# TECHNICAL GUIDANCE SERIES FOR THE DEVELOPMENT OF A NATIONAL OR SUBNATIONAL FOREST MONITORING SYSTEM FOR REDD+

# FRAMEWORK DOCUMENT

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This series was developed by Winrock International's Ecosystem Services Unit

Winrock International

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**Cite report as:**

**Brown S., F. Casarim F., K.M. Goslee, A.M. Grais, T.H. Pearson, S. Petrova, E.Swails, S.M. Walker. 2013. Technical Guidance Series for the Development of a National or Subnational Forest Monitoring System for REDD+. Developed by Winrock International under the LEAF Program.**

## Abbreviations & Definitions for all Modules

| | |
|---|---|
| **Activity** | A practice, in a defined area over a given period of time, leading to deforestation, degradation, or forest enhancement. |
| **Activity Data** | Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. The IPCC Guidelines describe three different Approaches for representing the activity data, usually reported as ha per year. |
| **AFOLU** | Agriculture, Forestry, and Other Land Use |
| **A/R** | Afforestation/Reforestation |
| **Approaches** | IPCC refers to three approaches for representing activity data. They are presented in order of increasing information content, increasing from 1 to 3. |
| **Carbon pool** | IPCC recognized reservoirs containing carbon: above and below-ground biomass, dead wood, litter, soil organic carbon, and harvested wood products. |
| **Carbon stock** | The quantity of carbon in a pool. |
| **CDM** | Clean Development Mechanism |
| **Driver** | Causes of forest and land use change, both positive (e.g. carbon stock enhancement) and negative (deforestation and forest degradation) |
| **Emission Factor** | The emissions and removals of greenhouse gases per unit of activity data, usually expressed in units of t CO2/ha. |
| **Forest** | Forest is a minimum area of land of 0.05 – 1.0 hectares with tree crown cover (or equivalent stocking level) of 10-30% , and minimum height at maturity in situ of 2-5 m. |
| **Gain-loss method** | Method to calculate changes in carbon stocks by estimating gains in carbon based on typical growth rates and losses from activities such as harvesting for timber and fuelwood. |
| **GIS** | Geographic Information System |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **Historical Reference Period** | The period from which data on past changes in forest area are established, analyzed, and projected into the future. |
| **LiDAR** | Light Detection and Ranging |
| **MRV** | Measuring, Reporting, and Verification |
| **NFI** | National Forest Inventory |
| **NFMS** | National Forest Monitoring System |
| **REDD+** | Reduced Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries |
| **RL/REL** | Reference Level/Reference Emission Level |
| **ROC** | Relative Operating Characteristic |

| | |
|---|---|
| **R-PP** | Readiness Preparation Plan |
| **RS** | Remote Sensing |
| **Stratification** | The subdivision of a population into strata or sampling blocks, which are more homogenous than the population as a whole |
| **Stock-difference method** | Method to calculate changes in carbon stocks as the difference in estimated carbon stocks pre and post forest cover change. |
| **Tier** | IPCC-defined levels of accuracy in estimating GHG emissions, increasing from 1 to 3. |
| **UNFCCC** | United National Framework Convention on Climate Change |

## Icons within the Document

The icons below are found throughout the document and indicate areas that the reader should pay special interests to:

| Icon | What does it signify? |
|---|---|
|  | A key decision that must be made. |
|  | A key technical step that must be accomplished before moving forward. |
|  | The need for personnel with specified skill set |
|  | An example |
|  | A key term described in the framework |
|  | A reference to relevant resource |

# 1. Background

Policies related to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) in developing countries have the potential to play a significant role in climate change mitigation. Although terrestrial carbon sequestration has always been recognized as a means to reduce atmospheric greenhouse gas concentrations under the United Nations Framework Convention on Climate Change (UNFCCC), initial agreements under the Clean Development Mechanism (CDM) of the UNFCCC Kyoto Protocol recognized only Afforestation/Reforestation (A/R) as an eligible project type. A UNFCCC mechanism to reduce emissions from deforestation and forest degradation and enhance sequestration by forests while raising developing country incomes has been under development since 2005.

The development of a national REDD+ carbon accounting program can be envisioned to include five key components (Figure 1), with each component requiring a series of steps to attain the outcome:


**Figure 1. Key components for developing a national or subnational REDD+ program.**

To start the process, an assessment of the technical capacity and infrastructure in both public and private sectors is needed, followed by steps to build the needed capacity. Much of the capacity building can be accomplished by the process of "learning by doing" as work on the other components is implemented. The next step will be to establish a national forest monitoring system (NFMS) to gather carbon stock inventory and land cover and land use data. This is the system that will be used to design the collection and analyses of all the data needed to produce estimates of carbon emissions and removals from changes in forest land cover. The outcomes of this system feed into the historic emission component of the RL/REL and also into the future MRV system.

The RL/REL is a likely projection of emissions in the absence of any REDD+ program and is based on the historic emissions. It will serve as the emissions projection against which the performance of REDD+ interventions will be assessed. Then, to achieve emissions reductions, policies and measures must be established and implemented that will result in reductions in forest emissions or enhanced removals by forests. Finally, the actual emissions and removals that take place over time must be estimated and compared to the projected RL/REL to estimate the emission reductions generated by the REDD+ program. Therefore, a system must be developed to measure, monitor, report, and verify actual emissions taking place across the landscape.

## 2. Purpose and Scope of Guidance Series

The full guidance series (see Section 5) provides information on the technical requirements for establishing a NFMS to produce the data and information inputs that will be used to establish the RL/REL and that will feed into the MRV system. The guidance series is divided into multiple modules describing different steps and technical components required to establish the NFMS and estimate historical emissions to develop the RL/REL. Each module describe, in a step-wise manner, the good practice guidance needed to produce transparent, complete, comparable, and consistent estimates of gross and net emissions with low uncertainties based on use of the Intergovernmental Panel on Climate Change (IPCC) framework methodologies.

The purpose of this framework document is to outline the individual steps and technical components that together form the overall technical framework of carbon accounting for the NFMS implementation and RL/REL development. From this framework, users may identify specific modules that are most relevant to their responsibilities and area of expertise. This document is directed at national to regional government technical staff and partners assigned to the design and implementation of the technical components of national and subnational REDD+ programs. The document is also designed to provide technical guidance to potential project developers and implementers of REDD+ interventions.

This series only focuses on how to estimate emissions and removals from REDD+ related activities. It does not include approaches to project future emissions and establish the RL/REL, but it will provide an overview of methods that may be used. Prior to setting a RL/REL, a number of initial policy decisions must be made. The outcome of these decisions will largely determine the design of the RL/REL and the eventual technical inputs required for its creation. These decisions and the methodological framework for RL/REL design is not covered in this guidance series. Winrock International has developed a methodological framework for the World Bank's Forest Carbon Partnership, to assist participant countries in building their capacity for RL/REL design; this is described in a separate report[1].

[1] Harris, N., T. Pearson, S. Brown, K. Andrasko, Al Lotsch, and G. Kapp. 2012. Draft Methodological Framework for Developing Reference Levels for REDD+. Prepared by Winrock International for the World Bank Forest Carbon Partnership Facility.

# 3. Inputs to Estimate Emissions/Removals

Two basic elements are needed to estimate emissions and removals of GHGs associated with land use change: activity data and emission factors. “Activity data” refer to the quantity of an activity that results in emissions/removals, such as area of land deforested, volume of timber removed, or quantity of fuelwood harvested. “Emission factors” are the estimated amount of emissions or removals of GHGs per unit of activity, such as tons of carbon emitted per unit area deforested or per unit of volume of timber removed. Emission factors will be combined with activity data to estimate total emissions and removals from deforestation, degradation, and enhancements in the past (used for the RL/REL) and going forward in the REDD+ implementation phase.

The development of the RL/REL and MRV can be broken down into steps based on the three key activity types (Figure 2). This guidance series focuses on the estimation of historical emissions to support the establishment of the RL/REL, and the estimation of current emissions to support the establishment of an MRV system.

The modules within this series, described in Section 5, fully describe each of the key inputs shown in the framework in Figure 2.

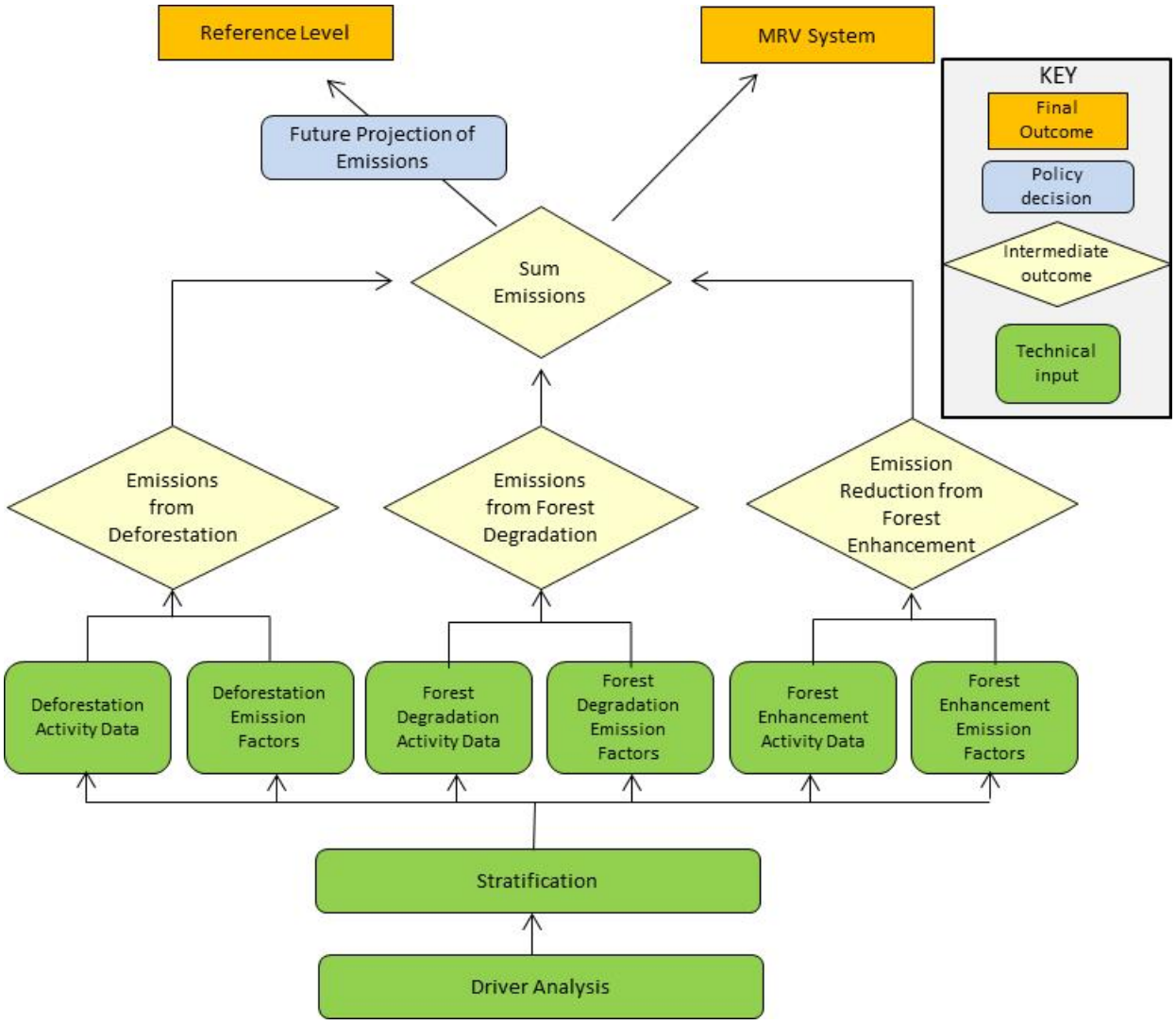


Figure 2. Framework for A National Forest Monitoring System to provide key inputs into the historical emissions for Reference Level Development and the Measuring, Reporting, and Verification System.

# 4. Prerequisites for Development of a National or Subnational Forest Monitoring System

There are numerous background activities that must be completed to develop a NFMS. Some of these items are specific to individual modules and are described within their respective module. Those elements that are broadly relevant for more than one module or activity are described within this section.

## Technical Decisions

Numerous policy decisions are required as countries or subnational units establish a REDD+ program. These decisions are described in detail, along with guidance on potential approaches, in a World Bank Forest Carbon Partnership Facility 'Decision Support Tool for Developing Reference Levels for REDD+'[2].Described below are the some of the key technical and policy decisions required prior to developing a NFMS. The UNFCCC does not provide strict guidance on how these decisions are to be made; rather, countries must provide a rationale for each decision. Such rationale will be based on factors such as availability of reliable data, conservatism, and cost/benefit analysis.

- A definition of '**forest**' must be identified at the country level. A forest definition contains parameters for minimum area, tree height and canopy cover. A country must decide whether to use an existing forest definition such as CDM definition or create a forest definition for the purpose of the REDD+ program.

- Change in carbon stocks is caused by many different **activities** that lead to deforestation, degradation, and forest enhancement. While not all activities must be included, a decision from the Durban COP17 indicates that significant activities should not be excluded from the RL/REL and that a step-wise approach to national forest RL/REL is allowed, enabling Parties to improve it over time. It is therefore necessary to identify which activities result in a significant change in carbon stocks.

- An **historical reference period** for the estimation of historical emissions must be defined. Each country should decide on the length of the historical reference period for developing the RL/REL. The Meridian Institute report on Reference Levels (www.REDD-OAR.org) recommends an historical reference period to be established within the past 10 years.

- Methods for **stratification** should be established prior to the estimation of the activity data (AD) and should assure that estimated AD are linked to the emission factors (EF) for deforestation.

[2] Harris, N., T. Pearson, S. Brown, K. Andrasko, Al Lotsch, and G. Kapp. 2012. Decision Support Tool for Developing Reference Levels for REDD+. Prepared by Winrock International for the World Bank Forest Carbon Partnership Facility.

- There are six IPCC recognized **carbon pools** and all significant pools must be included in the reference level. If a given pool represents a very small proportion of the total, justification can be provided for excluding it which will save time and resources

## Technical Skills and Equipment

The following technical skills and equipment are required to develop a NFMS:

- Understanding of the basic elements of a **REDD+** program.
- **Forest inventory** specialists(s) with ability to design and perform all measurements needed for forest carbon assessment.
- Expert(s) in **forest data analysis** with experience in use of allometric biomass equations, forest stratification, and statistical analysis.
- **Remote sensing expert(s)** with good understanding and experience of RS techniques such as image pre-procession, image classification, image segmentation, spectral mixing and accuracy assessment techniques for creating land cover maps or forest cover maps.
- **GIS expert(s)** with ability to perform change and geospatial analysis to determine the AD rate for deforestation and degradation and enhancement.
- **RS and GIS software platforms** such as IDRISI, eCognition, ERDAS, ArcGIS, MapInfo to conduct RS and GIS analysis.
- **Computer hardware** allowing for seamlessly running the RS and GIS software.

## Assess Existing Spatial Data and Spatial Data Needs

Relevant data may already be available, or may need to be collected. To identify available data and determine data needs, the following items must be addressed:

- Compile (or develop) land cover maps

The GOFC-GOLD Sourcebook (COP 18 version1) contains guidance on available satellite images and different RS techniques for creating land cover.

- Compile and examine spatial data and stratify forest (e.g. the LEAF publication: Pearson, T. et al. 2013. Guidelines for Stratification for REDD+ Using a National Inventory)
- Assess suitability of existing data for activity-specific emission factors, including criteria such as:
    - They are less than 10 years old,
    - They are derived from multiple measurement plots,
    - They include all tree species in the inventories,
    - They are sampled from good coverage of the strata over which they will be extrapolated,
    - They attain acceptable levels of uncertainty, i.e. <15% of the mean at a 95% confidence interval across all relevant pools.
- Develop sampling design and conduct necessary measurements

## Compile and examine existing field-based data

A thorough evaluation should be conducted to determine what field measurements have previously been taken and how they can be used. Figure 3 outlines the overall steps for compiling and assessing existing forest carbon stock data.

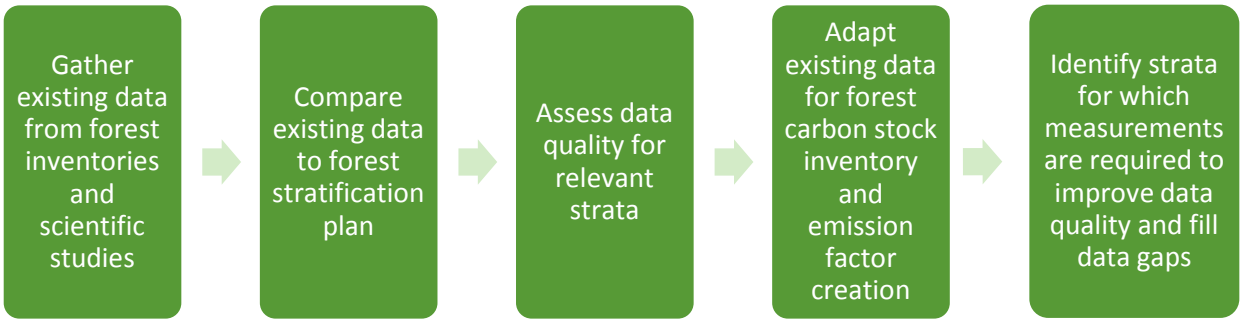


**Figure 3 Steps for compiling, assessing, and integrating existing data of forest carbon stocks for creating historic emissions**

In addition to forest carbon stock inventory data, existing data on conversion factors should be compiled and evaluated to identify gaps. Conversion factors include allometric equations, wood density values, biomass expansion factors, etc. for converting field measurements into carbon stock values.

After the inventory of existing data is completed, data gaps should be identified to inform the sampling design and implementation of the field measurement plan.

### Develop sampling design and conduct necessary measurements

Once strata have been established and existing data identified, it will be necessary to fill gaps to estimate carbon stocks. For each stratum, a sampling design will need to be created to undertake field measurements. The number of plots to be sampled will vary by stratum depending on the variability of carbon stocks and the desired precision of carbon stock measurements as well as the selected plot size. Data from a relatively small number of preliminary plots will be needed to determine the variability of carbon stocks in each stratum. The field measurement plan should be implemented to collect data for the selected carbon pools.

Further guidance on standard field measurements of carbon stocks can be found in Winrock's manual on Standard Operating Procedures for Terrestrial Carbon Measurement[3]. Additional information on assessing existing data and developing a sampling design will be available in a future module.

# 5. Modules and Tools for the Development of a National or Subnational Forest Monitoring System

[3] Walker, SM, TRH Pearson, FM Casarim, N Harris, S Petrova, A Grais, E Swails, M Netzer, KM Goslee and S Brown. 2012. Standard Operating Procedures for Terrestrial Carbon Measurement: Version 2012. Winrock International.

The technical guidance series includes the modules and tools described below. **Modules** describe a specific component of an overall methodology that can be applied to perform a specific task. **Tools** provide detailed guidelines for performing field work and analyses.

## Stratification Modules

Activity data will be developed using spatial datasets and expertise along with non-spatial data. Land cover maps from several intervals in the past will need to be defined, thereby establishing a historical land cover changes (especially forest cover changes) and a "benchmark map". The benchmark map is the land cover map from which all future activity data will be measured. The benchmark map is the extent of forest and other land cover classes at a pre-determined start year. Two **stratification** modules describe the steps required for the creation and stratification of a benchmark map and threat assessment for reducing uncertainty in estimates of emissions from deforestation, planning strategic sampling of forest carbon stocks. These two modules include

- **Stratification Using NFI Data (STR-NFI)**,
- **Stratification using other carbon stock data (STR-OTH)**,

## Activity Data Modules

**Deforestation activity data (AD-D) t**o estimate the amount of deforestation that has occurred, a series of land cover maps are needed.

**Degradation activity data (AD-SL)** for selective logging - both spatial and non-spatial data will be used to estimate historical degradation from this activity.

**Enhancement activity data (AD-E)** - for afforestation/reforestation both spatial and non-spatial data are used to estimate enhancement.

## Emission Factor Modules

**Emission factors for deforestation (EF-D)** — carbon stocks of forests (pre-deforestation) and post-deforestation land cover classes must be known.

**Emission factors for selective logging (EF-SL)** — requires field measurements in the logging gaps to estimate the direct impact of logging on key pools.

**Emission factors for enhancement (EF-E)** — requires measurement and/or knowledge of rates of carbon accumulation (or biomass), as well as carbon stocks prior to enhancement activities.

## Sum Historical Emissions Module

**Historical emissions from deforestation (EM-H) —** This module is based on combining activity data and emission factors for deforestation over a defined period of time.

## Creating a Reference Level

**Reference level development module (REDD-RL)** — The estimation of historical emissions provides the basis on which to develop a complete reference level, with emissions projected into the future. The projections can be based on the average of historical emissions, the continuation of past trends, or modelling anticipated changes in national circumstances that contribute to emissions.

### Implementing Nested REDD+

**Nested REDD+ Implementation Module (REDD-N)** — LEAF has already provided guidance on some of the critical decisions[4] for this activity.

### Sample Design Module

**Sample Design Module (REDD-SD)** - Sampling carbon stocks requires establishing a statistically well-designed system that reflects forest conditions within the country and ensures that the desired level of precision will be attained, at the same time being cost-efficient.

### Field Data Collection SOPs (SOP-FD)

Winrock has produced a set of Standard Operating Procedures for field measurements[5]. The document provides standard field measurement approaches to assist in quantifying the amount of carbon stored within the various IPCC-identified pools found within a landscape.

### Calculation SOP (SOP-Calc)

The analysis of field data to estimate carbon stocks and emission factors must be conducted using appropriate calculations to estimate mean carbon stocks, change in carbon stocks, and uncertainty in these estimates.

### Guidance on Use of Modules and SOPs

While each of the documents described above can be used as a stand-alone document for individual tasks, development of different aspects of a NFMS requires use of a combination of these documents. Table 1 below provides a general overview of which documents are required for deforestation, degradation, and enhancement activities.

**Table 1. List of modules/SOPs, and their relevance to different activities. R = required, O = optional**

| Module/SOP | Deforestation | Degradation | Enhancement |
|---|---|---|---|
| **REDD-SD** | R | R | R |
| **SOP-FD** | R | R | R |

[4] Broadhead, J., O'Sullivan, R., Costenbader, J., Pritchard L. and Conway, S. (2013), Decision Support Tool - Integrated REDD+ Accounting Frameworks: Nested National Approaches

[5] Walker, SM, TRH Pearson, FM Casarim, N Harris, S Petrova, A Grais, E Swails, S Brown. 2012. Standard Operating Procedures for Terrestrial Carbon Measurements. Winrock International

| | | | |
|---|---|---|---|
| **SOP-Spatial** | R | R | R |
| **SOP-Calc** | R | R | R |
| **STR-NFI*** | O | O | O |
| **STR-OTH*** | O | O | O |
| **AD-D** | R | | |
| **AD-SL** | | R | |
| **AD-E** | | | R |
| **EF-D** | R | | |
| **EF-SL** | | R | |
| **EF-E** | | | R |
| **EM-H** | R | R | R |
| **REDD-N** | O | O | O |
| **REDD-RL** | R | R | R |

* Note that stratification is usually recommended, in which case the most relevant of the modules addressing stratification should be followed.

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