Ministry of Agriculture and Rural Development

VIETNAM

Forest Carbon Partnership Facility (FCPF)

Carbon Fund

Emission Reductions Program Document (ER-PD)

Annex 16: MMR Report

ER Program

Name and Country: Vietnam

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Table of Contents

Acronyms and Abbreviations

AD	Activity data
BCEF	Biomass conversion and expansion factor
CF	Carbon Fund
CPMU	Central Project Management Unit
DARD	Dept. of Agriculture and Rural Development (at the Province)
EF	Emission factor
ER	Emission Reduction
ERPA	Emission Reduction Payment Agreement
ER-P	Emission Reduction Program (area)
ER-PD	Emissions Reduction Program Document
ER-PIN	Emissions Reduction Program Identification Note
ESMF	Environmental and Social Management Framework
FAO	Food and Agriculture Organization
FIPI	Forest Inventory and Planning Institute
FCPF	Forest Carbon Partnership Facility
FMS	Forest Monitoring System
FORMIS	Forest Resource Monitoring System
FPD	Forest Protection Department
FREC	Forest Resources and Environment Centre
FREL	Forest emission reference level
FRL	Forest reference level
GHG	Greenhouse gas
HHs/hhs	House holds
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LMS	Land Monitoring System
MARD	Ministry of Agriculture and Rural Development
METLA	Finish Forest Research Institute
MONRE	Ministry of Natural Resources and Environment
MMR	Measurement, reporting and verification
NCAR	North central agro-ecological region
NDVI	Normalized difference vegetation index
NFI	National forest inventory
NFIMAP	National Forest Inventory, Monitoring and Assessment Program
NFIS	National Forest Inventory and Statistics
NRAP	National REDD Action Plan
PFMB	Protection Forest Management Board (manages protection forest for a watershed)
PFSM	Provincial Forest Monitoring System
PPMU	Provincial Project Management Unit
PRAP	Provincial REDD Action Plan
QA/QC	Quality Assurance/Quality Control

REDD	Reducing emissions from deforestation and forest degradation
REDD+	Reducing Emissions from Deforestation and Forest Degradation, “plus” conservation, sustainable management of forests and enhancement of forest carbon stocks
RF	Removal factor
R-PP	Readiness-Preparation Proposal for the FCPF REDD readiness funding
RL	(Forest) Reference Level
SESA	Strategic Environmental Social Assessment
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
VAFS	Vietnam Academy of Forest Sciences
VFU	Vietnam Forest University
VNFOREST	Vietnam Forest Administration
VRO	Vietnam REDD+ Office
WB	World Bank

List of Figures

List of Tables

1. Background

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

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

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

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

2. Approach to MMR

2.1. Definition of forest

The definition of forests used for MMR applies the definitions provided under Circular No. 34 (2009)[1]. This definition is in line with the definition of forests used for FREL/FRL and the national GHG inventory. It is also consistent with the definition described in the Emission Reduction Program Idea Note (ER-PIN) submitted in May 2014 to the Forest Carbon Partnership Facility (FCPF).

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

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

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

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

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

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

2.2. Classification system

For the purpose of estimating historical emissions and removals with increased accuracy, Viet Nam has stratified its land use into six land use types including five forest types (Table 1). Emission Factors/Removal Factors (EFs/RFs) are calculated based on the average carbon stock in these forest and land use types.

Table 1: Forest and land use types used for MMR

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

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

2.3. REDD+ activities monitored

The MMR system will monitor all five REDD+ activities, which are defined as follows:

- **Reducing emissions from deforestation ("Deforestation")**: Activity of conversion of forests to non-forest land.

- **Reducing emissions from forest degradation ("Degradation")**: Activity resulting in a downward shift in terms of carbon stock between forest types, including Evergreen broadleaf forest volume-based sub-types of "rich, medium, and poor" (based on the average standing volume per ha) and other forest type (See Table 1).

- **Enhancement of forest carbon stocks from reforestation ("Reforestation"):** Activity of land use change from non-forest land to forest land.

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

- **Conservation of forest carbon stock:** Forest types remaining in the same forest types, are regarded as "conservation of forest carbon stock". These areas are accounted for, but understood that no carbon benefits will be derived (i.e., zero net emissions/removals).

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

2.4. Pools and gases monitored

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

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

Gases included in estimation of emission reduction and/or removal enhancement are only CO_2. Non-CO_2 gases such as CH_4, CO, N_2O, NOx etc. caused by burning of biomass (for example, forest fire) is not counted as such emission is not significant[2] and data on biomass of burnt forests are not available.

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

2.5. Approach for estimating emissions and/or removals

The approach for estimating emissions/removals follows the IPCC guidelines, multiplying the activity data with the emission/removal factors (Figure 1).

Figure 1: Approach for estimation of emissions/removals

Activity Data (ha per yr)	×	Emission/Removal Factors CO2 eq. per ha	=	GHG Emissions and removals C02 eq. per yr
Land monitoring		**National forest inventory allometric equations**		**REDD+ GHG Inventory**

2.6. Implementation organization

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

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

1) Ministry of Agriculture and Rural development (MARD)

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

2) Vietnam Administration of Forestry (VNFOREST)

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

- Cooperation with the ER Program in selecting suitable national and international consultants.
- Connect with People's Committees, branches and agencies of provinces in MMR implementation at provincial level.
- Organize of annual and final acceptance check of MMR product quantity and quality; receive outcomes and register carbon certificates for the Accounting Area.
- Update the central forest database annually.

3) Central Program Management Unit (PMU)

- Support MARD in activities such as the approval of the MMR implementation plans in six provinces; review and selection of technical issues, standard procedures including field survey manual, field data collection quality control, biomass calculation method, and technical guidelines of each specific work step.
- Support MARD on the approval of cost estimate of each work item and in identification of financial resources.
- Selects suitable national service providers and national consultant teams for implementing change detection using satellite imagery for the ER Program, field verification and the update of forest cover maps, accuracy assessment of the land

cover change map, calculation of emission reduction, and uncertainty assessment of emission reduction results.

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

4) Provincial People Committees and Provincial Program Management Units

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

- Support 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 central PMU to develop resource plans (human resource and cost) for MMR implementation at the provincial level.

5) Forest Inventory and Planning Institute (FIPI)

Since FIPI has been tasked with implementing the National Forest Inventory, Monitoring and Assessment Program (NFIMAP)[3] - which data were used to develop the FREL/FRL for the ER Program, has been being the main agency to implement the forest inventory step of the National Forest Inventory and Statistics (NFIS) period 2011-2016,[4] and has a mandate to implement the improved NFIMAP in the future, FIPI will implement the following work:

- Develop technical guidelines including a field data collection and survey manual; Satellite imagery processing manual; QA/QC guideline and forms; field data management and processing manual;
- Conduct forest change detection using remote sensing and generate forest cover map based on delineations by provincial MMR teams;
- Conduct a field inventory and quality control;
- Conduct training, technological transfer for provincial MMR team on field verification and validation of forest cover maps;
- Provide potential national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission results.

6) Central specialized agencies (VAFS etc.)

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

- Conduct a quality assurance for the field inventory implemented by FIPI;
- Conduct an accuracy assessment of land cover change map 2015-2020 in the Accounting Area;
- Provide potential national consultants on estimating emission reduction for the Accounting Area, uncertainty assessment of emission results.

7) Local communities

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

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

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

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

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

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

3. Monitoring activity data for forests using remote sensing

3.1 Selecting approach for representing Activity Data

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

3.2 Generating the baseline provincial forest cover maps

Currently, the National Forest Inventory and Statistics (NFIS) Project has been carrying out in Viet Nam since 2011. This project will generate forest cover maps (FCMs) at 1:10,000 for Viet Nam and to date 40 provinces (including Thanh Hoa, Nghe An and Ha Tinh provinces) have FMCs. The FMCs of the remaining 20 provinces will be completed in 2016. The status of provincial forest statistics maps for the six NCC provinces is given in Table 2 below:

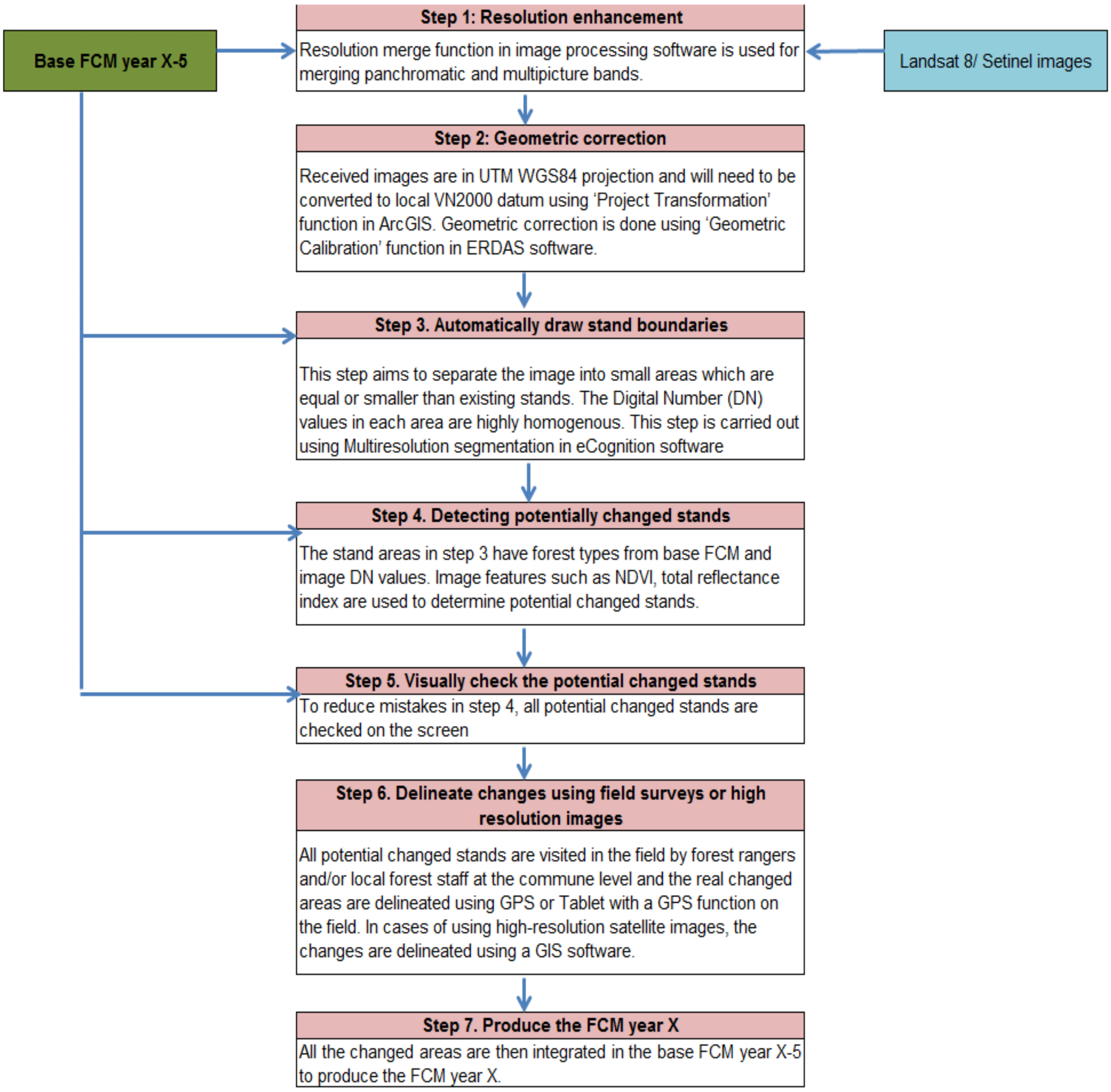
Table 2: Status of provincial forest cover maps (FCMs) of six NCC provinces

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

However, the approach for generating the FCMs under the NFIS Project is not consistent with the approach that has been used for generating the historical FCMs 2005-2010-2015 for FREL/FRL setting. The main inconsistency is the approach under NFIS allows two ways of estimating the volume of forest stand: (i) using randomly located sample plots and (ii) using a correlation relationship between forest stand volume and satellite imagery indexes. Recently, a preliminary analysis of FCM year 2010 (produced by FIPI under NFIMAP Cycle IV) and FCM year 2012 (produced by Vietnam National Forest University under NFIS) in Ha Tinh province shown a lot of changes during the period 2010-2012. These changes are likely artifacts due to the inconsistency of the approach used. Therefore, the FCMs produced under the NFIS are not suitable for MMR of the ER-P.

To maintain the consistency with historical FCMs used in FREL/FRL setting, the approach under the MMR of the ER-P to generate FCM year X is proposed as follows: (i) using medium resolution remote sensing imagery to identify the potential forest change areas from the base FCM year X-5; (ii) using high ground surveys and/or resolution remote sensing imagery to delineate all identified areas, (iii) reference all final forest strata boundaries to the boundaries existing in the base map, with the 2015 forest cover map as the original basis, to produce the FCM year X. The following **Error! Reference source not found.** summarizes the processing teps applying Approach 3 for generating the FCM year X based on medium-resolution satellite images and the FCM year X-5:

Figure 2: Approach for generation of the FCM year X from base FCM year X-5



All forest and bare land stands in the baseline map are examined based on medium resolution satellite images such as Landsat 8 and/or Sentinel. The image features of each stand are calculated for examination. For example, low homogeneity value in a stand indicates a potential change of forest type in the stand; high normalized difference vegetation index (NDVI) value in the bare land stand indicates a potential change from bare land to forest etc. Currently Landsat 8 and Sentinel images are considered to be the most suitable[5].

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

3.3 Generating forest and land use change map and matrix

By using the above procedure, FCMs will be generated for each province in the NCC region from 2020 with a 5-year interval in a manner consistent with the methods used to generate the forest cover maps used in 2005-2010-2015 for the Reference Level. The provincial forest and land use change map will be generated by intersecting the provincial FCMs in year X with the corresponding provincial FCMs in year X-5 for all the NCC provinces. They will then be combined to generate a regional NCC forest and land cover change map. A matrix of changed area (i.e., AD) will be extracted from this regional forest and land use change map. This matrix contains basic information for estimating emissions and removals for each of the REDD+ activities. Time series change sequences for individual parcels will be tracked over time to improve the classification of the Activity Data (deforestation, degradation, reforestation, etc) and to enable tracking of Reversals. In particular, land parcels which transition from forest to non-forest, then later from non-forest to plantation, will not be counted for FCPF purposes as Reforestation/Afforestation; they will be tracked as a separate forest-to-plantation class, and the conversion from non-forest to plantation on these land parcels will not counted as Carbon Removals.

3.4. Accuracy assessment of land cover change map

As described above, the AD are extracted from the forest and land cover change maps periods 2015-2020 and 2020-2025, which is generated by overlaying two forest cover maps in two dates of 5-year interval. The land cover change map are subject to interpretation errors in each forest cover map and the role of the accuracy assessment is to characterize the frequency of errors for each of the land cover change classes.

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

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

[5] The Landsat 8 satellite image include a spatial resolution of 30 m, image size 180 x 180 km, and revisit cycle of 16 days. The characteristics of Sentinel satellite image 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.

- Availability of reference data (e.g., ground truth data) for evaluation and calibration of the system.

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

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

The method described in Olofsson et al. (2013)[7] and Olofsson et al. (2014)[8] will be applied to build a confusion matrix, estimate un-biased areas per each class, derive errors of area estimates as well as calculate the user's accuracies per class, producer's accuracies per class and overall accuracy. The detailed steps are as follows:

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

		Reference data					
		Class 1	**Class 2**	**Class 3**	**…**	**Class 36**	**Total**
Map data	**Class 1**	$n_{1\cdot1}$	$n_{1\cdot2}$	$n_{1\cdot3}$	…	$n_{1\cdot36}$	$n_{1\cdot}$
	Class 2	$n_{2\cdot1}$	$n_{2\cdot2}$	$n_{2\cdot3}$	…	$n_{2\cdot36}$	$n_{2\cdot}$
	Class 3	$n_{3\cdot1}$	$n_{3\cdot2}$	$n_{3\cdot3}$	…	$n_{3\cdot36}$	$n_{3\cdot}$
	…	…	…	…	…	…	…
	Class 36	$n_{36\cdot1}$	$n_{36\cdot2}$	$n_{36\cdot3}$	…	$n_{36\cdot36}$	$n_{36\cdot}$
	Total	$n_{\cdot1}$	$n_{\cdot2}$	$n_{\cdot3}$	…	$n_{\cdot36}$	$n_{36\cdot}$

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

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

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

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

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

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

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

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

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

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

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

Where *A* is the total map area.

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

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

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

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

Step 6: Estimate the 95% confidence interval as:

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

4. Estimating emission/removal factors using forest inventory

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

4.1. Sampling design selection

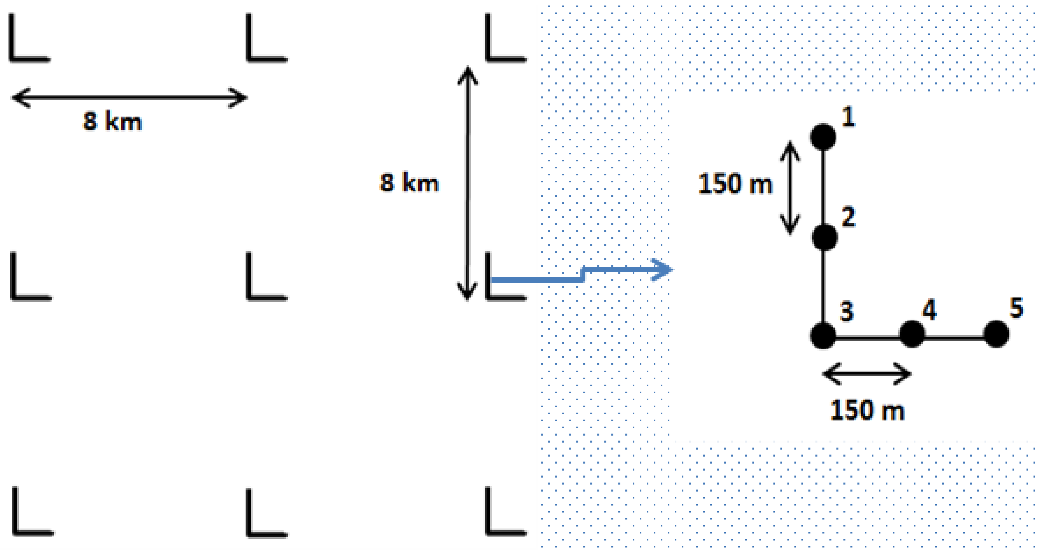
After the completion of Cycle IV, Viet Nam received support from FAO-Finland through the "Support to National Assessment and Long-term Monitoring of the Forest and Trees Resources in Vietnam (NFA)" Project to improve the sampling design of the NFIMAP to implement it in the 2016-2020 and subsequent cycles. The NFA Project has successfully developed an improved sample plot system that maintains the consistency with the old sample system but is more efficient. This improved sampling design has been reviewed by international experts from United States Forest Service and the World Bank and was highly regarded. Forest Inventory and Planning Institute (FIPI) is now preparing necessary steps for approving the improved sample plot system to be implemented in the 2016-2020 and subsequent cycles. These results will be available for purposes of updating Emission/Removal Factors during the FCPF performance period. Since this is a systematic sample across the landscape, it will capture any changes in C removals occurring as a result of FCPF and other related activities, in proportion to the area of the activities across the landscape. If this improved sample plot system is approved, it will function as the national MRV system for REDD+. Therefore, for the MRV system in the NCC region to be consistent with the emerging national MRV system, the improved sample plot system proposed by the NFA Project is selected for generating the EFs/RFs for the MRV system in the NCC region. Although very unlikely, in the case the improved sample plot system is not approved, it will still be implemented in the NCC region for the purpose of MRV for the ER-P.

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

The main parameters of sampling design are:

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

Figure 3: Shape and distance between clusters, sample plots.



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

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

Table 3: The number of clusters and plots by provinces

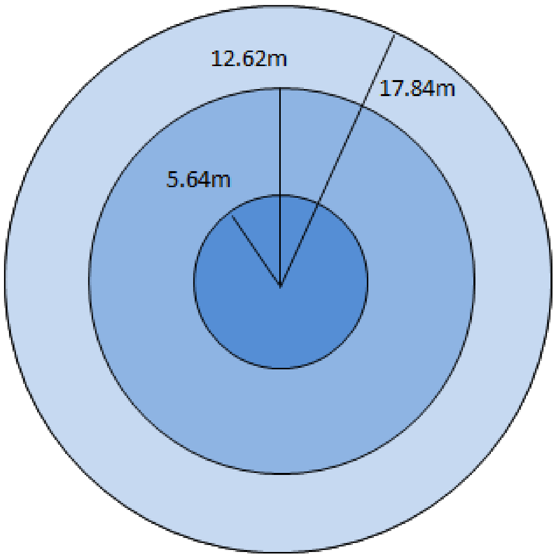
No	Province	Number of Clusters	Number of Plots
1	Thanh Hoa	179	895
2	Nghe An	252	1,260
3	Ha Tinh	87	435
4	Quang Binh	125	625
5	Quang Tri	72	360
6	Thua Thien Hue	74	370
Total		**789**	**3,945**

4.2. Sample plot design

4.2.1 Tree measurement

One sample plot consists of three concentric circular sub-plots with radiuses of 5.63 m (SP1), 12.62 m (SP2) and 17.84 m (SP3), respectively (Figure 44). The distance mentioned here refers to horizontal distance.

Figure 4: Sample plot design



- Sub-plot with area of 100m^2 and radius of 5.64m (SP1)

+ Measuring trees with DBH ≥ 6cm
+ Measuring bamboos with DBH ≥ 2cm

- Sub-plot with area of 500m^2 and radius of 12.62m (SP2):

+ Measuring trees with DBH ≥ 20cm
+ Measuring dead, stump-cut trees;
+ Measuring shrubs, ground cover vegetation
+ Measuring climber with D ≥ 2cm

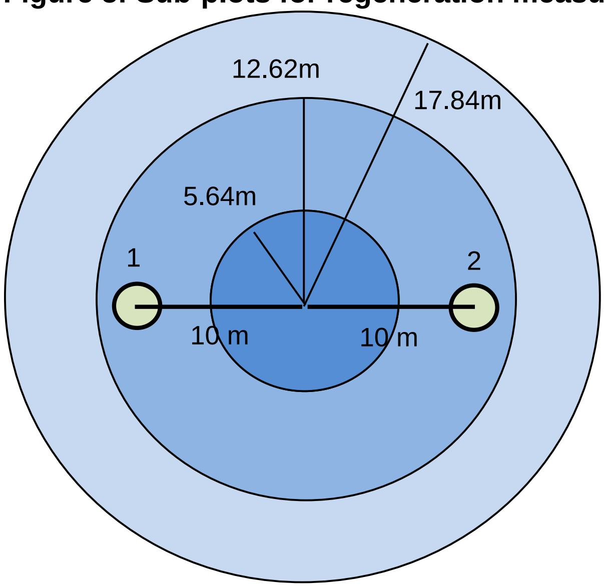
- Sub-plot with the area of 1,000 m^2 and radius of 17.84m (SP3):

+ Measuring all trees with the diameter at the height of 1.3 m (DBH) ≥ 40 cm.

4.2.2. Regeneration measurement

On each sample plot, there are 2 sub-plots for regeneration measurement with the radius of 1.5 m and the centres locating on the East-West axis and 10 m far from the centre of the sample plot (5).

Figure 5: Sub-plots for regeneration measurement



4.3. Parameters to be collected in the field

4.3.1. Sample plot description

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

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

4.3.2. Aboveground biomass parameters

a) Tree parameters:

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

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

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

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

Tree number:

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

Species name:

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

Diameter at Breast Height (DBH):

The diameter at the 1.3 m height of the stem.

Top height of tree (H_t):

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

Bole of height (H_b):

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

Stump diameter:

is measured in centimetre with one decimal digit for all sample trees.

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

b) Bamboo parameters

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

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

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

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

c) Regeneration parameters

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

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

d) Shrub and ground cover vegetation parameters

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

Shrub closure:

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

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

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

Shrub mean height (0.1 m):

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

Ground vegetation coverage:

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

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

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

Ground vegetation mean height (0.1m):

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

e) Climber

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

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

- Number of climbers located in SP2 is counted.

4.4. Method for estimating EFs/RFs from collected data

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

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

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

  (Number of samples = 331; Adjusted R^2 = 0.854; S% = -11.4%; MAE% = 33.6%)

- $AGB = 254.495 \times D2H^{0.947}$ (2)

  (Number of samples = 331; Adjusted R^2 = 0.878; S% = -2.0%; MAE% = 19.1%)

- AGB = $AGB = 0.699 \times D2HWD^{0.940}$ (3)

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

Where:

AGB is above ground biomass expressed in kg;

DBH is diameter at breast height expressed in cm;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Where:

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

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

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

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

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

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

$$TBi = AGBi + BGBi \quad (10)$$

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

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

Where:

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

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

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

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

Where:

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

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

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

Where:

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

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

After completion of calculating the average carbon stock for every forest type in the region. These values will be used to estimate EF/RF for every change in forests and land uses. As for mangrove forests, there is no measurement plot and carbon stock of mangrove forest is taken from a study[9]. The average carbon stock of non-forest land is assumed to be zero (0). The general formula for estimation of EF/RF is as follows:

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

Where:

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

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

If $\bar{C_i} > \bar{C_j}$, such change is considered emissions;

If $\bar{C_i} < \bar{C_j}$, such change is considered removal or sequestration;

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

5. Quality assurance/quality control (QA/QC)

5.1. Scope of the instructions

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

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

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

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

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

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

5.2. Carrying out the control measurements

5.3.1. Preparations

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

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

5.3.2. Data transfer

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

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

5.3.3. Field work

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

5.3.4. Feedback and reporting

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

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

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

5.3.5. Analysis of the results

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

a) Table of Yes/No answers from checklist

b) Summary table of main results

c) Summary table of each measurements

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

6. Calculating emission reduction/ removals enhancement

6.1. Calculating emissions/removals

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

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

Where:

E/R is the emissions/removals;

n is the number of classes;

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

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

6.2. Calculating emissions reduction and removals enhancement

The emissions reductions and/or removals enhancements are calculated by subtracting the emissions/removals calculated above from the forest emission reference levels / forest reference level.

7. Conducting uncertainty assessment

7.1. Uncertainties in AD

As mentioned above, the accuracy assessment will be conducted for the land cover change maps for the periods 2015-2020 and 2020-2025. From the results of accuracy assessment, area estimates and their associated uncertainties (errors at the 95% confidence interval) per change class are obtained. $\hat{A}_{ij}$ presents the area estimate of land cover change class from land cover class *i* in the start to land cover class *j* in the end, and E_AD_{ij} presents the associated absolute error at 95% confidence interval for $\hat{A}_{ij}$, the percentage error is calculated using the formula:

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

7.2. Uncertainties in EF/RF estimates

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

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

Of which: SE_i is standard error of carbon stock in measurement plot of forest type *i*. As the measurement plot is sampled using two-stage sampling, therefore SE is estimated as follows (Dahm, 2006).

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

Where:

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

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

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

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

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

$$E\%_i = \frac{t_{\alpha/2,(l_i-1)} \times CV\%_i}{\sqrt{np_i}} \quad (18)$$

Where:

$t_{\alpha/2,(li-1)}$ is the Student's *t-value* with (l_i-1) degrees of freedom at the confidence interval of (1-α). In this case, the confidence interval used is 95% (α = 0.05).

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

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

Where:

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

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

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

7.3. Uncertainty in emissions/removals estimate

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

The error propagation approach is selected because of easy implementation and it is consistent with Forest reference setting. Monte Carlo method can be used for assessing uncertainty of the estimates of ER (following indicator 9.2 in the FCPF Methodological Framework Document) in needs to be consistent to the approach to FREL/FRL setting.

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

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

Where:

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

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

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

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

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

Where:

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

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

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

8. Data management

As part of the MMR, an information system will be established. This information system will have a GIS database that stores 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/Removal factors;
- Average annual emissions over the Reference Period;
- Adjusted emissions, if applicable; and
- Any spatial data used to adjust emissions, if applicable.

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

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

9. Reporting

The ER Program, when approved, will be nested into the national REDD+ implementation to avoid double accounting of emission reduction and/or removal enhancement at the national 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 Program to FCPF Carbon Fund following required template (which is not available now), the ER Program also needs to report biennially its performance to the Vietnam REDD+ Office (VRO), which is the focal point for 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
- The information on how safeguards are respected and addressed (Decision 1/CP.16) in the ER Program.

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

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

10. Other functions of MMR

10.1. Actions to address Displacement

10.1.1. Identification of risk of Displacement

Domestic Displacement

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

Table 5: Identification and assessment of Risk of Displacement

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

International Displacement

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

10.1.2. Design features to prevent and minimize potential Displacement

Domestic Displacement

The potential risk of both domestic and international displacement of emissions from the proposed ER Program activities are summarised in Table 4 and elaborated further below. Residual domestic displacement will be measured and fully accounted for by a robust National Forest Monitoring System (NFMS) currently under development.

Table 4: Summary of possible risk mitigation design features

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

International Displacement

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

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

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

10.2. Actions to address Reversals

10.2.1. Identification of risk of Reversals

Reversal of GHG benefits could result from fire, disease, illegal logging, unplanned agricultural expansion (responding to global commodity price hikes), centrally planned infrastructure development, or climate change (particularly increased frequency and intensity of typhoons). Table 56 provides an assessment of the *anthropogenic and natural risks* of Reversals that might affects ERs during *the Term of the ERPA*.

Table 5: Identification and assessment of risk of Reversals

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

10.2.2. ER Program design features to prevent and mitigate Reversals

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

Table 6: Mitigation strategies for risk of Reversals

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

10.2.3. Reversal management mechanism

Table 7: Selection of Reversal management mechanism

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

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

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

10.3. Linking MMR with Benefit sharing mechanism (BSM)

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

11. Budget estimate

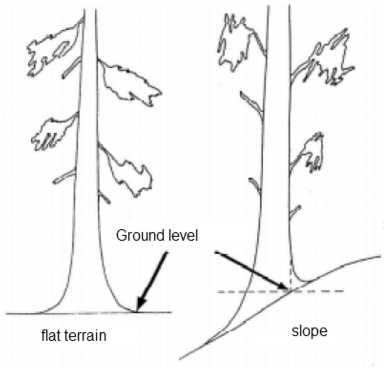
The cost estimate for operating the proposed MMR system for the NCC region in period 2016-2020 is 1,392,800 USD, as detailed in Table below:

Table 8: Cost estimate for the MMR system in the NCC region during 2016-2020

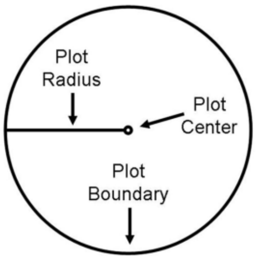
Activities	Unit	Quantity	Price (USD)	Total (USD)
Initial procurement of equipment and software	Province	6	10,000	60,000
Potential change detection using medium satellite imagery	Year	5	10,000	50,000
Field check of potential changes and update	Year	5	30,000	150,000
High resolution satellite images (e.g.,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

Glossaries

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



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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Carbon stock: The quantity of carbon in a pool.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Annex 1

Vietnam context on MMR for REDD+

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

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

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

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

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

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

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

- Effective and multi-purpose in design;

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

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

- Encourage the participation of relevant stakeholders and forest owners;

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

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

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

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

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

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

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

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

Management Agency: Vietnam Forest Administration (VNFOREST)

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

Objectives:

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

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

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

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

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

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

Disaggregation:

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

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

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

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

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

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

Progress:

To date FCMs of 40 provinces (including Thanh Hoa, Nghe An and Ha Tinh provinces) have been produced. The FMCs of the remaining 20 provinces will be completed in 2016. The status of provincial forest statistics maps for the six NCC provinces is given Table 10 below:

Table 9: Status of provincial FCMs of the six NCC provinces

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

Limitations:

The approach for generating the FCMs under the NFIS Project is not consistent with the approach that has been used for generating the historical FCMs 2005-2010-2015 for FREL/FRL setting. The main inconsistency is the approach under NFIS allows two ways of estimating the volume of forest stand: (i) using a randomly located sample plots and (ii) using a correlation relationship between forest stand volume and satellite imagery indexes. Recently, a preliminary analysis of FCM year 2010 (produced by FIPI under NFIMAP Cycle IV) and FCM year 2012 (produced by Vietnam National Forest University under NFIS) in Ha Tinh province shown a lot of changes during the period 2010-2012. These changes are likely artifacts due to the inconsistency of the approach used. Therefore, the FCMs produced under the NFIS are not suitable for MMR of the ER-P.

2. Annual Monitoring of Forest and Forestry Land Program

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

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

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

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

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

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

Implementation steps:

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

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

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

Outcomes:

1. Forest status map:

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

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

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

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

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

Table 1. Forest and forestry land areas by forest types

Table 2. Forest and forestry land areas by functions.

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

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

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

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

Achievements:

- The Program provides annual data on forest and forestry land area. The database contributes to the development of forest protection and policy-making.
- The monitoring of forest resource change at the plot, compartment and block levels, requires a huge amount of work to develop and update the database. However, the detailed database is without question highly useful to all levels and sectors to understand the changes in forest and forestry land area, and from this, to develop the most effective planning for forest and forestry land utilization.

Limitations:

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

- The Program's results only focus on the changes in forest area and forest status. Other forest parameters, such as forest stock, forest structure, silviculture characteristics, and biodiversity, etc., are not collected. Therefore, it can be said that the program only outlines the "forest's outer shell", but does not reveal the inner characters of forests.
- The Program only focuses on forest area and applies out-dated methods that have significant limitations, so the accuracy of the data collected remains low. Despite the long duration for data collection, the database has also not yet been completed.
- Human resources available consist primarily of forest rangers, with data collection at the local level mainly carried out by them and/or commune forestry staff, both of whom have limited capacity in relation to forest inventory issues. The database is collected and synthesized from a variety of different sources.
- The Program data are updated based on baseline data and maps generated by the NFIS period 1997-2000. The data has subsequently been updated annually, however, it has been done so without the application of remote sensing, while fieldwork has also been limited, meaning that the accuracy of program data has been getting lower and lower over time.
- There remains no adequate guidelines for the inspection, monitoring, evaluation and quality assessment of data collected, nor for data processing, thus, the accuracy and transparency of the data is not high.
- The main responsibility of forest rangers is forest protection, thus, the reported data may not be transparent and may not reflect reality.

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

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

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

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

Objectives:

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

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

Technology:

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

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

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

Implementation Methods:

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

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

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

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

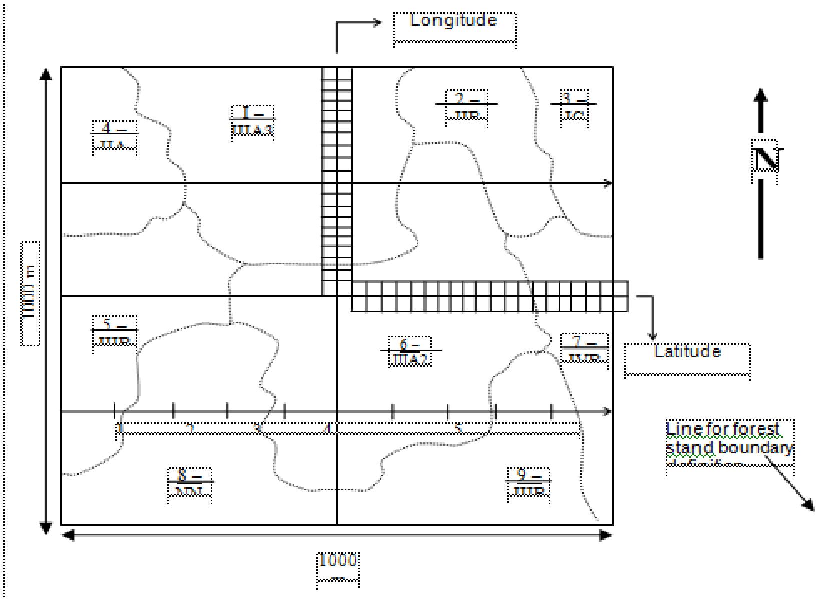

Figure 6 Layout of a primary sample plot

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

Achievements:

- Through four cycles (1991-2010), over a period of 20 years, the Program has provided information and data about forest resources to inform the development of the national forestry development strategy, as well as forest development planning in each of the country's provinces. A database of Vietnam's forest resources, established and stored using specialized software provides long-term value and has contributed important data to the FAO's Global Forest Resource Assessment. FIPI has received FAO capacity building support in relation to information collection contributing to the national forest resource management system, and reporting to the FAO on national forest resource change over 5 year periods.
- With significant experience in forest inventory and the use of advanced technology, the results of the NFIMAPs are diversified. The program has not only provided information on fluctuations in forest area and land, but also data on forest structure and ecological parameters that can be used in more in-depth researches.

Limitations:

- Under the guidance of the UNFCCC, Vietnam must submit GHG National Communication every 4 years and provide biennial update reports. However, the NFIMAP is implemented over a period of five years, with forest area and quality results only collected and synthesised at the end of this period – i.e., only once every five years.
- The technical verification of the results of the NFIMAP have not been conducted frequently, with it only occurring during the last cycle (cycle IV). The statistical data on forest area and land was collected from annual reports at the local level. However, these data were not assessed, and its accuracy not high.
- The NFIMAP database has been developed and, while abundant, the data is scattered and, thus, very difficult to use. Therefore, the efficient utilisation of data to inform the development of policy, strategies and plans, and in management, is still limited.
- The quality of supervision, monitoring activities and technician expertise is limited. This, in turn, places limitations on data collection, particularly data required for thematic reports. In addition, material facilities, technical equipment, base maps, and satellite imagery quality are not up to standards, further negatively influencing the results of the program.
- Human resources for implementing the NFIMAP, from sub–FIPIs up to FIPI headquarter, have not been adequate, which is exacerbated by the large area over which the Program is implemented. Consequently, the results do not fully meet requirements.
- Limitations on plot design and data collection methods:
    - Measurement of highly correlated neighbouring plots: from a statistical point of view, this does not make sense. Variation is a good thing in forest inventory. Sampling should be designed to maximize the variation in the sample.
    - All trees over 6 cm are measured, although, the large number of small trees measured represented a small part of the total volume. Two-thirds of the time spent in the field is used for measuring small sized trees, which represents less than one-third of the total volume.
    - Rectangular plot measurement in the field are difficult due to the challenging terrain. The correct locations of neighbouring rectangular plots (i.e., L-shape lines of 40 sub-plots), with no gaps between them, are difficult to identify in the field using just maps, compasses and measuring tapes. In mountainous areas, the measurement of such plots can be almost impossible.
    - Cost and time taken for implementation in the field: historical data reveals that it can take up to one month to measure one L-shape plot with 40 sub-plots.
    - Plots were established only in forested areas. No reliable estimates of land use classes or their changes were taken. Similarly, no information on trees outside of forests has been collected.
    - The number of sample plots would not meet statistical requirements in areas which have high diversity and topography divided into climatic micro regions.