to produce the FCM year X. The **Figure A4-1A4-2** summarizes the processing steps applying Approach 3 for generating the FCM year X based on medium-resolution satellite images and the FCM year X-n.

Figure A4-1: Approach for generation of the FCM year X from base FCM year X-n (n = 4 or 5)



The land cover for monitoring includes 6 following types that are consistent with that used in construction of reference level for the ERP:

- Evergreen broadleaf - Rich (EBF-R)
- Evergreen broadleaf - Medium (EBF-M)

- Evergreen broadleaf - Poor (EBF-P)
- Other forest
- Plantations
- Non-forest land

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 2. 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 2 images are considered to be the most suitable[20].

As for Step 6, high resolution images such as VNREDSat-1, SPOT-6, and SPOT-7 which could be used. One advantage of delineating the changes using GPS or tablet that this process can allow identification of the causes of forest changes.

Generating a forest and land cover change map and matrix:

By using the above procedure, FCM year X are generated for each province in the NCC region in a manner consistent with the methods used to generate the forest cover maps used in 2005-2010-2015 for the Reference Level. Each successive map has its boundaries registered to the previous map to maintain consistency in the time series over time. The provincial forest and land use change maps period year X-n to year X are generated by intersecting the provincial FCMs in year X with the corresponding provincial FCMs in year X-n for all the NCC provinces. They are then combined to generate a regional NCC forest and land cover change map. Finally, the resulting areas of Activity Data are adjusted based on statistical analysis of the accuracy assessment described below (e.g. the methods of Olofsson 2014).

The NCC forest and land cover change maps are used to update the time series database of change sequences for individual parcels. The time series for individual parcels are tracked over time to improve the classification of the Activity Data (deforestation, degradation, reforestation, etc.) and to identify areas where forests grow. Adjustment Factors are applied to adjust (reduce) the rates of Removals for land changing from a lower biomass to higher biomass forest class. Land parcels which transition from forest to non-forest, then later from non-forest to plantation, are counted for FCPF purposes as Reforestation/Afforestation; they are tracked as a separate forest-to-plantation class, and the conversion from non-forest to plantation on these land parcels are not counted as Carbon Removals.

Accuracy assessment of AD

As described above, AD is generated from overlaying two forest cover maps at two different dates. Such maps are subject to interpretation errors and the role of the accuracy assessment is to characterize the frequency of errors for each land cover change class in each map and to use this information to obtain unbiased estimates of the area for each change class (Olofsson et al 2014).

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 preprocessing (correct geo-location);

[20] 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 2 satellite images 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.

- Cartographic standards (i.e., land category definitions and minimum mapping unit);
- 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 and adjusting strata sizes 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 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 during the ERPA with the assistance of the Open Foris Collect Earth software. A stratified sampling method will be used to randomly generate the observation points. At a 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. (2014) 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.

Estimating emission factors:

Dataset of NFIMAP cycle 5 (2016-2020) and cycle 6 (2021-2025) is used for the construction of emission factors. The use of this dataset is consistent with the national reference level and the datasets include measurement data of secondary sample units (SSUs) in primary sample units (PSUs)[21].

Sampling design:

After the completion of Cycle IV, of NFIMAP, Vietnam 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 be implemented in the 2016-2020 and subsequent cycles. The NFA Project has successfully developed an improved sample plot system that maintains the consistency with the old sample system but is more efficient. This improved sampling design was reviewed by international experts from United States Forest Service and the World Bank and was highly regarded. This sampling design was chosen in the NFIMAP period 2016-2020 (under the National Target Programme for Sustainable Forest Development period 2016-2020).

Since this is a systematic sample across the landscape, it will capture any changes in carbon removals occurring due to the ER program interventions and other forest management activities, in proportion to the area of the activities across the landscape. This improved sample plot system is also function as part of the national Measurement, Reporting and Verification (MRV) system for REDD+. Therefore, in order for the MMR system in the NCC region be consistent with the emerging national MRV system, the improved sample plot system proposed by the NFA Project is selected for generating the EFs for the MMR system in the NCC region.

[21] The datasets are available at FIPI. The access of the data needs to be authorized by VNForest

The sample plots system is designed by the systematic method covering whole six provinces (Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue). On each intersection (grid point) one cluster is established (see **Error! Reference source not found.**).

Main parameters of the sampling design are:

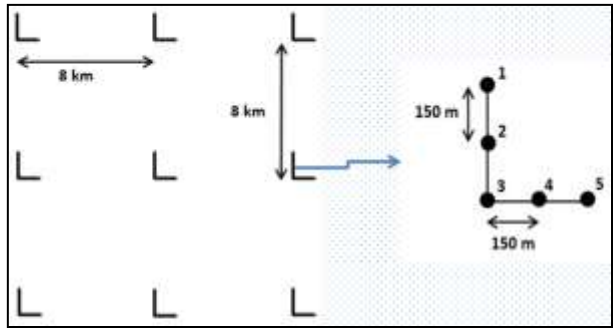
The distance between the clusters is 8km x 8km;

The cluster is in L shape;

The number of the sample plots in one cluster is five; and

The distance between the sample plots is 150m.

Figure A4-2: Shape and distance between clusters sample plots



There are 453 clusters with 2,265 plots in the NCC region. The numbers of clusters and plots per provinces are provided in Table 9.1. The precise locations of the sample plots will be kept confidential, so as to avoid possible manipulation of the results over time.

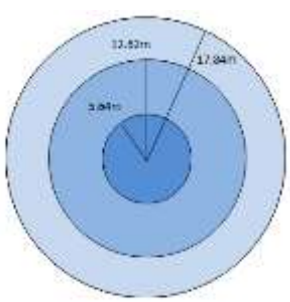
Table A4-6: The number of clusters and plots by provinces in the NCC region

No	Province	Number of clusters	Number of plots
1	Thanh Hoa	84	420
2	Nghe An	160	800
3	Ha Tinh	42	210
4	Quang Binh	75	375
5	Quang Tri	45	225
6	Thua Thien Hue	47	235
Total		**453**	**2,265**

Plot design:

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 (**Error! Reference source not found.**). The distance mentioned here refers to horizontal distance.

Figure A4-3: Sample plot design



- Sub-plot with the area of 100 m^2 and radius of 5.64m (SP3): Measuring trees with DBH ≥ 6 cm; measuring bamboos with DBH ≥ 2 cm
- Sub-plot with area of 500m^2 and radius of 12.62m (SP2) to measure): trees with DBH ≥ 15 cm
- Sub-plot with area of 1,000m^2 and radius of 17.84m (SP1) to measure): trees with the DBH > 25cm

Estimation of biomass and carbon densities for all forest types in 2019:

The aboveground biomass (AGB) of individual trees in the SSUs will be estimated using AEs developed by UN-REDD Vietnam for NCC (Gael Sola et al, 2014). Under the UN-REDD Vietnam, a number of AEs for tree level biomass estimation are developed for national and major eco-regions (northeast, NCC, central highland and southeast). A single equation is also developed for national scale application. The equations are prepared for evergreen broadleaf forests, deciduous forests and bamboo forests that cover most forest area in Vietnam, particularly evergreen broadleaf forests. There are several choices available for using the developed AEs depending on data availability measured such as DBH only; DBH and tree height; and DBH, tree height and wood density (WD). The AEs using different predictors have different accuracies. Of these three predictors, DBH can be measured quite accurately. The NFIMAP data can only estimate the tree heights and WD of woody trees indirectly via height curves and species identification, which can generate additional but often unknown uncertainty. Therefore, tree height and WD are not used as predictors for forest carbon density estimation in this work.

Calculation of aboveground biomass (AGB) for individual trees and bamboos:

1) AGB estimation of trees in evergreen broadleaf forests (including plantations): the following AE is used (Huy, 2014):

$$AGB = 0.121155 \times DBH^{2.415395} \quad (1)$$

(observation = 311; MAE% = 33.6%; adjusted R^2 = 0.854)

Where:

AGB is above ground biomass expressed in kg;
DBH is diameter at breast height expressed in cm;

2) Aboveground biomass estimations for bamboo forests, the equations used are based on bamboo species. The equations are as follows (Phuong *et al*, 2014).

- *Bambusa balcooa*:

$$AGB = 0.0612 \times DBH^{2.0848} \times H^{0.2778} \quad (2)$$

(observation = 120; MAE% = n.a; adjusted R^2 = 0.875)

- *Dendrocalamus membranaceus*:

$$AGB = 0.1012 \times DBH^{1.9667} \times H^{0.2778} \quad (3)$$

(observation = 100; MAE% = 16%; adjusted R^2 = 0.875)

- *Bambusa chirostachyoides*:

$$AGB = 0.3558 \times DBH^{1.2154} \times H^{0.2778} \quad (4)$$

(observation = 120; MAE% = n.a; adjusted R^2 = 0.875)

- *Indosasa angustata*:

$$AGB = 0.2829 \times DBH^{1.4306} \times H^{0.2778} \quad (5)$$

(observation = 70; MAE% = n.a; adjusted R^2 = 0.875)

Where:

AGB is above ground biomass expressed in kg;

DBH is diameter at breast height expressed in cm;

H is the height expressed in m.

Calculation of carbon stock for each SSU

Step 1: Estimating AGB of SSU.

Total AGB of trees in each SSU is estimated as the sum of all individual tree AGBs in this SSU.

$$AGB\_T_i = \sum_{j=1}^{n_i} AGB\_T_{ij} \quad (6)$$

Where: AGB_T_i is the total AGB of trees in SSU *i*, n_i is the number of trees in SSU *i*, and AGB_T_{ij} is the AGB of the *j*th tree in SSU *i*.

Total AGB of bamboos in each SSU is estimated as the sum of all individual bamboo AGBs in this SSU.

$$AGB\_B_i = \sum_{j=1}^{m_i} AGB\_B_{ij} \quad (7)$$

Where AGB_B_i is the total AGB of bamboos in SSU *i*, m_i is the number of bamboos in SSU *i*, and AGB_B_{ij} is the AGB of the *j*th in SSU *i*.

Since the area of tree measurement in each SSU is 1000 m^2 but the area of bamboo measurement in each SSU is only 100 m^2, the total AGB of both trees and bamboos in SSU *i*, AGB_i, is:

$$AGB_i = AGB\_T_i + 10 \times AGB\_B_i \quad (8)$$

The AGB for each SSU is in the unit of kg per 1000 m^2. Apply the following formula to convert to the unit of ton per ha:

$$tAGB/ha_i = AGB_i \times \frac{10000}{1000 \times 1000} = AGB_i/100 \quad (9)$$

Step 2: Estimating below-ground biomass (BGB) of SSU.

BGB is be estimated for each SSU as follows:

$$tBGB/ha_i = tAGB/ha_i \times R \quad (10)$$

Where: $tBGB/ha_i$ is the BGB of SSU *i* in the unit of ton per ha; *R* is the root-to-shoot ratio. As Vietnam has no specific data on R and the development of such factor is very costly, therefore, the default values of *R* of 0.20 for forest type with AGB < 125 tdm/ha and *R* of 0.24 for forests with AGB ≥ 125 tdm/ha (IPCC 2006) are used for calculation of BGB.

Step 3: Estimate total living biomass (including AGB and BGB) for each SSU.

Total living biomass in SSU *i* is the sum of AGB and BGB of this SSU:

$$tB/ha_i = tAGB/ha_i + tBGB/ha_i \quad (11)$$

Step 4: Estimating carbon stock of each SSU.

Carbon stock of SSU *i* in the unit of ton carbon per ha, tC/ha_i, is calculated as follows:

$$tC/ha_i = tB/ha_i \times CF \quad (12)$$

Where tB/ha_i is total living biomass of SSU *i* in tdm per ha; *CF* is the carbon fraction coefficient. This work applied the IPCC default value for CF, which is 0.47 (IPCC, 2006).

Calculation of carbon density for each forest type

The carbon density (i.e., average carbon stock per ha) of forest type *i* is the mean of the carbon stock per ha over all SSUs in this forest type.

$$\overline{tC/ha}_i = \frac{1}{np_i}\sum_{j=1}^{np_i} tC/ha_{ij} \quad (13)$$

Where np_i is the number of SSUs in forest type *i*; tC/ha_{ij} is the carbon stock per ha of SSU *j* in forest type *i*.

Regarding the other forests category (bamboo and mangrove forests are combined), its carbon density is calculated using weighted value as follows:

$$\overline{tC/ha}_i = \frac{Cb * Ab + Cm * Am}{Ab + Am} \quad (14)$$

Where: *Cb* is the carbon density (tC/ha) of other forest (excluding mangrove forest) calculated from its biomass using equations and plot data
Ab is area of other forest excluding mangrove forest (ha) derived from a forest cover map
Cm is the carbon density (tC/ha) of mangrove forest
Am is area of mangrove forest (ha) derived from a forest cover map.

Regarding the mangrove forests, there are no measurement plots in PSU in mangrove forests, however there are a number of studies on biomass of mangroves. A review report on biomass and carbon stock suggests that the average weighted carbon density for mangrove forest in the North (Northeast, NCC and South Central Coast) is 35.2 tC/ha and in the South (Southeast and Southwest) is 64.4 tC/ha and at national level is 58.0 tC/ha (Phuong *et al*, 2015).

Parameters monitored:

Parameter:	Cover changes over 2015-2019
Description:	Cover change following 6 land uses: Evergreen broad leaf forest – rich (EBF-R); Evergreen broad leaf forest – medium (EBF-M); Evergreen broad leaf forest – poor (EBF-P); Other forests; Plantation and non forests.
Data unit:	Ha over 2015-2019
Value monitored during this Monitoring / Reporting Period:	

REDD+ activities	AD 2015-2019 (ha), 90% CI
Enhancement	**102,266**
2. EBF_M to 1. EBF_R	848
3. EBF_P to 2. EBF_M	8,380
4. Other forest to 3. EBF_P	288
4. Other forest to 5. Plantation	5,431
5. Plantation to 1. EBF_P	272
6. Non forest to 2. EBF_P	53,043
6. Non forest to 3. Other forest	23,581
5. Plantation to 4. Other forest	10,423
Stable forest	**2,721,879**
1. EBF_R to 1. EBF_R	161,909
2. EBF_M to 2. EBF_M	517,945
3. EBF_P to 3. EBF_P	1,245,396
4. Other Forest to 4. Other Forest	143,531
5. Plantation to 5. Plantation	653,098
Deforestation	**27,727**
1. EBF_R to 6. Non-Forest	89
2. EBF_M to 6. Non-Forest	1,425
3. EBF_P to 6. Non-Forest	22,952
4. Other Forest to 6. Non-Forest	3,260
Degradation	**146,441**
1. EBF_R to 2. EBF_M	1,302
1. EBF_R to 3. EBF_P	2,436
1. EBF_R to 4. Other Forest	1,842
1. EBF_R to 5. Plantation	66
2. EBF_M to 3. EBF_P	845
2. EBF_M to 4. Other Forest	1,028
2. EBF_M to 5. Plantation	895
3. EBF_P to 4. Other Forest	25,588
3. EBF_P to 5. Plantation	34,935
5. Plantation to 6. Non forest	77,503
Reforestation	**212,193**
6. Non-forest to 5. Plantation	212,193
Stable non forest	**1,934,016**
Total	**5,144,521**

Source of data and description of measurement/calculation methods and procedures applied:	2019 forest cover map was developed based on remote sensing information (Sentinel 2 and Landsat 8 images). The pre-processing remote was applied. The images segmentation and classification method for forest cover classification was applied. Training samples were developed for images interpretation using eCognition software. Overlaying 2015 cover map and 2019 cover map to detect changes. Independent images were used to assess accuracy of the cover change detection
QA/QC procedures applied:	• Standard procedure for generating the forest cover map was applied QC/QC at some main step checking as: image data collection, Data pre-processing, Objet-based classification, illogical conversion checking. • SOP for Accuracy assessments of the forest cover maps year 2015 and year 2019 are based on interpretation of high-resolution satellite images (Planet) and Google Earth image Google earth engine time series. The 5% sample was used for crosscheck (re-interpretation of independent expert) at sample respond steep, using stratified sampling and applies the method described in Olofsson et al. (2014) to calculate the overall accuracies and area adjusted at CI 90%.
Uncertainty for this parameter:	Cover change are grouped into REDD+ activities (deforestation, forest degradation, forest enhancement and reforestation) and allocated a degree of uncertainty, calculated by means of an assessment of accuracy based on Sample based analysis (Random stratification method). Margin of Error (MoE) of Deforestation (forest 2015 converted to non-forest land 2019) is 27.1% at CI of 90%. MoE of Forest degradation (high carbon density forest in 2015 converted to other low carbon density forest-land in 2019) is 15.0 % at CI of 90%. MoE of Reforestation (non-forest land in 2015 converted to forest land in 2019) is 5.7 % at CI of 90%; and MoE of Forest enhancement (low carbon density forest in 2015 converted to other high carbon density forest-land in 2019) is 13.5% at CI of 90%
Any comment:	

9.2 Organizational structure for measurement, monitoring and reporting

Organizational structure of agencies associated with MMR is provided in
Figure 1A4-5. The MMR is an integral part of the overall M&E system for the ER-P, other issues, for example, monitoring of safeguards is covered separately and is integrated into the M&E system.

Local communities participate in monitoring activities under Article 32.2 of the current Forest Protection and Development Law (2004), which specifies that "Forest owners shall have to report 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:

Directly, as forest owners (individual households or collectively as village communities under community forest management); or

Indirectly as subcontracted service providers to larger state-managed forest owners (e.g. state forest companies or protected area management boards).

Figure A4-5: Responsibility of the relevant Ministries, agencies and localities

1) Ministry of Agriculture and Rural Development (MARD)

MARD acts as manager of the ER P and organises a central PMU to manage the implementation of the ER-P

2) Vietnam Administration of Forestry (VNFOREST)

The VNFOREST will supervise the forest monitoring process in the Accounting Area, including:

*Cooperate with the CPMU in selecting suitable national and international consultants;
*Connect with People's Committees, branches and agencies of provinces in MMR implementation at provincial level;
*Organize annual and final quantity and quality checks of the MMR system and receive outcomes and register carbon certificates for the Accounting Area
*Updates the central forest database annually.

3) Program Management Unit (CPMU)

Provide support to MARD in activities such as

*Approval of the MRV implementation plans in six provinces, and review technical issues, procedures and guidance on field measurement, field data collection, quality control, biomass estimation methods, and technical guidelines of each specific work step

*Supports MARD in for the approval of cost estimates and in identification of financial resources
*Selects national service providers and national consultant teams for implementing change detection using satellite imagery for the ER-P, field verification and update of forest cover maps, accuracy assessment of the land cover change map, calculation of emission reduction, uncertainty assessment of emission reduction results
*Selects 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 the PPCs in establishing provincial MMR teams to verify the potential changes identified by remote sensing and update the confirmed changes to the provincial forest database
*Cooperate with the PMU to develop resource plans (human resource and financial resources) for MRV implementation at the provincial level

5) Forest Inventory and Planning Institute (FIPI)

FIPI has been implementing the NFIMAP and this data was used to develop the FREL/FRL for the ER-P. FIPI is also the main agency to implement the forest inventory step of the National Forest Inventory and Statistics (NFIS) for the period 2011-2016 and has a mandate to implement the improved NFIMAP in the future, it is therefore expected that FIPI will implement the following work:

*Develop standard technical guidelines including a field data collection and survey manual; satellite imagery processing manual; QA/QC guidelines and forms; field data management and processing manual
*Conduct of forest change detection using remote sensing
*Organize field inventory and quality control
*Conduct training and support knowledge transfer to provincial MMR teams on forest monitoring, measurement, field verification and update of activity data and forest cover maps;
*Provide guidance to national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission reductions

6) Support from central specialized agencies

The central specialized agencies such as Vietnam Academy of Forest Science (VAFS) and Vietnam National University of Forestry will act as 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

Local communities are expected to participate in the monitoring, pilots are now in place in three provinces in the NCC and they are planned for all provinces to introduce the commune PFMS to mobile and electronic equipment such as tablets for forest monitoring system that will link with FORMIS

The selection and management of GHG related data and information

The selection of GHG related data and information

Currently, Vietnam's national forest monitoring system consists of three elements:

(1) National Forest Inventory, Monitoring and Assessment Program (NFIMAP)

Based on a series of Prime Minister's Decisions, NFIMAP has been implemented by FIPI since 1991. So far, four 5-year cycles (Cycle I: 1991-1995; Cycle II: 1996-2000; Cycle III: 2001-2005; and Cycle IV: 2006-2010) have been completed. It is, however, not being implemented for the period 2011-2015. This is because a NFIS (see below) is being implemented during this period. The NFIMAP period 2016-2020 has been completed at the end of 2020 and the results are awaiting appraisal and approval by MARD. The Program uses remote sensing in combination with ground surveys to monitor forest resources changes. Each cycle has generated provincial forest cover maps at the scale of 1:100,000; regional forest cover maps at the scale of 1:250,000; and a national forest cover map at the scale 1:1,000,000. Data from a systematic sample plot system were also collected in each cycle. The forest cover maps and sample plot data of NFIMAP Cycle III and IV are used for FREL/FRL setting in the Accounting Area. The MMR of the ER-P is based mainly on the NFIMAP. The sample plot data are used for EFs calculation and the forest cover maps of NFIMAP are used for AD generation in the Accounting Area.

(2) National Forest Inventory and Statistics (NFIS) Projects

Based on Prime Minister's Decisions, several NFIS Projects have been carried out in the past and the latest NFIS Project was being implemented during 2011-2016. In the latest NFIS Project, there are two stages in generating the forest cover maps: (i) "Forest survey stage" - interpretation of RS imagery will be used in combination with ground surveys to generate non-cadastral-dossier-based forest cover maps (which are called the "forest inventory maps"); (ii) "Forest statistics stage" - the forest inventory maps will be used as inputs to overlay with the cadastral-based forest owner boundary maps to generate the cadastral dossier-based forest cover maps (which are called the "forest statistics maps"). The forest statistics maps will be printed out as a deliverable to each forest owner for verification and revised as necessary. As the generation of forest statistics maps employs a participatory method, higher accuracy is expected compared to the forest inventory maps.

The scales of forest cover maps are 1:10,000 or 1:25,000 for the commune level, 1:50,000 for the district level, and 1:100,000 for the provincial level. During the forest inventory stage, a system of sample plots is inventoried to estimate the mean volume stocks for each forest type. These sample plot data can also be used to estimate the mean carbon stocks in AGB pool for each forest type. The main agency to implement the forest inventory stage is FIPI under MARD. For the forest statistics stage, the main actors are provincial authorities and local forest owners with the technical support from national institutions such as FIPI, Vietnam National Forest University and Vietnam Academy of Forest Sciences.

Due to the coarse frequency (almost every ten years) and the different approach on generating the FCMs, the FCMs of NFIS will not be used to generate the AD the ER-P. However, these FCMs can be used as a reference layer for AD verification and improvement.

(3) Annual Forest and Forestry Land Resources Monitoring and Reporting Program (Program No. 32 or FRMS)

This Program has been conducted by FPD under VNFOREST since 2001 following the Directive No. 32/2000/CT-BNN-KL dated 27/03/2000 by MARD. Based on forest baseline maps of the latest NFIS Project, forest rangers collect information on changes in the communes under their responsibility, and then update these changes in a database. These updates are usually based on reports from forest owners and do not requires remote sensing imagery or field surveys. Data are then aggregated through the FPD system from commune to district to province up to the central level. The Program has generated a dataset on area of forest and forestry land, broken down by drivers, forest owners, forest functions, and administrative units. However, this dataset still has some limitations, including: (i) the data are just for forest area; there is no data on forest stocks; (ii) the data on area changes cannot be tracked spatially as they are not associated with maps; and (iii) Recently, with support from JICA, this element has been improved by addressing limitations on accuracy, credibility, transparency and quality assurance of Program no. 32. Where forests are allocated to villages a Village Based Forest Patrolling Team will be established and undertake forest patrols and report to commune-based forest rangers. The team will conduct field measurements of forest change and submit the collected data to a data server. Satellite images and photographs are used to verify forest changes, and the resulting information is used to update forest cover maps and the use of a tablet-based approach will allow update information to be sent to a data server.

Among the three systems above, NFIMAP is the main source of information to construct FREL/FRL and calculate REDD+ emission reductions. FRMS is not integrated yet to the MRV for REDD+ but contributes alongside NFIMAP to the monitoring of the National REDD+ Action Program, and its provincial plans.

The FRMS is the main data source for official forest area in Vietnam however it is not used for the REDD+ MRV for the following reasons:

- FRMS data was not used for the FREL/FRL construction. Therefore, it couldn't be used for the calculation of REDD+ results for the sake of consistency.
- FRMS mainly provides updates on deforestation and reforestation; it is challenging to obtain timely updates on changes in forest conditions using FRMS system (due to its forest stratification of 98 forest types). Therefore, this prevents calculating reduced emissions from forest degradation and enhanced removals from forest restoration based on FRMS data.
- FRMS doesn't include the measurement of forest plots for monitoring timber volumes and forest carbon stocks as a basis to update EF/RF.

However, FRMS contains invaluable information on forest ownership and especially on new forest plantations which cannot be easily interpreted using medium resolution satellite images. Thus, Vietnam is working on integrating this system into the safeguards information system for REDD+.

The management of GHG related data and information

All of the GHG related data and information are managed by VNFOREST using an information system. This information system has a GIS database that store all the maps and data collected by the MMR 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 factors
- Average annual emissions over the Reference Period
- Adjusted emissions, if applicable; and
- Any spatial data used to adjust emissions, if applicable.

Processes for collecting, processing, consolidating and reporting GHG data and information

For the ER-P to be performance-based, a MMR is needed to estimate ERs generated by the ER-P. To be consistent with Decision 11/COP19, the MMR will be built based on existing forest monitoring systems.

As mentioned in Section 9.1.5, the proposed MMR will rely on an improved Annual Monitoring of Forest and Forestry Land Programme, which uses NFIS results as a base, to generate the AD. The improved NFIMAP proposed by the NFA Project will be used to generate EFs/RFs for the MMR of the ER-P.

The ER-P, when approved, will be nested into the national REDD+ implementation to avoid double accounting of emission reduction and/or removal enhancement at the national level. This means that the FREL and/or 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-P to FCPF Carbon Fund following required template, the ER-P also needs to report biennially its performance to the Vietnam REDD+ Office (VRO), which is the focal point for national REDD+ implementation and has the mandate to oversee and coordinate all REDD+ projects/programs in Vietnam, to be included in Biennial Report Updates and submitted to UNFCCC. Information to be reported to VRO includes:

- FREL and/or FRL of the Accounting Area, prepared on the basis of agreed guidelines (Decision 12/CP.17 and the FCPF Methodological 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/or 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
- Information on how safeguards are respected and addressed (Decision 1/CP.16) in the ER-P.

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 adherence to the guidelines; and
- The results are accurate, to the extent possible.

Systems and processes that ensure the accuracy of the data and information

The accuracy of field measurement data is ensured and controlled by a quality assurance/quality control (QA/QC) protocol.

The accuracy of AD is ensured by conducting an accuracy assessment of the forest cover map following the method of Olofsson (2014). In the case the overall accuracy of the forest cover map is below a threshold (70%), more ground truthing is conducted to enhance the accuracy of the forest cover map above this threshold.

The accuracy of EF and emission reduction is ensured by organized a scientific committee of 5-7 experts having deep knowledge on REDD+ and GHG inventories to appraise the results.

Design and maintenance of the Forest Monitoring System

In Viet Nam, the Development of Management Information System for Forestry Sector – Phase I (FORMIS I) Project (2009-2013) has 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 standardized manners; 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 limitation, 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 has started in May 2013 and will last until 2018. FORMIS II aims to integrate most of forest resources data including the results of the NFIS 2011-2016 into the system developed by FORMIS I. If the proposed ER-P is approved, the Government of Viet Nam 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-P.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

There are standard operating procedures for: (1) conducting plot measurement in the field, (2) inputting the field data into a database using a software developed based on FAO's Open Foris Collect, (3) Field data processing, calculation and reporting, (4) Forest cover mapping. These SOPs are available in Vietnamese as NFIMAP's technical guidelines.

A QA/QC protocol for field measurement data is also available. The QA/QC team controls the quality of measurements of the plots measured by other field teams. 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 controlling measurements are conducted within 1–2 weeks after the measurements by the initial team. 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. 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 oversees 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 considered 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.

Role of communities in the forest monitoring system

The role of local communities in the implementation of the proposed ER-P forest monitoring system is as follows:

- Identifying and monitoring the key drivers of forest cover change, forest degradation, and carbon stock enhancement across the landscape;
- Assisting in field data collection for estimating forest carbon stocks and EFs;
- Assisting in accuracy assessments of (spatial and non-spatial) activity data generated for REDD+, for verifying or validating remote sensing products; and
- Accessing AD, EF and emission reduction information from the national REDD+ information system and conducting basic analysis to inform management interventions.
- Participatory forest monitoring under the proposed ER-P will be integrated into a modified annual monitoring of forest and forestry land program to be implemented by the FPD, which has the mandate and human resource capacity (at all levels of administration from commune to national level), to engage with forest owners and local communities[22].

9.3 Relation and consistency with the National Forest Monitoring System

A measurement, monitoring and reporting (MMR) system for implementation of Vietnam's REDD+ has been developed based on the existing programs/projects. The NFIMAP has been used to generate the AD and EFs while the NFIS in combination with the Program no. 32 have been used to verify and improve the AD generated by NFIMAP as well as providing safeguards information. This system allows sub-national forest monitoring at the provincial level. Provincial forest cover maps will be generated every 5 years, based on medium resolution satellite imagery with the previous map as a base for generating AD. Since the Accounting Area of the ER-P consists of six provinces, the AD of the ER-P are aggregated from all data generated by the sub-national forest monitoring operating in each of the six provinces so the AD are fully consistent with the national measurement, monitoring and reporting system for REDD+. The MMR relied on an approach which relies on the use of medium resolution satellite imagery and the base FCM year X-5 to generate the AD.

The plot measurement data of NFIMAP are used to generate EFs for the MMR of the ER-P. The NFIMAP will generate the EFs at the regional level every 5 years, and the latest EFs were generated in 2019 based on the NFIMAP period 2016-2020 (all the sample plots have been inventoried by the end of 2019). Since the Accounting Area of the ER-P covers fully one region (the NCC region) of Vietnam, the EFs of the ER-P MMR are also calculated based on the same raw plot data, although, the equations applied to calculate the EFs are somewhat different (the equation applied to calculate the AGB of timber trees for national REDD+ reporting uses DBH, Height and WD as three input variables while that applied in ER-P MMR uses DBH as the only input variable).

[22] Consistent with the Criterion 16 of the FCPF Carbon Fund Methodological Framework.

Since the NFIMAP is a national program, its technical procedures are all standard technical procedures for Vietnam. Therefore, the ER-P MMR, which is based on data generated by the NFIMAP, will also follows these standard technical procedures in Vietnam.

10 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

10.1 Identification and assessment of sources of uncertainty

Sources of uncertainty	Analysis of contribution to overall uncertainty
Activity Data	
Measurement	The sources of uncertainty associated with the use of satellite imagery: 1) the quality and suitability of the satellite data in terms of spatial and temporal resolutions, 2) the consistency and quality of radiometric and geometric preprocessing of annual images data, 3) the thematic and cartographic standards such as the land cover type and the minimum mapping unit, and 4) the interpretation procedure from either automatic classification of the imagery or the visual interpretation, 5) the error for visual interpretation of sampling in SAE.
Representativeness	This source of uncertainty is related to the representativeness of the estimate which is related to the sampling design. If the sample is not representative for the area of interest or the time of interest (e.g. not all elements of the population or region of interest are included in the sampling frame; . deforestation is not measured for the period of interest), the estimate given by the sample will not be representative and this can be a cause of bias. Biases must be avoided as far as practical and this can be avoided through a correct sample design which can be ensured through adequate QA/QC processes. This source of uncertainty might be High or Low depending on the circumstances and REDD Countries may assess the magnitude. Vietnam assesses this source of uncertainty is low.
Sampling	SRS (Stratified random sampling) method was applied for AD sampling desgin.
Extrapolation	The SAE of AD was carried out at the forest/nonforest level, then the resulting estimates of AD were allocated back to the 5 strata proportionally to mapped area. AD estimates at the stratum level are needed in order to combine with stratum-specific EFs to estimate emissions and removals. However, evolving understanding has raised the concern that this may be biased: for example it assumes that deforestation and degradation happen equally across all forest types in proportion to the mapped forest type area, but in reality, deforestation and degradation rates may not be constant for all forest types.
Approach 3	IPCC Approach 3 was used to develop spatially disaggregated AD using updated forest cover maps for 2005, 2010, 2015 and 2019 based on remote sensing images (Landsat, Sentinnel 2). Successive maps are overlaid to detect the land use changes for each periods. Land use changes for the periods are then aggregated by time series (2005-2010-2015 -2019) for NCC.
Emission factor	
DBH measurement	Measurement of DBH, H, and plot delineation are subject to errors. Errors may be caused by multiple factors such as poor training, poor measurement protocols, etc. While measurement errors are significant at the tree level, they usually average out at plot level and inventory level (Chave et al. 2004). Picard et al. (2015) also found the
H measurement	

Sources of uncertainty	Analysis of contribution to overall uncertainty
Plot delineation	measurement error to be small when compared to the other errors. The FMT conducted an assessment of the contribution of this source of error (c.f. Annex) and found that this source of error should be negligible for Emission Reduction estimation, provided minimal QA/QC procedures are in place. Vietnam applied QA/QC procedures to avoid both random error and systematic error caused by DBH measurement and plot delineation. Therefore, the contribution of this source of error to random error is expected to be low. In Vietnam case, H is not used as a parameter to estimate the emission reductions and therefore the uncertainty of H measurement does not affect the combined uncertainty of emission reductions.
Wood density estimation	In Vietnam case, wood density is not used as a parameter to estimate the emission reductions and therefore the uncertainty of wood density estimation does not affect the combined uncertainty of emission reductions.
Biomass allometric model	The error of biomass allometric equations (tree level) are 10-18% for natural timber forest, plantation and bamboo forest, respectively. Since these equations are used to estimate AGB at the individual tree/bamboo level, the contribution of allometric equation errors to ramdom carbon stock errors at forest type level are assumed to be low. However, since these equations are developed based on a non-representative sample, the contribution of allometric equation errors to systematic errors (bias) at forest type level are assumed to be high.
Sampling	This source of error is applicable for Vietnam case when the carbon densities of forest used to derive emission factors are based on a terrestrial inventory based on a systematic sampling design with the grid size of 8 km. Sampling uncertainty is the statistical variance of the estimate of aboveground biomass. This source of uncertainty is random and is expected to be high.
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	In Vietnam case, some other parameters are used to estimate emission factors, such as aboveground biomass in non-forest land, carbon fraction and root-to-shoot ratios. These are not measured but sourced from the 2006 IPCC Guidelines. This can lead to both random and systematic errors. The random error of each individual parameter might be low but the aggregated effect might be high. Moreover, the lack of QA/QC procedures for the selection of the values may lead to high systematic errors.
Representativeness	Vietnam applied a systematic sampling design to estimate AGB of forest types, which in turn are used to estimate the emission factors. Therefore, the sample is expected to be representative for the accounting area, and this source of error is bias and is expected to be low.
Integration	
Model	In Vietnam case, sources of both random and systematic error are the calculations themselves (e.g. mistakes made in spreadsheets) and the process of data preparation (e.g. pre-processing, data cleansing, data transfer, etc). In addition, the assumption on the adjustment factors for calculating removals could be a source of bias to emission reductions. All these sources are addressed with adequate QA/QC processes.
Integration	This source of uncertainty is related to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. In Vietnam case, Activity Data is estimated through remote-sensing observations, whereas Emission Factors for a specific forest type are based on ground-based observations of the forest types. These may not be comparable, and it may represent a source of low bias.

10.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

The Monte Carlo Method was applied to assess uncertainties of emissions and removals estimates in reference level and the reporting period. In this analyse, all parameters associated with emissions and removals estimates are simulated with assumption of normal probability distribution. The parameters analyzed are as follows:

- Above ground biomass of 5 forest types for 2005, 2010 and 2015
- Activity data of forest and land uses change for 2 periods: 2005-2010 and 2010-2015
- Root to shoot ratio (RS)
- Carbon fraction (all types of forest biomass)
- Conversion factor of carbon (C) to carbon dioxide (CO_2)

The details of description on parameters, parameters values, standard errors and probability distribution function are provided in separate spreadsheet[23]

Quantification of the uncertainty of the estimate of the Reference level

Table A4-7. Estimates of uncertainties for reference level using Monte Carlo method

		Total emissions	Emission from degradation
A	**Median**	24,223,228	19,016,482
B	**Upper bound 90% CI** (Percentile 0.95)	31,516,038	26,213,807
C	**Lower bound 90% CI** (Percentile 0.05)	16,953,657	11,781,464
D	**Half Width Confidence Interval at 90% (B – C / 2)**	7,281,190	7,216,171
E	**Relative margin (D / A)**	30%	38%
F	**Uncertainty discount**	**4%**	**8%**

Sensitivity analysis and identification of areas of improvement of MRV system

Sensitivity analysis was conducted independently for 4 parameters:

- Root to shoot ratio (RS)
- Carbon fraction (CF) in forest biomass
- Above ground biomass (AGB) of all forest types; and
- Activity data (AD)

The value of those parameters was set to very small value (0.00001) to remove from the simulation. The results of sensitivity analysis indicated that the uncertainty associated with AGB has the largest overall contribution to the uncertainty of total emission reductions, to degradation, and to estimates of removals from enhancement and reforestation. The uncertainty associated with AD has the largest overall contribution to the uncertainty of emissions associated with deforestation. The uncertainty associated with RS and CF terms contributes relatively little to the overall uncertainty.

[23] Spreadsheet of MC analysis is available for sharing.

Table A4-8. Sensitivity analysis of uncertainties for emission reduction and removal for reference level

Analysis type	Total Emission Reductions*	Emissions - Deforestation	Emissions - Degradation	Total removal	Removal - Enhancement	Removal - Reforestation
With All Uncertainty Terms	31%	19%	39%	-36%	-45%	-30%
Dropping AGB Uncertainty	8%	19%	8%	-9%	-8%	-22%
Dropping AD Uncertainty	29%	7%	37%	-35%	-45%	-21%
Dropping RS Uncertainty	30%	18%	38%	-35%	-45%	-30%
Dropping CF Uncertainty	30%	19%	38%	-36%	-45%	-30%

It suggests that the greatest potential for reducing uncertainty in estimates of emission reductions would be through reducing uncertainty in estimates of AGB, perhaps through increasing sample sizes in the NFI.

Document history

Version	Date	Description
2.1	November 2020	Aspects on uncertainty analysis were revised based on the guidelines on uncertainty analysis.
2	June 2020	Version approved virtually by Carbon Fund Participants. Changes made: • Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0) • Update to consider the changes made to the Validation and Verification Guidelines
1	January 2019	The initial version approved by Carbon Fund Participants during a three-week non-objection period.