M-EXP

VCS REDD Methodology Module

"Methods for ex-post monitoring of greenhouse gas emissions and removals" – M-EXP

Version – April 2010

I. SCOPE, APPLICABILITY, DATA REQUIREMENT AND OUTPUT PARAMETERS

Scope

This module provides methods for monitoring ex post emissions and removals of GHGs due to deforestation, forest degradation, and carbon stock enhancement that has been induced as a result of project implementation within the project area and leakage belt.

This module must also be used to define and periodically revisit the baseline of a REDD project activity and to monitor changes for the revisiting of the baseline at the end of each baseline period.

This methodology module monitors:

a. The area of forest land converted to non-forest land and associated changes in carbon stocks;

b. The area of forest land undergoing loss in carbon stock from degradation activities and associated changes in carbon stocks;

c. The area of forest land undergoing gain in carbon stock from enhancement activities and associated changes in carbon stocks.

Applicability conditions

Strata as defined in the relevant baseline modules are fixed and may not be changed without baseline revision.

The module is always mandatory. Without application of this module the methodology shall not be used.

Output parameters

This module provides methods to determine the following parameters:

Parameter	SI Unit	Description

ΔC_P	t CO_2-e	Net CO_2 equivalent emissions within the project boundary in the project case
$\Delta C_{P,LB}$	t CO_2-e	Net CO_2 equivalent emissions within the leakage belt in the project case
$A_{RR,unplanned,hrp}$	ha	Total area deforested during the historical reference period in the reference region
$A_{DefPA,i,t}$	ha	Area of recorded deforestation in the project area in the project case in stratum *i* at time *t*
$A_{DefLB,i,t}$	ha	Area of recorded deforestation in the leakage belt in the project case in stratum *i* at time *t*
$A_{burn,i,t}$	ha	Area burnt in stratum *i* at time *t*

II. PROCEDURE

For the project area the net greenhouse gas emissions in the project case is equal to the sum of stock changes due to deforestation and degradation plus the total greenhouse gas emissions minus any eligible forest carbon stock enhancement:

$$\Delta C_P = \sum_{t=1}^{t}\sum_{i=1}^{M} \Delta C_{P,DefPA,i,t} + \Delta C_{P,Deg,i,t} + GHG_{P-E,i,t} - \Delta C_{P,Enh,i,t} \tag{1}$$

Where:

ΔC_P — Net CO_2 equivalent emissions within the project boundary in the project case; t CO_2-e

$\Delta C_{P,DefPA,i,t}$ — Net carbon stock change as a result of deforestation in the project area in the project case in stratum *i* at time *t*; t CO_2-e

$\Delta C_{P,Deg,i,t}$ — Net carbon stock change as a result of degradation in the project case in stratum *i* at time *t*; t CO_2-e

$GHG_{P\text{-}E,i,t}$ — Greenhouse gas emissions as a result of deforestation and degradation activities within the project boundary in the project case in stratum *i* at project year *t*; t CO_2-e

$\Delta C_{P,Enh,i,t}$ — Net carbon stock change as a result of forest growth and sequestration during the project in areas projected to be deforested in the baseline in stratum *i* at time *t*; t CO_2-e

i — 1, 2, 3 …*M* strata in the project scenario

t — 1, 2, 3, … *t* years elapsed since the projected start of the REDD project activity

For the leakage belt the net greenhouse gas emissions in the project case is equal to the sum of stock changes due to deforestation in the leakage belt:

$$\Delta C_{P,LB} = \sum_{t=1}^{t} \sum_{i=1}^{M} \Delta C_{P,Def\,LB,i,t} \qquad (2)$$

Where:

$\Delta C_{P,LB}$	Net CO_2 equivalent emissions in the leakage belt in the project case; t CO_2-e
$\Delta C_{P,DefLB,i,t}$	Net carbon stock change as a result of deforestation in the leakage belt the project case in stratum *i* at time *t*; t CO_2-e
i	1, 2, 3 …*M* strata in the project scenario
t	1, 2, 3, … *t* years elapsed since the projected start of the REDD project activity

The calculation procedure is implemented by applying the following 3 steps:

STEP 1. Selection and analyses of sources of activity data (AD)

STEP 2. Interpretation and analyses

STEP 3. Documentation

STEP 1. Selection and analyses of sources of activity data (AD)

In general, the same source of remotely sensed data and data analysis techniques must be used within a period for which the baseline is fixed. If remotely sensed data have become available from new and higher resolution sources (e.g. from a different sensor system) during this period then it is possible to change the source of the remotely sensed data. Equally if the same source is no longer available (e.g. due to satellites or sensors going out of service) an alternate source may be used. A change in source data may only occur if the images based on interpretation of the new data overlap the images based on interpretation of the old data by at least 1 year and they cross calibrate to acceptable levels based on commonly used methods in the remote sensing community.

The data collected and analyzed must cover:

- The entire reference region: data shall be available for the year of baseline renewal or no further in the past than the year prior to baseline renewal.
- The entire project area: data shall be available for the year in which monitoring and verification is occurring

  The entire leakage belt, where required: data shall be available for the year in which monitoring and verification is occurring

1.1 Processing AD

The remotely sensed data collected must be prepared for analysis. Minimum pre-processing involves geometric correction and geo-referencing and cloud and shadow detection and removal. Guidance for interpretation of remote sensing imagery is given in the GOFC-GOLD 2008[1] Sourcebook for REDD and shall be followed as appropriate.

1.2 Post-processing and accuracy assessment

Post-processing is required to:

1. Map area change detected in the imagery.
2. Calculate the area of each category of change within the project area and, where required, the leakage belt. For periodical revisiting of the baseline, do this also for the reference region,

For the calculation of each category of change:

a) At the end of each monitoring period:
   - Calculate the area of each category within the project area and, where required, the leakage belt.
   - Update the Forest Cover Benchmark Maps for the project area and leakage belt.

b) Every 10 years (when the project baseline must be revisited):
   - Calculate the area of each category within the reference region, project area and, where required, the leakage belt.
   - Update the Forest Cover Benchmark Maps for the reference region, project area and leakage belt.
   - Estimate the total area deforested during the historical reference period in the reference region ($A_{RR,unplanned,hrp}$).

c) Estimating activity data in cloud-obscured areas:

   Calculating the rate of deforestation when maps have gaps due to cloud cover is a challenge. As described in module BL-UP (Part 1, section 2.3) multi-date images must be used to reduce cloud cover to no more than 10% of any image. If the 10% cloud cover in either date in question in the area for which the rate is being calculated do not overlap exactly, then the rate should come from areas that were cloud free in both dates in question. This should be estimated in % per year. Then, a maximum possible forest cover map should be made for the most recent time period. The historical rate in % should be multiplied by the maximum forest cover area at the start of the period for estimating the total area of deforestation during the period.

The overall classification accuracy of the outcome of the previous steps must be

[1] GOFC-GOLD, 2008, Reducing greenhouse gas emissions from deforestation and degradation in developing countries: a sourcebook of methods and procedures for monitoring, measuring and reporting, GOFC-GOLD Report version COP13-2, (GOFC-GOLD Project Office, Natural Resources Canada, Alberta, Canada) – available at: http://www.gofc-gold.uni-jena.de/redd/sourcebook/Sourcebook_Version_June_2008_COP13.pdf

80% or more.

STEP 2. Interpretation and analyses

2.1 Monitoring deforestation

This step will produce an estimate of the emissions resulting from any deforestation that occurs within the project area and leakage belt ($\Delta C_{P,Def,i,t}$).

Many methods exist to detect and map deforestation using remotely sensed data. The method selected must be based on common good practice in the remote sensing field and will depend on available resources and the availability of image processing software. The same method should be used within a period for which the baseline is fixed. The key is that the method of analysis results in estimates of any deforestation that may occur in the project and leakage areas. See IPCC 2006 GL AFOLU, Chapter 3A.2.4 and the GOFC-GOLD 2008 Sourcebook for REDD for additional guidance.

The net carbon stock change as a result of deforestation is equal to the area deforested multiplied by the emission per unit area.

$$\Delta C_{P,DefPA,i,t} = A_{DefPA,i,t} * \Delta C_{pools,P,Def,i,t} \quad (3)$$

$$\Delta C_{P,DefLB,i,t} = A_{DefLB,i,t} * \Delta C_{pools,P,Def,i,t} \quad (4)$$

Where:

$\Delta C_{P,DefPA,i,t}$	Net carbon stock change as a result of deforestation in the project case in the project area in stratum *i* at time *t*; t CO_2-e
$\Delta C_{P,DefLB,i,t}$	Net carbon stock change as a result of deforestation in the project case in the leakage belt in stratum *i* at time *t*; t CO_2-e
$A_{DefPA,i,t}$	Area of recorded deforestation in the project area stratum *i* at time *t*; ha
$A_{DefLB,i,t}$	Area of recorded deforestation in the leakage belt stratum *i* at time *t*; ha
$\Delta C_{pools,Def,i,t}$	Net carbon stock changes in all pools in the project case in stratum *i*; t CO_2-e ha^{-1}
i	1, 2, 3 …*M* strata in the in the project case
t	1, 2, 3, … *t* years elapsed since the projected start of the REDD project activity

The emission per unit area is equal to the difference between the stocks before and after deforestation minus any wood products created from timber extraction in the process of deforestation:

$$\Delta C_{pools,Def,i,t} = C_{BSL,i} - C_{P,post,i} - C_{P,wp,i} \quad (5)$$

Where:

$\Delta C_{pools,Def,i,t}$	Net carbon stock changes in all pools as a result of deforestation in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{BSL,i}$ Carbon stock in all pools in the baseline case in stratum *i*; t CO_2-e ha^{-1}

$C_{P,post,i}$ Carbon stock in all pools in the project case post-deforestation in stratum *i*; t CO_2-e ha^{-1}

$C_{P,WP,i}$ Carbon stock sequestered in wood products in the project case in stratum *i*; t CO_2-e ha^{-1}

i 1, 2, 3 …*M* strata in the in the project case

t 1, 2, 3, … *t* years elapsed since the projected start of the REDD project activity

For calculation of carbon stock sequestered in wood products, see the Module "Estimation of carbon stocks and changes in carbon stocks in the harvested wood products carbon pool in REDD project activities" (CP-W). It is conservative in the project case to assume no wood products are produced.

Instead of tracking annual emissions through burning and/or decomposition, this methodology employs the simplifying assumption that all carbon stocks are emitted in the year deforested and that no stocks are permanently sequestered (beyond 100 years after deforestation). This assumption applies regardless of whether burning is employed as part of the forest conversion process or as part of post conversion land use activities.

Changes in carbon stocks in the selected pools (must be the same as those used in the baseline modules) must be measured and estimated using the methods given in modules CP-AB, CP-D, CP-L, CP-S.

$$C_{post,i} = C_{AB\_tree,i} + C_{BB\_tree,i} + C_{non-tree,i} + C_{DW,i} + C_{LI,i} + C_{SOC,i} \quad (6)$$

Where:

$C_{P,post,i}$ Carbon stock in all pools in the project case post-deforestation in stratum *i*; t CO_2-e ha^{-1}

$C_{AB\_tree,i}$ Carbon stock in aboveground tree biomass in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{BB\_tree,i}$ Carbon stock in belowground tree biomass in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{non-tree,i}$ Carbon stock in non-tree vegetation in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{DW,i}$ Carbon stock in dead wood in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{LI,i}$ Carbon stock in litter in the project case in stratum *i*; t CO_2-e ha^{-1}

$C_{SOC,i}$ Carbon stock in soil organic carbon in the project case in stratum *i*; t CO_2-e ha^{-1}

i 1, 2, 3 …*M* strata in the in the project case

Carbon pools excluded from the project can be accounted as zero. Herbaceous non-tree vegetation is considered to be *de minimis* in all instances. For the determination which carbon pools must be included in the calculations as a minimum, see Tool T-SIG.

2.2 Monitoring degradation

2.2.1 Monitoring degradation through wood extraction

At the time of methodology approval, remote sensing technology using optical sensors is not capable of direct measurements of biomass and changes thereof[2] but has some capability to identify forest strata that have undergone a change in biomass[3].

The key is that the monitoring method results in estimates of any emissions from degradation that may occur in the project area and leakage belt ($\Delta C_{P,Deg,i,t}$). This degradation and thus reduction of forest carbon stocks will result from either illegal extraction of trees for timber or for fuel and charcoal. As remote methods for monitoring degradation are not available at the time of methodology approval, the following ground based methods must be used.

The first step in addressing forest degradation is to complete a participatory rural appraisal (PRA) of the communities surrounding the project area to determine if there is the potential for illegal extraction of trees to occur. If this assessment finds no potential pressure for these activities then degradation ($\Delta C_{P,Deg,i,t}$) can be assumed to be zero and no monitoring is needed. The PRA must to be repeated every 2 years.

If the results of the PRA suggest that there is a potential for degradation activities, then limited field sampling must be undertaken. First, the area that is potentially subject to degradation needs to be delineated ($A_{Deg,i}$). An output of the PRA shall be a distance of degradation penetration from all access points (access buffer), such as roads and rivers or previously cleared areas, to the project area. The distance of degradation penetration will vary by form of degradation with a deeper penetration likely for illegal logging than for fuelwood/charcoal.

The area subject to degradation shall be delineated ($A_{Deg,i}$) based on an access buffer from all access points, such as roads and rivers or previously cleared areas, to the project area, with a width equal to the distance of degradation penetration. $A_{Deg,i}$ shall

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2 However, technology is developing rapidly, including techniques such as RADAR, SAR, or LiDAR, which certainly hold promise.

3 For example, a multi-temporal set of remotely sensed data can be used to detect changes in the structure of the forest canopy. A variety of techniques, such as Spectral Mixture Analysis (Souza et al. 2005), SAR or LiDAR, can be used under this approach but no specific technology is prescribed here. Some of the newer technologies can estimate carbon contents of forest types, if supported by field information such as sample plots to calibrate the technology and fieldwork leading to allometric equations of key species. Project proponents should use techniques that are suitable to their specific situation and that have been published in peer-reviewed papers.

be sampled by surveying several transects of known length and width across the access-buffer area (equal in area to at least 1% of $A_{Deg,i}$) to check whether new tree stumps are evident or not. If there is little to no evidence that trees are being harvested (see next paragraph on how to estimate emissions and use tool T-SIG to determine if significant or not) then degradation can be assumed to be zero and no monitoring is needed. This limited sampling must to be repeated each time the PRA indicates a potential for degradation.

If the limited sampling does provide evidence that trees are being removed in the buffer area, then a more systematic sampling must be implemented. The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone ($A_{Deg,i}$). The diameter of all tree stumps will be measured and conservatively assumed to be the same as the DBH. If the stump is a large buttress, identify several individuals of the same species nearby and determine a ratio of the diameter at DBH to the diameter of buttress at the same height above ground as the measured stumps. This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree. The above and below ground carbon stock of each harvested tree must be estimated using the same allometric regression equation and root to shoot ratio used in the module for estimating the carbon pool in trees (CP-AB) in the baseline scenario[4]. The mean above and below ground carbon stock of the harvested trees is conservatively estimated to be the total emissions and to all enter the atmosphere. This sampling procedure shall be repeated every 5 years and the results annualized by dividing the total emissions by five.

Where the PRA or the limited sampling indicate no degradation occurring:

$$\Delta C_{P,Deg,i,t} = 0$$

Where the PRA and the limited sampling indicate degradation is occurring:

$$\Delta C_{P,Deg,i,t} = A_{Deg,i} * \frac{C_{Deg,i,t}}{AP_i} \qquad (7)$$

Where:

$\Delta C_{P,Deg,i,t}$	Net carbon stock changes as a result of degradation in stratum *i* at time *t*; t CO_2-e
$A_{Deg,i}$	Area potentially impacted by degradation processes in stratum *i*; ha
$C_{Deg,i,t}$	Biomass carbon of trees cut and removed through degradation process in stratum *i* at time *t*; t CO_2-e
AP_i	Total area of degradation sample plots in stratum *i*; ha
i	1, 2, 3 …*M* strata in the in the project case

[4] If species-specific equations are used in the baseline and species can not be identified from stumps then it shall be assumed that the harvested species is the species most commonly harvested for the specific degradation purpose (e.g. fuel wood, charcoal or timber). A PRA shall be used to determine the most commonly harvested species

t	1, 2, 3, … *t* years elapsed since the projected start of the REDD project activity

2.2.2 Monitoring degradation through fire

Where fire occur ex-post in the project area, the area burned shall be delineated.

For planned deforestation all fires shall be considered as a project emission. The area burned ($A_{burn,i,t}$) shall be delineated and emissions calculated using E-BB.

For unplanned deforestation $A_{burn,i,t}$ shall be equal to the area of overlap between the delineated area of the fire and the summed area of unplanned deforestation in the project area ($A_{BSL,PA,unplanned,t}$); summed to the year in which the fire occurred. Emissions shall be calculated using E-BB.

2.3 Monitoring areas undergoing carbon stock enhancement

Only applicable for project areas with a deforestation baseline (planned or unplanned).

If during initial stratification (using X-STR) the project contains forest areas that are both deforested in the baseline and assumed to be accumulating carbon, then their geographic boundaries will be known—this will be one or more of the strata. The system in place for monitoring the project area will be used for monitoring any change that occur in this stratum (or strata). Ground measurements will be used to monitor the change in carbon stocks through time as given in the carbon pool modules.

It is conservative to assume that no carbon stock enhancement is occurring. Projects may elect to set $\Delta C_{P,Enh,i,t} = 0$.

If any of the strata identified as accumulating carbon are subject to degrading activities described in 2.2 above, the emissions from these activities will be estimated according to the methods given in 2.2 and deducted from the amount estimated to be sequestered in the accumulation areas to generate a net estimation of carbon sequestration or emission.

For a planned deforestation baseline:

$$\Delta C_{P,Enh,i,t} = \sum_{t=1}^{t} \sum_{i=1}^{M} \left(\left(C_{P,i,t} - C_{BSL,i} \right) * A_{Enh,PL,i,t} \right) \quad (8)$$

Where:

$\Delta C_{P,Enh,i,t}$	Net carbon stock changes as a result of forest carbon stock enhancement in stratum *i* at time *t*; t CO_2-e
$C_{P,i,t}$	Carbon stock in all pools in the project case in stratum *i* at time *t*; t CO_2-e
$C_{BSL,i}$	Carbon stock in all pools in the baseline in stratum *i*; t CO_2-e ha^{-1}
$A_{Enh,PL,i,t}$	Project area in stratum *i* in which carbon stocks are accumulating but that would have undergone planned deforestation in the baseline scenario at time *t*; ha

i	1, 2, 3 …M strata in the project scenario
t	1, 2, 3, … t years elapsed since the projected start of the REDD project activity

The eligible area is determined from area due to be deforested in each year of the baseline (See BL-PL).

$$A_{Enh,PL,i,t} = D\%_{planned,i,t} * A_{planned,i,t} \quad (9)$$

Where:

$A_{Enh,PL,i,t}$	Project area in stratum i in which carbon stocks are accumulating but that would have undergone planned deforestation in the baseline scenario at time t; ha
$D\%_{planned,i,t}$	Projected annual proportion of land that will be deforested in stratum i at year t; % year^{-1}
$A_{planned,i,}$	Total area of planned deforestation over the entire project lifetime for stratum i; ha

For an unplanned deforestation baseline:

$$\Delta C_{P,Enh,i,t} = \sum_{t=1}^{t}\sum_{i=1}^{M}\left(\left(C_{P,i,t} - C_{TOT-FOR,iF}\right) * A_{Enh,UP,i,t}\right) \quad (10)$$

Where:

$\Delta C_{P,Enh,i,t}$	Net carbon stock changes as a result of forest carbon stock enhancement in stratum i at time t; t CO_2-e
$C_{P,I,t}$	Carbon stock in all pools in the project case in stratum i at time t; t CO_2-e
$C_{TOT-FOR,iF,t}$	Carbon stock in all carbon pools in the forest stratum iF at year t; t CO_2-e ha^{-1}
$A_{Enh,UP,i,t}$	Project area in stratum i in which carbon stocks are accumulating but that would have undergone unplanned deforestation in the baseline scenario at time t; ha
i	1, 2, 3 …M strata in the project scenario
t	1, 2, 3, … t years elapsed since the projected start of the REDD project activity

The eligible area is determined from area due to be deforested in each year of the baseline (See BL-UP).

$$A_{Enh,PL,i,t} = A_{BSL,PA,unplanned,t} \quad (11)$$

Where:

$A_{Enh,UP,i,t}$	Project area in stratum *i* in which carbon stocks are accumulating but that would have undergone unplanned deforestation in the baseline scenario at time *t*; ha
$A_{BSL,PA,unplanned,t}$	Annual area of unplanned baseline deforestation in the Project Area at year *t*; ha yr^{-1}

For both planned and unplanned baselines the carbon stock in the Project case is equal to:

$$C_{P,i,t} = C_{AB\_tree,i} + C_{BB\_tree,i} + C_{DW,i} + C_{LI,i} + C_{SOC,i} \qquad (12)$$

Where:

$C_{P,i,t}$	Carbon stock in all pools in the project case in stratum *i* at time *t*; t CO_2-e
$C_{AB\_tree,i}$	Carbon stock in aboveground tree biomass in the project case in stratum *i*; t CO_2-e ha^{-1}
$C_{BB\_tree,i}$	Carbon stock in belowground tree biomass in the project case in stratum *i*; t CO_2-e ha^{-1}
$C_{DW,i}$	Carbon stock in dead wood in the project case in stratum *i*; t CO_2-e ha^{-1}
$C_{LI,i}$	Carbon stock in litter in the project case in stratum *i*; t CO_2-e ha^{-1}
$C_{SOC,i}$	Carbon stock in soil organic carbon in the project case in stratum *i*; t CO_2-e ha^{-1}
i	1, 2, 3 …*M* strata in the in the project case

Carbon pools excluded from the project can be accounted as zero. Herbaceous non-tree vegetation is considered to be *de minimis* in all instances. For the determination which carbon pools must be included in the calculations as a minimum, see Tool T-SIG.

2.4 Monitoring project emissions

Where significant, non-CO_2 gas greenhouse emissions occurring within the project boundary must be evaluated. For example, where deforestation or degradation occur within the project boundaries or in the leakage belt and fire is used as a means of forest clearance the non-CO_2 emissions may be significant. For the determination which emissions must be included in the calculations as a minimum, see Tool T-SIG.

$$GHG_{P,E,i,t} = ET_{FC,t} + E_{BiomassBurn,t} + N_2O_{direct-N,t} \qquad (13)$$

Where:

$GHG_{P,E}$	Greenhouse gas emissions as a result deforestation activities within the project boundary in the project case stratum *i* at project year *t*; t CO_2-e
$ET_{P,FC,t}$	CO_2 emission from fossil fuel combustion during year *t* in the project case; t CO_2-e $year^{-1}$
$E_{P, BiomassBurn,t}$	Greenhouse emissions due to biomass burning during the year *t* in the project case; t CO_2-e $year^{-1}$
$N_2O_{P,direct\text{-}N,t}$	Direct N_2O emission as a result of nitrogen application on the alternative land use within the project boundary in year *t* in the project case; t CO_2-e $year^{-1}$
t	*1, 2, 3 …t* years elapsed since the start of the REDD VCS project activity

STEP 4. Documentation

A consistent time-series of data on land use-change, and emissions and removals of CO_2 must emerge from periodical monitoring. This is only possible if a consistent methodology is applied over time.

The methodological procedures used in steps 1-3 above must be documented. In particular, the following information must be provided when remotely sensed data are used:

a) Data sources and pre-processing: Type, resolution, source and acquisition date of the remotely sensed data (and other data) used; geometric, radiometric and other corrections performed, if any; spectral bands and indexes used (such as NDVI); projection and parameters used to geo-reference the images; error estimate of the geometric correction; software and software version used to perform tasks; etc.

b) Data classification: Definition of the classes and categories; classification approach and classification algorithms; coordinates and description of the ground-truth data collected for training purposes; ancillary data used in the classification, if any; software and software version used to perform the classification; additional spatial data and analysis used for post-classification analysis, including class subdivisions using non-spectral criteria, if any; etc.

c) Classification accuracy assessment: Accuracy assessment technique used; coordinates and description of the ground-truth data collected for classification accuracy assessment; and final classification accuracy assessment.

d) Changes in Data sources and pre-processing / Data classification: If in subsequent periods changes will be made to the original data or use of data:

- Each change and its justification should be explained and recorded; and
- When data from new satellites are used documentation must follow a) to c) above

III. DATA AND PARAMETERS MONITORED FOR BASELINE RENEWAL

Data / parameter:	*Regional Forest Cover / Non-Forest Cover Benchmark Map*
Data unit:	
Used in equations:	3
Description:	Map showing the location of forest land within the reference region at the beginning of the crediting period
Source of data:	Remote sensing in combination with GPS data collected during ground truthing
Measurement procedures (if any):	The minimum map accuracy should be 80% for the classification of forest/non-forest in the remote sensing imagery If the classification accuracy is less than 80% then the map is not acceptable for further analysis. More remote sensing data and ground truthing data will be needed to produce a product that reaches the 80% minimum mapping accuracy.
Measurement Frequency	At a minimum three times over the ten leading up to baseline renewal
QA/QC Procedures	
Any comment:	

Data / parameter:	*Project Forest Cover Benchmark Map*
Data unit:	
Used in equations:	3,7
Description:	Map showing the location of forest land within the project area at the beginning of each monitoring period. If within the Project Area some forest land is cleared, the benchmark map must show the deforested areas at each monitoring event
Source of data:	Remote sensing in combination with GPS data collected during ground truthing
Measurement procedures (if any):	The minimum map accuracy should be 80% for the classification of forest/non-forest in the remote sensing imagery If the classification accuracy is less than 80% then the map is not acceptable for further analysis. More remote sensing data and ground truthing data will be needed to produce a product that reaches the 80% minimum mapping accuracy.
Measurement Frequency	At a minimum every ten years prior to baseline renewal

QA/QC Procedures	
Any comment:	Where forest land contains more than one forest class, the map must be stratified into forest classes using module X-STR.

Data / parameter:	*Leakage Belt Forest Cover Benchmark Map*
Data unit:	
Used in equations:	3
Description:	Map showing the location of forest land within the leakage belt area at the beginning of each monitoring period. Only applicable where leakage is to be monitored in a leakage belt
Source of data:	Remote sensing in combination with GPS data collected during ground truthing
Measurement procedures (if any):	The minimum map accuracy should be 80% for the classification of forest/non-forest in the remote sensing imagery If the classification accuracy is less than 80% then the map is not acceptable for further analysis. More remote sensing data and ground truthing data will be needed to produce a product that reaches the 80% minimum mapping accuracy.
Measurement Frequency	At a minimum every ten years prior to baseline renewal
QA/QC Procedures	
Any comment:	Where forest land contains more than one forest class, the map must be stratified into forest classes using module X-STR.

Data / parameter:	$A_{RR,unplanned,hrp}$
Data unit:	Ha
Used in equations:	
Description:	Total area deforested during the historical reference period in the reference región
Source of data:	Remote sensing imagery
Measurement procedures (if any):	
Measurement Frequency	At a minimum every ten years prior to baseline renewal

QA/QC Procedures	
Any comment:	Where forest land contains more than one forest class, the map must be stratified into forest classes using module X-STR.

III. DATA AND PARAMETERS MONITORED FOR VERIFICATION

Data / parameter:	*Project Forest Cover Monitoring Map*
Data unit:	
Used in equations:	3,7
Description:	Map showing the location of forest land within the project area at the beginning of each monitoring period. If within the Project Area some forest land is cleared, the benchmark map must show the deforested areas at each monitoring event
Source of data:	Remote sensing in combination with GPS data collected during ground truthing
Measurement procedures (if any):	The minimum map accuracy should be 80% for the classification of forest/non-forest in the remote sensing imagery If the classification accuracy is less than 80% then the map is not acceptable for further analysis. More remote sensing data and ground truthing data will be needed to produce a product that reaches the 80% minimum mapping accuracy.
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Where forest land contains more than one forest class, the map must be stratified into forest classes using module X-STR.

Data / parameter:	*Leakage Belt Forest Cover Monitoring Map*
Data unit:	
Used in equations:	3
Description:	Map showing the location of forest land within the leakage belt

	area at the beginning of each monitoring period. Only applicable where leakage is to be monitored in a leakage belt
Source of data:	Remote sensing in combination with GPS data collected during ground truthing
Measurement procedures (if any):	The minimum map accuracy should be 80% for the classification of forest/non-forest in the remote sensing imagery If the classification accuracy is less than 80% then the map is not acceptable for further analysis. More remote sensing data and ground truthing data will be needed to produce a product that reaches the 80% minimum mapping accuracy.
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Where forest land contains more than one forest class, the map must be stratified into forest classes using module X-STR.

Data / parameter:	*Degradation PRA Results*
Data unit:	
Used in equations:	Section 2.2.1
Description:	
Source of data:	PRA
Measurement procedures (if any):	The PRA shall consist of semi-structured interviews / questionnaires. The PRA shall evaluate whether the following activities may be occurring in the project area: -harvesting of fuel wood -harvesting of wood for charcoal production -timber harvest If ≥ 10% of those interviewed/surveyed believe that degradation may be occurring within the project boundary then the limited on-the-ground degradation survey shall be triggered An additional output of the PRA shall be a depth of penetration of degradation pressure. A maximum distance shall be recorded for penetration into the forest from access points (such as roads, rivers, already cleared areas) for the purpose of harvesting fuel wood, charcoal and/or timber. It is likely that differing distances shall exist for each degradation pressure. If multiple pressures exist in the same stratum the deepest depth of penetration shall

	be used to define $A_{deg,i}$
Measurement Frequency	Every two years
QA/QC Procedures	
Any comment:	Ex-ante an estimation shall be made of degradation in the with-project case. If the belief is that zero degradation will occur within the project boundaries then this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent deforestation.

Data / parameter:	*Result of Limited Degradation Survey*
Data unit:	
Used in equations:	Section 2.2.1
Description:	
Source of data:	
Measurement procedures (if any):	Sampled by surveying several transects of known length and width across the access-buffer area (equal in area to at least 1% of $A_{Deg,i}$) to check whether new tree stumps are evident or not.
Measurement Frequency	Must to be repeated each time the PRA indicates a potential for degradation
QA/QC Procedures	
Any comment:	Ex-ante an estimation shall be made of degradation in the with-project case. If the belief is that zero degradation will occur within the project boundaries then this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent deforestation.

Data / parameter:	$A_{burn,i,t}$
Data unit:	ha
Used in equations:	Section 2.2.2
Description:	Area burnt in stratum *i* at time *t*
Source of data:	GPS coordinates and/or Remote Sensing data
Measurement procedures (if any):	N/A
Monitoring Frequency:	Areas burnt shall be monitored at least every five years

Any comment:	Ex-ante estimations of areas burned shall be based on historic incidence of fire in the Project region

Data / parameter:	$A_{DefPA,i,t}$
Data unit:	Ha
Used in equations:	3
Description:	Area of recorded deforestation in the project area in stratum *i* at time *t*
Source of data:	Remote sensing imagery
Measurement procedures (if any):	
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Ex-ante an estimation shall be made of deforestation in the with-project case. If the belief is that zero deforestation will occur within the project boundaries then this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent deforestation.

Data / parameter:	$A_{DefLB,i,t}$
Data unit:	Ha
Used in equations:	4
Description:	Area of recorded deforestation in the leakage belt in stratum *i* at time *t*
Source of data:	Remote sensing imagery
Measurement procedures (if any):	
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Ex-ante an estimation shall be made of deforestation in the leakage belt in the with-project case. The area of deforestation shall be made conservatively equal to:

	$\left(\sum_{t=1}^{t}(1 - PROP_{IMM}) * A_{BSL,LK,unplanned,t}\right) * (1 - PROP_{LPA})$ Where: $PROP_{IMM}$ Estimated proportion of baseline deforestation caused by immigrating population; proportion (Calculated in LK-ASU) $A_{BSL,LK,unplanned,t}$ Project rate of unplanned baseline deforestation in the Leakage Belt Area at year *t; ha. yr*$^{-1}$ (Output parameter from BL-UP) $PROP_{LPA}$ Estimated proportion of baseline deforestation agents given the opportunity to participate in leakage prevention activities; proportion (proportion shall be conservatively estimated and justifiable. Leakage prevention activities must be planned to fully replace income, product generation and livelihood. Projects have the option ex-ante to conservatively set $PROP_{LPA}$ as equal to 1). *t* *1, 2, 3 …t* years elapsed since the start of the project activity

Data / parameter:	$A_{Deg,i}$
Data unit:	Ha
Used in equations:	7
Description:	Area potentially impacted by degradation processes in stratum *i*
Source of data:	GIS delineation and ground truthing
Measurement procedures (if any):	$A_{Deg,i}$ shall be composed of a buffer from all access points (access buffer), such as roads and rivers or previously cleared areas. The width of the buffer shall be determined by the depth of degradation penetration as defined as a PRA output
Measurement Frequency	Must to be repeated each time the PRA indicates a potential for degradation
QA/QC Procedures	
Any comment:	Ex-ante a limited survey can be used to determine a likely depth of degradation penetration

Data / parameter:	AP_i
Data unit:	Ha

Used in equations:	7
Description:	Total area of degradation sample plots in stratum *i*
Source of data:	Ground measurement
Measurement procedures (if any):	The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone.
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Ex-ante an estimation should be made of area of plots. This should be set to exactly 3% of the buffer zone $A_{Deg,i}$

Data / parameter:	$C_{Deg,i,t}$
Data unit:	t CO_2-e
Used in equations:	7
Description:	Biomass carbon of trees cut and removed through degradation process in stratum *i* at time *t*
Source of data:	Field measurement
Measurement procedures (if any):	The diameter of all tree stumps is the designated plots will be measured and conservatively assumed to be the same as the DBH. If the stump is a large buttress, identify several individuals of the same species nearby and determine a ratio of the diameter at DBH to the diameter of buttress at the same height above ground as the measured stumps. This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree. The above and below ground carbon stock of each harvested tree must be estimated using the same allometric regression equation and root to shoot ratio used in the module for estimating the carbon pool in trees (CP-AB) in the baseline scenario. See detailed guidance in CP-AB for aboveground biomass estimation
Measurement Frequency	At a minimum every five years prior to verification
QA/QC Procedures	
Any comment:	Ex-ante an estimation shall be made of likely degradation in the with-project case. Such an estimation shall be based on rates of degradation in surrounding areas and the degree of protection that will be in place (e.g. forest guards) in the with-project case.

V. PARAMETERS ORIGINATING IN OTHER MODULES

Data / parameter:	$A_{BSL,PA,unplanned,t}$
Data unit:	Ha
Used in equations:	12
Description:	Annual area of unplanned baseline deforestation in the Project Area at year *t*
Module parameter originates in:	BL-UP
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$A_{planned,i,t}$
Data unit:	Ha
Used in equations:	9
Description:	Total area of planned deforestation over the entire project lifetime for stratum *i*
Module parameter originates in:	BL-PL
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{BSL,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	5, 8
Description:	Carbon stock in all pools in the baseline in stratum *i*
Module parameter originates in:	BL-PL, BL-DFW
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{AB,tree,i,}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6, 12
Description:	Carbon stock in aboveground biomass in trees in the project case in stratum *i*
Module parameter originates in:	CP-AB

Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{BB,tree,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6,12
Description:	Carbon stock in belowground biomass in trees in the project case in stratum *i*
Module parameter originates in:	CP-AB
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{nontree,i,}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6
Description:	Carbon stock in non-tree vegetation in the project case in stratum *i*
Module parameter originates in:	CP-AB
Any comment:	Herbaceous vegetation considered *de minimis* in all instances Corresponding information shall be included in the PDD

Data / parameter:	$C_{DW,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6,12
Description:	Carbon stock in dead wood in the project case in stratum *i*
Module parameter originates in:	CP-W
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{LI,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6, 12
Description:	Carbon stock in litter in the project case in stratum *i*
Module parameter originates in:	CP-L
Any comment:	

Data / parameter:	$C_{SOC,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6,12
Description:	Carbon stock in soil organic carbon in the project case in stratum *i*
Module parameter originates in:	CP-S
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{WP,i}$
Data unit:	t CO_2-e ha^{-1}
Used in equations:	6,12
Description:	Carbon stock in wood products in the project case in stratum *i*
Module parameter originates in:	CP-W
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$C_{TOT\text{-}FOR,iF}$
Data unit:	t CO_2-e
Used in equations:	10
Description:	Carbon stock in all carbon pools in the forest stratum *iF* at year *t*
Module parameter originates in:	BL-UP
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$D\%_{planned,i,t}$
Data unit:	% yr^{-1}
Used in equations:	9
Description:	Projected annual proportion of land that will be deforested in stratum *i* at year *t*
Module parameter originates in:	BL-PL
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$E_{BiomassBurn,t}$
Data unit:	t CO_2-e $year^{-1}$

Used in equations:	13
Description:	Greenhouse emissions due to biomass burning as part of degradation activities during the year *t* in the project case; t CO_2-e
Module parameter originates in:	E-BB
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$ET_{FC,t}$
Data unit:	t CO_2-e year^{-1}
Used in equations:	13
Description:	CO_2 emission from fossil fuel combustion during year *t* in the project case; t CO_2-e
Module parameter originates in:	E-FFC
Any comment:	Corresponding information shall be included in the PDD

Data / parameter:	$N_2O_{direct\text{-}N,t}$
Data unit:	t CO_2-e year^{-1}
Used in equations:	13
Description:	Direct N_2O emission as a result of nitrogen application on the alternative land use within the project boundary in year *t* in the project case; t CO_2-e year^{-1}
Module parameter originates in:	E-NA
Any comment:	Corresponding information shall be included in the PDD