UN-REDD
PROGRAMME

Bộ Nông nghiệp và
Phát triển nông thôn

Technical Manual for Participatory Carbon Monitoring

UN-REDD Viet Nam PROGRAMME

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Acronyms

AGB	Above-ground Biomass
AGTB	Above-ground Timber Biomass
AGTC	Above-ground Timber Carbon
AGBB	Above-ground Bamboo Biomass
AGBC	Above-ground Bamboo Carbon
BB	Below-ground Biomass
BC	Below-ground Carbon
BGB	Below-ground Biomass
BGC	Below-ground Carbon
DBH	Diameter at breast height
DPC	District Peoples' Committee
EF	Emission Factor
FAO	Food and Agriculture Organization of the United Nations
FC	Forest Company
FIPI	Forest Inventory and Planning Institute
FPD	Forest Protection Department
GIS	Geographic Information System
GPS	Global Positioning System
IPCC	Intergovernmental Panel on Climate Change
LMS	Land Monitoring System
MRV	Measurement, Reporting and Verification
NFI	National Forest Inventory
NRIS	National REDD+ Information System
PCM	Participatory Carbon Monitoring
PFMB	Protective Forest Management Boards
PPC	Provincial Peoples' Committee
REDD	Reducing Emissions from Deforestation and Forest Degradation
SDOF	Sub-department of Forestry
SOC	Soil Organic Carbon
UN-REDD	United Nations – REDD
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Background on REDD+ and the National MRV System

With successful negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), an international carbon fund or market for Reducing Emissions from Deforestation and Forest Degradation – Plus (REDD+) may be on its way. This will be an opportunity for developing countries such as Viet Nam to receive payments from developed countries for its performance in REDD+ activities, which include:

- Reducing emissions from deforestation
- Reducing emissions from forest degradation
- Conservation of forest carbon stocks
- Sustainable management of forests
- Enhancement of forest carbon stocks

To receive payments, developing countries will need to generate evidence of "results-based actions". The national Measurement, Reporting and Verification (MRV) system holds the key for producing this evidence. According to the deliberations under the UNFCCC, the MRV will need to

> *"transparently[1] generate consistent[2] and as far as possible accurate[3] and complete[4] estimates of carbon emissions and enhanced removals using comparable[5] methodologies, and providing information on safeguards[6]."*

For Viet Nam, stakeholders are currently engaging in discussions to develop a national MRV system with a geo-spatial database which integrates data collected at national and sub-national levels. The MRV system of Viet Nam will be based on four main pillars:

- **A Land Monitoring System (LMS)** to assess activity data - forest area and forest area changes;
- **A national biomass inventory** based on multipurpose National Forest Inventory (NFI) and Participatory Carbon Monitoring (PCM) to assess carbon stocks and carbon stock changes (i.e. emission factors (EF));
- **A National GHG Inventory** to estimate and report anthropogenic emissions by sources and removals by sinks.

[1] All the assumptions and the methodologies used in the inventory should be clearly explained and appropriately documented, its correctness can be verified.
[2] The same definitions and methodologies should be used over time. This should ensure that differences between years and categories reflect real differences in emissions. Under certain circumstances, estimates using different methodologies for different years can be considered consistent if they have been calculated in a transparent manner.
[3] Estimates should systematically neither over- nor underestimate the true value, so far as can be judged, and uncertainties are reduced so far as is practicable. Appropriate methodologies should be used, in accordance with the IPCC, to promote accuracy in inventories and to quantify the uncertainties in order to improve future inventories.
[4] Estimates should include all the agreed categories and pools. When gaps exist, all the relevant information and justification on these gaps should be documented in a transparent manner.
[5] Parties should follow the IPCC methodologies and standard formats (including the allocation of different source/sink category) and UNFCCC reporting guidelines for estimating and reporting anthropogenic GHG emissions and removals.
[6] The national MRV system should also be fully integrated in the national system for reporting on the greenhouse gas inventory to the UNFCCC. The UNFCCC negotiations have deliberated on the need for a stakeholder consultation on the GHG inventory for the forestry sector.

- **A National REDD+ Information System (NRIS)** to share information on all forest and REDD+ related issues, to allow the participation of all relevant stakeholders and to ensure that the implementation of national REDD+ policies and measures, including safeguards, are results-based throughout the implementation of all the REDD+ activities and all the forest related issues.

The national MRV system is being planned for development in phases and aims to establish a framework which will support a fully operational performance-based REDD+ mechanism within a time-frame of three-five years.

1.2 Principles of PCM

The following are some of the key principles of PCM for REDD+, which have also been applied as the basis for developing this manual.

- **Participation:** PCM is based on the principles of participation in forest management, including in monitoring for carbon (biomass). Apart from the reasons cited under the section on the "Objectives of PCM", PCM is also a meaningful means of engaging communities to promote awareness raising, by enhancing people's understanding of environmental values of forests in the context of climate change, and how they may better improve their forest management for carbon and other purposes. At the same time, the collaborative work experience will promote a culture of cooperation between forest owners/communities, local government officers and national institutions responsible for other tasks related to PCM.
- **Simple methods and tools:** In the current context of Vietnam, PCM methodologies must be simple enough for communities to implement with some training and assistance of technical forestry institutions. Development of easy to understand training tools will also become necessary.
- **Cost and time effectiveness:** Cost- and time-effectiveness of procedures are also an important principle. As PCM will be an additional activity for communities on top of regular forest management practices and other non-forest-based livelihoods communities may be engaged in, time-effectiveness will be an important factor which may affect the community's willingness to partake. Cost-effectiveness is another consideration especially in choices of instruments and equipment to be applied, particularly until REDD+ payments to be made can cover for such investments. Payment to community participants who engage in PCM is currently being considered under the REDD+ strategy for Viet Nam. This payment can be considered a "participation payment" and will also account for at least parts of the upfront costs which communities will incur in engaging in REDD+, before payments can be made.
- **Reliability of data:** In order to secure reliability of data, PCM methods must conform to IPCC guidelines. Also, within the context of the national MRV system, data generated from PCM will be integrated with the other components of the MRV

system, which should generate feedback on the logical probability and consistency of PCM data. [7]

1.3 Objectives of Participatory Carbon Monitoring (PCM)

A potentially very large and important source of information for the national MRV system is the forest managers – including community and households. Participatory Carbon Monitoring (PCM) recognizes and capitalizes on community, households, and other local stakeholders engaged in participatory forms of forest management (hereafter referred to collectively as "community") in monitoring forests carbon stocks.

PCM is considered an important mechanism for REDD+ for the following reasons and values it adds (Skutsch M. and McCall M.K):

- Changes in carbon stocks in managed forests over a typical accounting period will likely be too small to be detected accurately by remote sensing from satellites. The National Forest Inventory will collect highly accurate data, but with insufficient resolution in space and time to properly capture local changes in biomass. Changes will need to be measured on the ground in a dense pattern to reach an acceptable accuracy.
- Mobilizing communities can be more cost-effective compared to the use of professional surveyors in conducting ground-based surveys.
- Community's understanding of carbon monitoring will work as an incentive to promote further improvements in forest management, thereby securing further carbon payments.
- Community's engagement in carbon monitoring will increase the likelihood that carbon payments received at the national level will be distributed down to communities at the local level.

1.3.1 PCM participants in the context of Viet Nam REDD+

While forest and carbon monitoring will be implemented by all forest owners, the PCM exercise is developed specifically targeting "communities" – including households, collective entities of local residents – as the implementer. In the context of Viet Nam, this includes the following targets:

- Households owning forests allocated through red-book certificates
- Community groups managing forests allocated through red-book certificates[8]
- Households managing forests through contracts with other forest owners (i.e. Protective Forest Management Boards (PFMBs), Forest Companies, National Parks)

[7] The discussion on the reliability of data collected by community should be assessed based on results of actual PCM experiences, such as those carried out in the Central Highlands and the national program of community forest management in 10 provinces (implemented by MARD 2007-2009). These results showed that with appropriate training community are well positioned to carry out the basic steps of forest inventorying. In addition, in 2010 PCM methodology, methods tested in 2 places of Di Linh and Lam Ha districts under UN-REDD program and 3 places of Bao Lam and Cat Tien districts (under SNV), the participatory evaluation results showed that community members are confident of their ability to carry out PCM.

[8] At the time of this manual development, PCM had yet to be tested with community managed forests. Based on experiences of community forest management, PCM should be applicable. Lessons learned should be documented after testing.

1.3.2 Integration of PCM with the MRV system

Under the current discussions, data for monitoring biomass will collected at two levels:

- **Level 1:** Through Participatory Carbon Monitoring (PCM) involving participants in the National REDD+ Program, activity data and emission factors can be collected in a statistically significant number of sample plots;
- **Level 2:** For the comprehensive national data, activity data will be collected primarily through a satellite-based land monitoring system, while emission factors can be based on the data collected for the National Forest Inventory (NFI).

The monitoring of forests for generation of Level 1 data will be conducted through engagement of forest owners on the ground – including PCM. Level 1 data will be limited to basic forest mensuration on forest area and for estimating biomass per management unit and stratified by eco-zone[9].

Nevertheless, data collected will amount to a very large and statistically significant number of samples. Up to a million plots can be measured per year, if all households managing forests in Viet Nam are engaged.

The Level 1 data is in itself not sufficient to estimate biomass, and will be supplemented by Level 2 data. The NFI will provide the additional data (Level 2) to convert the Level 1 data into carbon estimates.

1.3.3 Target audience of the manual

This manual has been developed to outline procedures necessary for orienting community on steps and activities in PCM, and its actual implementation.[10] [11]

The manual is developed for the use of local foresters (including forest officers from provincial, district, commune levels, and staff of forest management boards) who can train and support the actual PCM process for the above PCM target groups, engaging them through an initial PCM orientation on methods and skills and in applying techniques for simplified surveying of forests in order to generate reliable data on carbon stocks.

The intended direct audiences of this manual are local foresters who will be mandated to train and support the PCM process. They may include province, district, and commune level Department of Agriculture and Rural Development (DARD) and Department of Forestry (DOF) officers, such as extension agents, rangers, foresters in forestry companies, commune forestry board.

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[9] To make strata as homogeneous as possible, a forest within the forest management unit or ecological zone is divided into different layers or blocks.

[10] The manual was developed through steps of a) developing a draft outline, followed by b) piloting of PCM orientation and field exercises with a number of target groups in the Central Highlands of Viet Nam, and c) revising and completing the manual. The manual is intended as first version of a living-document, to be updated and revised as the National REDD+ Program for Viet Nam (including the national MRV system) are discussed and defined, and based on feedback from more PCM experiences to be implemented in Viet Nam and internationally.

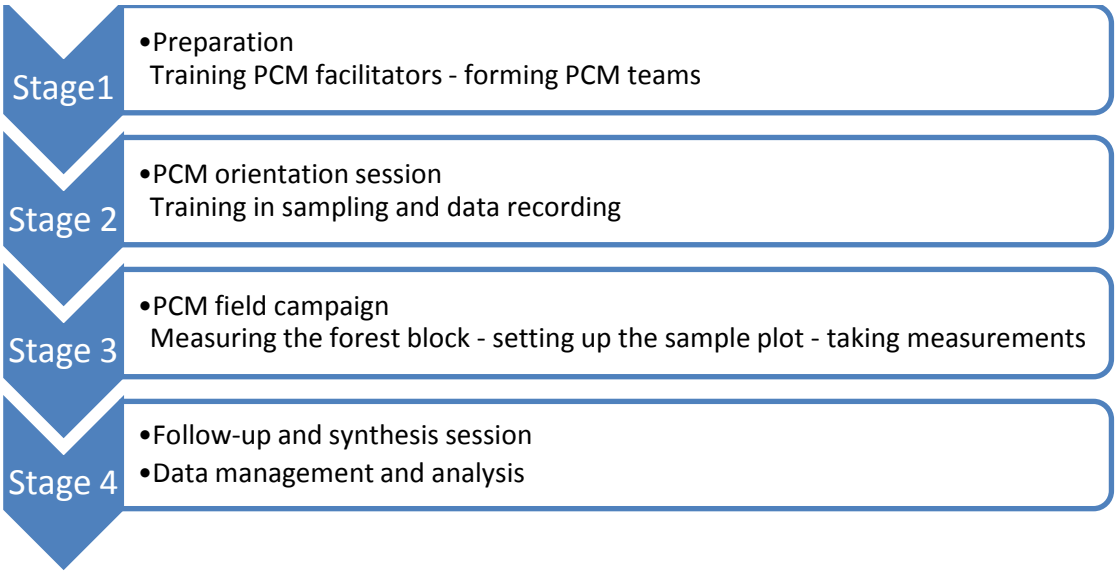
[11] It is not the intention of this manual to develop the technical carbon monitoring parameters, which to a large extent have universal applicability throughout forests the world. Thus, such monitoring parameters were largely adopted from existing literature including key documents such as Forest Carbon Stock Measurement Guidelines for measuring carbon stocks in community-managed forests (Bhishma et. al, 2010, ABSAB, FECOFUN, ICIMOD, Norad) and *A guide to Monitoring Carbon Storage in Forestry and Agro-forestry Projects* (McDicken, K.G., 1997) and *Manual – technical Issues Related to Implementing REDD+ Programs in Mekong Countries* (Silva H.P., 2010).

For actual application of PCM additional manuals will be developed for each specific task in PCM. In particular the following three manuals are foreseen:

1. Field manual for use by PCM teams (local communities);
2. Operational manual for facilitators (staff of FCs, PFMBs, district DOF and FPD);
3. Procedural manual for provincial managers of PCM (SDOF, FPD, DARD).

This manual provides a practical overview of PCM and it will form the basis for the above-mentioned manuals. It can also be a useful tool for understanding simplified forest surveying for any other agency, organization, and individuals engaging in REDD+. The manual can also be used educational material on REDD+ at universities, forestry colleges, and technical staff.

1.4 A summary of the PCM approach



1.4.1 Parameters for measurement

There are largely two groups of parameters for measurement:

- Changes in forest area (Activity Data)
  - Forest area per management unit, management objective and eco-zone (initial year).
  - Area of land-use change (subsequent years) per management unit, management objective and eco-zone.
- Basic forest mensuration for estimating biomass (to be converted into EF). Of the five carbon pools the above-ground biomass (trees and bamboo) is essential. Dead wood and litter may also be collected, but on a lower sampling density. Below-ground biomass measurement is outside of the scope of PCM.

The procedures for measurement applied in PCM are simple step-by-step procedures using standard forest survey principles and techniques and can be carried out by local forest owners and managers after basic training is provided.

1.4.2 Frequency of the PCM exercise

In principle, the more data is generated through PCM, the more robust will be the national data set for reporting on forest carbon. From this perspective, it is suggested that PCM should be carried as an on-going activity to be engaged by local forest offices (DARD offices) and communities. In order to save time and other resources, PCM is ideally combined with other forest management activities. Since PCM is not very time consuming – once a suitable location in the forest is reached – it can easily be integrated in the scheduling of other tasks (e.g. patrolling boundaries, layout or maintenance of fire breaks, enrichment planting or thinning, collection of NTFPs).

In any event, changes in forest land use and area need to be reported at least annually.

In this manual, the terms "first year" and "second year onwards" is used, referring to the instance where PCM will be carried out annually with the participation of all forest owners reporting on their forest blocks. Certain parameters will need to be measured and reported only in the first year, and simplified or not measured in the second year onwards, if land use remains consistent.

The frequency and/or rolling-nature of implementing the PCM exercise will need to be considered within the larger context of the MRV system and reporting. Future versions of this manual should update this aspect.

2 Organizing PCM

Before the PCM field campaign can be implemented, it is necessary to organize and prepare the PCM activity.

2.1 Preparation

2.1.1 General coordination and data management

PCM will be implemented by local communities or individual forest owners (in the households or community classes of forest owner), but the coordination and data management should be organized at a higher level. It is suggested that the general coordination is undertaken at the provincial level, planning of forest areas to be sampled at district level, while the data management can be done by institutional forest owners (PFMBs and FCs) or the district DARD offices for small forest owners.

In Vietnam, forest management offices at provincial and district levels are the Sub-department of Forestry (SDOF) and the Forest Protection Department (FPD) under the DARD, all reporting to the respective Provincial People's Committees (PPCs) or District People's Committees (DPCs).

Provincial level tasks include the following:

- Organize PCM "training of trainers" (ToT) for participation of the designated provincial officer(s) in charge of PCM and staff from district and commune offices, PFMBs and FCs on PCM orientations and field campaigns;
- Each year, determine the number of sample plots to be measured per forest eco-zone;
- Compile data from within the province for provincial reports.

Tasks which need to be undertaken at the district level include the following:

- Maintain scheduling of PCM field campaigns within the district (for organizing the rotational use of tools and equipment, and monitoring by district, provincial, PFMB or FC staff as necessary);
- Prepare, arrange, maintain and distribute tools and equipment;
- Compile data from within the district for district reports.

Other tasks to be undertaken at the provincial and district level include providing information on relevant new policies and legislation, as well as information on REDD+ in general and PCM to commune level technicians and forest managers as appropriate.

2.1.2 Organizing the activities

PCM orientations and field campaigns will need to be organized at the level of administration closest to the community, so as to be able to incorporate needs of the different forest management types and communities. From this perspective, organization of PCM orientations and field campaigns are suggested to be undertaken at the village level. Where forest management units (e.g. forestry enterprises, PFMBs, national parks, community forests) may exist extending beyond the area of one village, such units can then be organized in a way similar to one village, whereby members of the management unit will need to take on the roles of village level officers.

2.1.3 Organization of PCM exercises

Forests managed by individual households	Village chairs with the assistance from commune FPD officers, to coordinate the households or any other type of forest management units/groups to which households belong.
Forests managed through PFMBs, Forestry Companies, or National Parks	The members of the Management Board organize the PCM.
Forest being managed by communities	The members of the community forest management board carry out the PCM, with assistance from the district or commune DARD office or an external contractor.

General tasks to be undertaken at the village (or forest management unit) level include the following:

- Form teams for carrying out the PCM exercise
- Organize PCM orientation to train participants on PCM methods
- Input collected data in data management system
- Organize follow-up sessions to review data and receive feedback from participants

PFMBs, forest companies, national parks should engage their own staff (number depending on the scale of their forests and community participation in management) in PCM training to be able to provide support for communities (where they are contracted to engage in forest management) in their implementation of PCM.

2.1.4 Training local forest officers to become "PCM facilitators"

Facilitators are tasked to guide the participants in achieving the objective of the activity, in this case, PCM. It is suggested that the provincial, district and other local officers designated as the PCM officer be trained not only on the technical skills and knowledge of PCM, but as facilitators to guide the entire PCM process.

The facilitator should strive for communication which generates mutual trust, creating an open and engaging learning environment, and ultimately to strengthen cooperation among community and with local forest officers. Facilitators should be equipped with the skills and sensitivity of communicating with people of different backgrounds, age groups, gender, and levels of understanding.

2.1.5 Forming PCM teams

As the main unit for carrying out the PCM field campaign, groups need to be formed:

- Households engaged in forest management (either on allocated forest through management contracts): Households often perform management practices in groups. In such cases, such groups should be applied as the group of PCM. It would be ideal to have about five to 10 members per group, including at least two members who can participate in the facilitator's training sessions and understand the theory of PCM methods.
- Forest being managed collectively by communities: Normally, community forests have a management board with five to seven members, and other non-board members. For each unit, a group of five to 10 should be formed as the PCM team, including at least two members from the management board to participate in the facilitator's training (orientation) sessions to understand the PCM methods.

Each team should have at least one member as Team leader who should fully understand the PCM procedures to be followed. Ideally other team members have also received full training.

2.1.6 Preparation of maps, tools, materials and equipment

Preparation of physical technical inputs (maps, tools, materials and equipment) is suggested to be undertaken by at provincial DARD offices, with assistance from other technical agencies.

- **Forest stratum maps with eco-zones:** Using a forest stratum map produced by a professional institute (e.g. FIPI) and overlaid with forest eco-zones and forest ownership, and marked into four forest stratum (primary forests, secondary forests (exploited and multi-use forests), regeneration forest, and forest land without forests). This map will be used for the selection of sample plots.
- **Field equipment:** Each PCM team to conduct a survey will need to be equipped with a set of equipment. The purchase and maintenance of this equipment is best done at the district DARD office, with as many sets as the number of teams which will survey on a single day (equipment can be used on a rotational basis). Most of this equipment is locally available. However, a number of instruments may be difficult to procure locally, such as GPSs and clinometers.

List of equipment:

- GPS for forest boundary survey and plot location
- Rope for plot radius identification
- A-frame for slope determination
- Diameter tape for measuring DBH
- Recording data, either of:
  - Board and paper forms, ballpoint pen
  - Field computer

2.2 Classroom orientation session

Prior to the PCM field campaign, a classroom session to orient members of the PCM teams on PCM methods and theory should be conducted. The orientation should be organized at the commune level/forest management unit, and facilitated by local forest officers who have received PCM facilitator training ideally from the province / district, or by/with support from provincial and district DARD officers.

After the training, participants should be able to inform and demonstrate to the other members of the PCM team on:

- Why PCM is necessary?
- Steps of the PCM survey
- How to use GPS and other survey tools
- How to set up sample plots
- How to take measurements
- Reporting collected data
- Use of the collected data

Each orientation session should be composed of the facilitator and his/her assisting technical staff (at least one), and participants:

- Representative members of each PCM team (at least two per team)
- Facilitator: local forest officer from province, district, commune or from the forest management unit (e.g. PFMB or FC) who have received PCM facilitator training
- Assisting technical staff: local forest officer from province, district, commune, inventory institutes or from the forest management unit (eg PFMBs or FC) ideally who have received PCM facilitator training.

2.2.1 Topics of the orientation session

- Identify boundaries of forest management units (and areas under contracts per household, if possible) on forest stratum maps
- Using GPS to identify the sample plots on the map; checking forest boundaries
- Introducing equipment for measuring trees such as diameter, tree height, biomass, and sampling
- How to establish permanent sample plots
- How to record data in the form

3 PCM in the field

Step 1: Identifying and measuring the area of forest blocks

Objective	To record the forest of each forest owner
Result	Boundaries of forest management units per forest owner reflected on map
Responsibility	PCM team members, with assistance of FPD, PFMB or FC
Materials/ equipment	• GPS for checking boundary of forest boundary of the forest owners
Implementation	**Initial year:** Go to each of the forest blocks and, using the "tracking" function of the GPS, record the forest boundaries of each forest block. Also track the boundaries between forest types within the block (e.g. broad-leaf forest, pine forest, plantations). **Later years:** Use the same GPS "tracking" function to detect location and area of forest land use change (e.g. where deforestation, degradation or other changes have taken place).

Step 2: Upload and update the forest area information onto maps

Objective	Update maps on forest location and land use change
Result	Location information of forest blocks and land use change is reflected on to updated forest stratum maps
Responsibility	District DARD staff, or PFMB or FC if relevant
Materials/ equipment	• Forest stratum maps developed from topographic forest maps (1:10.000 - 1:25,000) and satellite imagery interpretation (provided by technical inventory agencies) • GPS data recording forest area (and land use change) tracks • GIS software such as Mapinfo, ArcGIS, DNRGarmin
Implementation	• Download GPS Track data (delineate variable areas in GIS) • Save in shape file format to be compatible with GIS software like Mapinfo, ArcGIS. This file is opened in GIS to reflect onto maps as area of forest/ land use change. • Estimate the areas of individual forest blocks after digitizing and editing the data downloaded.

Step 3: Determine the optimal number of plots to be surveyed

Objective	To determine the minimum sampling density per stratum
Result	Number of sample plots per each forest stratum determined with confidence level 95% and estimation error below 10%.
Responsibility	NRP and SDOF
Materials/ equipment	• Forest status map (interpreted from satellite imageries or forest status map which checked/updated) • ArcGIS software • Computer for data analysis

Implementation	A preliminary inventory needs to be completed to estimate the variance of the carbon stock in each forest stratum and to provide a basis for calculating the number of plots required for surveying; this is the responsibility of the National REDD+ Program. On the basis of the information from the NRP (mean and standard deviation of biomass per forest stratum) the optimal sampling density is calculated. This is adjusted for the local situation: at least one sample per 10 hectares is surveyed annually. The National REDD+ Program may instruct the forest owners to collect more data. This may be because a new campaign is required after a certain period, to increase the accuracy of the biomass estimate, or to replace data suspected of containing error or other unwanted characteristics.

Step 4: Set up sample plots in the forest

Objective	To set up plots in which measurements will be taken
Result	Random sample plots located
Responsibility	PCM team
Materials/ equipment	• GPS • Tape measure • Metal peg with attached rope • A-frame
Implementation	The sampling plots are located at random locations in the forest. Every subsequent survey in a forest block can use different locations for the plots. Care should be taken to use representative locations (i.e. neither too dense nor too open, flat versus slope, etc). The location of the plot is recorded by GPS if the forest block is larger than 4 hectares. The slope of the plot is recorded using the A-frame. The dimension of the plot is dependent on the type and condition of the forest:

Type	Condition		Size (radius)
Natural	10 or more trees with DBH >6cm		500m² (12.62m)
	Less than 10 trees with DBH >6cm	25 or more trees with DBH <6cm	500m² (12.62m)
		Less than 25 trees with DBH <6cm	1,000m² (17.84m)
	No trees with DBH >6cm		500m² (12.62m)
	Bamboo		100m² (5.64m)
	Mixed forest	Tree – bamboo	500m² (12.62m)
		Bamboo – tree	100m² (5.64m)
Plantation	Irregularly spaced		As above for trees or bamboo
	Regularly spaced		5 rows x 5 trees

The metal peg with attached rope is driven into the ground in the center of the plot (except for the regularly spaced plantation). Depending on the plot size, a knot is made in the rope to indicate the limit of the plot (this can also be prepared by the facilitators in the office; use colored bands to indicate the distance).

Step 5: Measurement of trees and bamboo

Objective	Measure the properties of trees and bamboo
Result	Forest properties measured for plot-wise above-ground biomass calculation
Responsibility	PCM team
Materials/ equipment	• Diameter tape • Writing board with paper forms or field computer
Implementation	**For natural forests with trees:** • The rope is extended from the metal peg until it is straight. One person now walks a circle around the metal peg, holding the rope at the distance adequate for the plot. Mark the first tree that is encountered. You will have to walk towards the metal peg to go around every tree inside the plot. • Measure the diameter at breast height of every tree with DBH >6cm using the diameter tape. (If the tree is on the edge of the plot, only record it if the center is inside the plot.) Record the BDS in centimeter. Record the name of the tree if it can be identified. If the tree is on a slope, forked, leaning, etc. use the appropriate height for measurement from the figure on the next page. • Tally every tree that has a DBH <6cm (i.e. count the total number of small trees in the plot; do not measure them). • Repeat until the first marked tree is encountered. **For natural forests with bamboo:** • Walk the circle as indicated above. • Bamboo is measured by age and average height, if possible. Age of bamboo can be determined using the information in the annex. • If the bamboo is monopodial (single stem), DBH is measured as for trees. • If the bamboo is growing sympodial (in a culm), DBH of 10 individual stems in each culm (spread out over the culm) is taken, as well as the DBH of the entire culm **For mixed forests:** • Use the approach for trees and bamboo as specified above. • Use separate forms for the trees and bamboo (monopodial or sympodial). **For plantations, regularly spaced:** • Record the distance between the rows and between trees within rows. • Record the DBH of 5 trees in 5 adjacent rows in centimeter. • Record the height of these trees where possible. • Record the species.

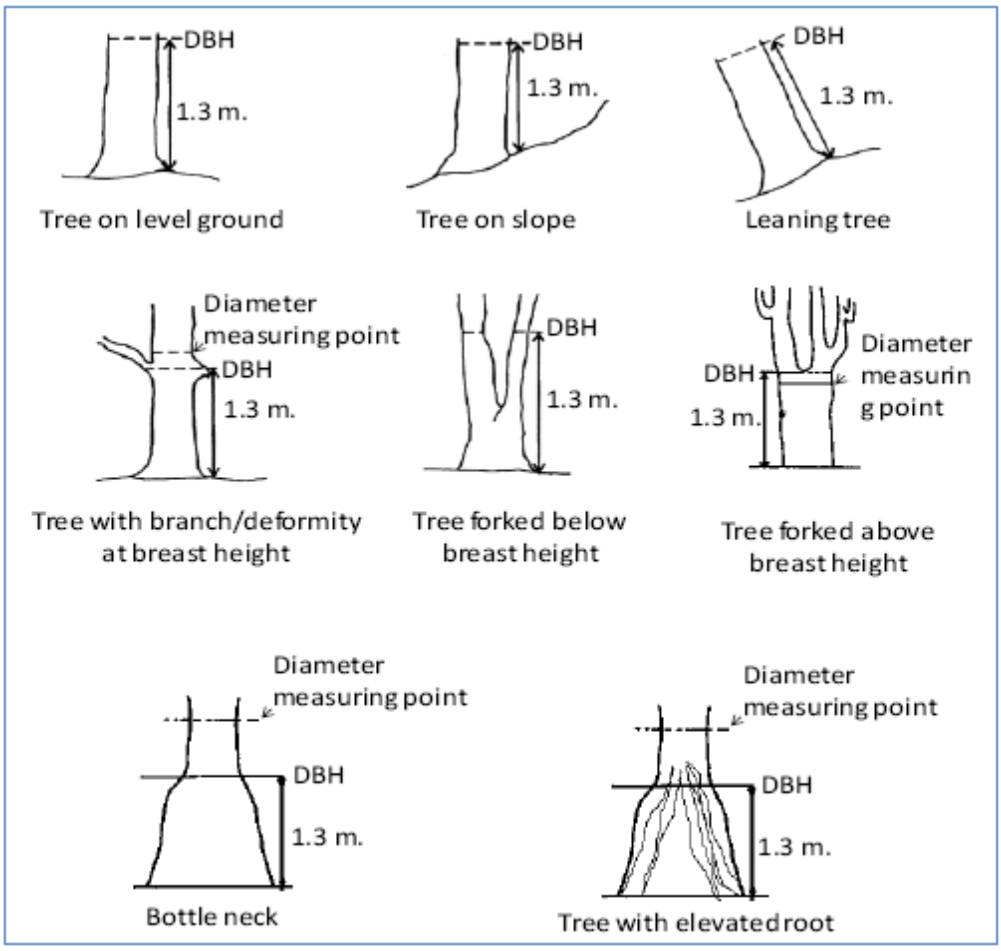


Figure 1: Measuring DBH of trees. (Source: Bhishma et al, 2010)

Step 6: Litter measurement (optional)

Objective	To take measurements of the litter
Result	Litter measured for plot-wise litter biomass calculation
Responsibility	PCM teams
Materials/ equipment	• Measuring tape • Bag for collecting litter • Spring scale • Writing board with paper forms or field computer
Implementation	• Within the plot (step 5), mark a 50cmx50cm square sub-plot. • Weigh the bag on the spring scale. • Collect all litter within the sub-plot, taking care not to collect and soil. • Weigh the bag on the spring scale, subtract the weight of the bag and record the difference. • This procedure may be repeated up to four times in the larger plot.

Step 7: Dead wood measurement (optional)

Objective	To take measurements of the dead wood
Result	Dead wood measured for plot-wise dead wood biomass calculation
Responsibility	PCM teams
Materials/ equipment	• Measuring tape • Bag for collecting dead wood (fallen branches) • Spring scale • Writing board with paper forms or field computer
Implementation	**For small branches:** • Within the plot (step 5), mark a 100cmx100cm square sub-plot. • Weigh the bag on the spring scale. • Collect all small branches within the sub-plot. If branches are partially within the sub-plot, break them at the sub-plot boundary and weigh only the part that was inside. • Weigh the bag on the spring scale, subtract the weight of the bag and record the difference. • This procedure may be repeated up to four times in the larger plot. **For large branches (>6cm diameter) or dead tree trunks (fallen or standing):** • If dead trees (fallen or standing) are present these must be measured. • Count these within the large plot (step 5) • Measure their length (height) and diameter. Record in centimeter.

Step 8: Data management

Objective	To securely store all data measured in the forest
Result	All measured data is stored in the MRV system
Responsibility	SDOF and district FPD, FC or PFMB staff
Materials/ equipment	• Paper forms with field data or field computer • Internet connected computer
Implementation	• If a field computer with appropriate software is used, data can be uploaded to the MRV database automatically. Once connected to the internet, follow the instructions on screen. • If paper forms have been used, navigate to the National REDD+ Program website on a computer with internet connection and enter the data manually. • In both cases it is possible to review the data entered and compare it with data entered previously or with regional averages. This information can and should be shared with the communities or households having measured the data.

4 References

1. Bao Huy and Pham Tuan Anh, 2008, Estimating CO_2 sequestration in natural broad-leaved evergreen forests in Vietnam. Asia-*Pacific Agroforestry Newsletter – APANews, FAO, SEANAFE*; No.32, May 2008, ISSN 0859-9742.
2. Bao Huy and Aschenbach C., 2009, *Participatory Carbon Stock Assessment Guideline for Community Forest Management* Areas in Vietnam. GTZ/GFA Consulting Group.
3. Bao Huy and Vo Hung, 2009, Increased income and absorbed carbon found in Litsea glutinosa – cassava agroforestry model. *APANews (Asia-Pacific Agroforestry Newsletter), No. 35, ISSN 0859-9742, FAO, SEANAFE*, pp 4-5.
4. Bao Huy 2009, Methodology for research on CO_2 sequestration in Natural Forests to join the program of Reducing emissions from deforestation and degradation (REDD). *National Journal on Agriculture and Rural Development, No1/2009*, Hanoi, ISSN 0866-7020, pp85-91.
5. Bao Huy, 2010, *Number of required sample plots for carbon monitoring and randomly permanence sample plot arrangement within SNV – REDD project area in 4 communes of Cat Tien and Bao Lam districts, La, Dong province.* SNV – REDD.
6. Eleonor B. S. et al., 2009, *What is REDD ?.* AIPP, FPP, IWGIA.
7. McDicken, K.G. 1997, *A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Projects*. Winrock Internationl Institute for Agricultural Development.
8. Skutsch M. and Mcall M.K., 2011, "Why Community Forest Monitoring?" in *Community Forest Monitoring for the Carbon Market Opportunities under REDD.* Earthscan.
9. Silva H. P., Erin S., Michael N., Sarah M. W., Sandra B, 2010, *Manual – Technical Issues Related to Implementing REDD$^+$ Programs in Mekong Countries.* Winrock International.

5 Annexes

Method of identifying bamboo ages based on aerial stem

(Lâm Xuân Sanh và Châu Quang Hiền - 1984)

- *First year:* bamboo tree that finished it growing period during the previous rainy season is characterized by:
  - Sheath still exists on stem, usually near root;
  - Main stem is light green and covered by a layer of "white powder";
  - No lichen present;
  - Many small branches appear along main stem. Very few young branches occur on top of tree.
- *Second year*:
  - Sheath is not found;
  - Main stem is green in colour and covered by a layer of "white powder" but less than that at the first year;
  - No or very few lichen appear near tree root;
  - Main branches clearly appear. Young sub-branches may occur.
- *Third year*:
  - Main stem converts to dark green, numerous lichens account for 30-40%. They create white spots, but green colour of stem is still recognized;
  - Branches are mainly on top of stalk. Old main branches manifest dark green colour with spots of lichen. Sub-branches may be shown.
- *Fourth year*:
  - Main stem is white due to strong development of lichen (account for 70-80%). Green background of stem nearly disappears;
  - Branches are mainly on top of tree. Old main branches manifest dark green with spots of lichen.
- *Older:*
  - Main stem converts to yellow, lichen densely developed;
  - Decay and fall are apparent.

Data forms for forest survey

Data form for measuring trees with DBH ≥6cm

Compartment		**Forest type**	☐ Natural evergreen ☐ Natural deciduous ☐ Tree – bamboo ☐ Plantation
Sub-compartment			
Management plot			

Sample No.					
Sample size	m^2	**Canopy cover**	%	**Slope**	%
GPS coordinates	_____N_____’_____”	_____E_____’_____”			
Date		**Measured by**			

No.	Species	DBH (cm)	Comment	No.	Species	DBH (cm)	Comment
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

Trees with DBH <6cm:

Tick:	Total:

Data form for measuring monopodial bamboo (single stem)

Compartment		**Species**	
Sub-compartment			
Management plot			

Sample No.					
Sample size	100/500 m^2	**Average height**	m	**Slope**	%
GPS coordinates	_____N_____’_____”	_____E_____’_____”			
Date		**Measured by**			

No.	DBH (cm)	Age (yr)	Comment	No.	DBH (cm)	Age (yr)	Comment
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

Data form for measuring sympodial bamboo (culm)

Compartment		**Species**	
Sub-compartment			
Management plot			

Sample No.					
Sample size	100/500 m^2	**Average height**	m	**Slope**	%
GPS coordinates	_____N_____'_______" _______E_____'_______"				
Date		**Measured by**			

Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		
Culm DBH		cm		**Age**		yrs	
Stem DBH:		**1.**	cm	**2.**	cm	**3.**	cm
4.	cm	**5.**	cm	**6.**	cm	**7.**	cm
8.	cm	**9.**	cm	**10.**	cm		

Data form for measuring litter and dead wood

(Copy sample data from form for trees / bamboo)

Compartment		**Forest type**	☐ Natural evergreen
Sub-compartment			☐ Natural deciduous
Management plot			☐ Tree – bamboo
			☐ Plantation

Sample No.			
Sample size		**Slope**	%
GPS coordinates	_____N_____'_____" _____E_____'_____"		
Date		**Measured by**	

Litter, 50 x 50 cm square sub-plots:

Weight	gr	gr	gr	gr	gr

Dead wood, small branches, 100 x 100 cm square sub-plots:

Weight	gr	gr	gr	gr	gr

Dead wood, standing or fallen trees, full sampling plot:

No.	**Species**	**S / F**	**DBH (cm)**	**Length (cm)**	**No.**	**Species**	**S / F**	**DBH (cm)**	**Length (cm)**
1					6				
2					7				
3					8				
4					9				
5					10				

S = standing F = fallen