Approved VCS Module VMD0017
Version 1.0
REDD Methodological Module:
Estimation of uncertainty for REDD project activities (X-UNC)
Sectoral Scope 14

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This module allows for estimating uncertainty in the estimation of emissions and removals in REDD project activities. The module shall also be used for project planning purposes. Use of the module while planning the project can assure the monitoring is of sufficient intensity to minimize uncertainty deductions. The purpose of the methodology is for calculating *ex-ante* and *ex-post* a precision level and any deduction in credits for lack of precision following project implementation and monitoring. The module assesses uncertainty in baseline estimations and in estimations of with-project sequestration, emissions and leakage.

Applicability

The module is mandatory. It is applicable for estimating the uncertainty of estimates of emissions and removals of CO_2-e generated from REDD project activities. The module focuses on the following sources of uncertainty:

- Determination of rates of deforestation and degradation
- Uncertainty associated with estimation of stocks in carbon pools and changes in carbon stocks
- Uncertainty in assessment of project emissions

Where an uncertainty value is not known or cannot be simply calculated, then a project must justify that it is using an indisputably conservative number and an uncertainty of 0% may be used for this component.

Guidance on uncertainty – a precision target of a 95% confidence interval equal to or less than 15% of the recorded value shall be targeted. This is especially important in terms of project planning for measurement of carbon stocks; sufficient measurement plots should be included to achieve this precision level across the measured stocks.

Parameters

This module provides procedures to determine the following parameter:

Parameter	SI Unit	Description
Adjusted-C_{REDD}	t CO_2-e	Cumulative total net GHG emission reductions at time *t* adjusted to account for uncertainty

II. PROCEDURE

Estimated carbon emissions and removals arising from AFOLU activities have uncertainties associated with the measures/estimates of: area or other activity data, carbon stocks, biomass growth rates, expansion factors, and other coefficients. It is assumed that the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), expert judgment[1], or estimates based on sound statistical sampling.

Alternatively, (indisputably) conservative estimates can also be used instead of uncertainties, provided that they are based on verifiable literature sources or expert judgment. In this case the uncertainty is assumed to be zero. However, this module provides a procedure to combine uncertainty information and conservative estimates resulting in an overall *ex-post* project uncertainty.

Planning to Diminish Uncertainty

It is important that the process of project planning consider uncertainty. Procedures including stratification (see module X-STR), and the allocation of sufficient measurement plots can help ensure that low uncertainty in carbon stocks results and ultimately full crediting can result.

It is good practice to apply this module at an early stage to identify the data sources with the highest uncertainty to allow the opportunity to conduct further work to diminish uncertainty.

Part 1 – Uncertainty in Baseline Estimates

Step 1: Assess uncertainty in projection of baseline rate of deforestation or degradation

Relevant modules:

BL-PL	"Estimation of baseline carbon stock changes and greenhouse gas emissions from planned deforestation"

[1] Justification should be supplied for all values derived from expert judgement

BL-UP	"Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation"
BL-DFW	"Estimation of baseline emissions from forest degradation caused by extraction of wood for fuel"

Relevant parameters:

$A_{BSL,RR,unplanned}$	BL-UP
$D\%_{planned,i,t}$	BL-PL

It is here assumed that there is zero uncertainty in baseline rate of deforestation or degradation where numbers are equal to a long-term average (BL-UP), are based on actual deforestation plans (BL-PL) or are derived from PRA (BL-DFW). In these specific cases assume:

$Uncertainty_{BSL,RATE} = 0$

In all other scenarios the uncertainty in rate shall be a component of net project uncertainty.

a. Planned Deforestation: where rate of deforestation is derived from measurements of proxy areas (see module BL-PL):

   The uncertainty shall be equal to the 95% confidence interval as a percentage of the mean of the area deforested in each proxy ($D\%_{pn}$) divided by the number of years over which deforestation occurred in each proxy (Yrs_{pn}).

b. Unplanned deforestation: where deforestation rate is derived using regression equations of past deforestation rate versus time, the uncertainty introduced by this analysis must be incorporated (see module BL-UP). The r^2 value is a measure of the fit of the equation to the source data. In BL-UP it is a requirement that the relationship be statistically significant and that the input data be evenly distributed across the reference period. Thus the r^2 value presents an indication of how closely the data reflects the model and provides a simple method that can be used here without the need for high level statistics.

$$Uncertainty_{BSL,RATE} = (1-r^2) * 100 \quad (1)$$

Where:

$Uncertainty_{BSL,RATE}$	Uncertainty in the baseline rate of deforestation; %
r^2	The r^2 value derived from the regression of historic deforestation against time; dimensionless

Step 2: Assess uncertainty of emissions and removals in project area

Relevant modules:

CP-AB	"Estimation of carbon stocks and changes in carbon stocks in the above-ground and below ground biomass carbon pool"
CP-D	"Estimation of carbon stocks and changes in carbon stocks in the dead-wood carbon pool"
CP-L	"Estimation of carbon stocks in the litter carbon pool"
CP-S	"Estimation of carbon stocks in the soil organic carbon pool"
CP-W	"Estimation of carbon stocks and changes in carbon stocks in the wood products carbon pool"
E-BB	"Estimation of non-CO_2 emissions from biomass burning"
E-FFC	"Estimation of emissions from fossil fuel combustion"
E-NA	"Estimation of direct N_2O emissions from nitrogen application"

Relevant parameters:

$C_{AB\text{-}tree}$	CP-AB
$C_{BB\text{-}tree}$	CP-AB
C_{DW}	CP-D
C_{LI}	CP-L
C_{SOC}	CP-S
C_{WP}	CP-W
$E_{BiomassBurn}$	E-BB
E_{FC}	E-FFC
$N_2O_{direct\text{-}N}$	E-NA

Uncertainty should be expressed as the 95% confidence interval as a percentage of the mean.

$$\text{Uncertainty}_{\text{BSL,SS,i}} = \frac{\sqrt{\left(U_{BSL,SS1,i} * E_{BSL,SS1,i}\right)^2 + \left(U_{BSL,SS2,i} * E_{BSL,SS2,i}\right)^2 + \ldots + \left(U_{BSL,SSn,i} * E_{BSL,SSn,i}\right)^2}}{E_{BSL,SS1,i} + E_{BSL,SS2,i} + \ldots + E_{BSL,SSn,i}} \quad (2)$$

Where:

$Uncertainty_{BSL,SS,i}$	Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case in stratum *i*; %
$U_{BSL,SS,i}$	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case in stratum *i* (1,2…n represent different carbon pools and/or GHG sources); %
$E_{BSL,SS,i}$	Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in stratum *i* (1,2…n represent different carbon pools and/or GHG sources) in the baseline case; t CO_2-e
i	1, 2, 3 …*M* strata

Step 3: Estimate total uncertainty in baseline scenario

To assess uncertainty across combined strata:

$$\text{Uncertainty}_{\text{BSL,SS}} = \frac{\sqrt{\left(\text{Uncertainty}_{\text{BSL,SSi1}} * E_{BSL,i1}\right)^2 + \left(\text{Uncertainty}_{\text{BSL,SSi2}} * E_{BSL,i2}\right)^2 + \ldots + \left(\text{Uncertainty}_{\text{BSL,SSM}} * E_{BSL,iM}\right)^2}}{E_{BSL,i1} + E_{BSL,i2} + \ldots + E_{BSL,iM}} \quad (3)$$

Where:

$Uncertainty_{BSL,SS}$	Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case; %
$Uncertainty_{BSL,SS,i}$	Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in stratum *i* in the baseline case; %
$E_{BSL,SS,i}$	Sum of combined carbon stocks and GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning in stratum *i* (1,2…n represent different carbon pools and/or GHG sources) multiplied by the area of stratum *i* (A_i) in the baseline case; t CO_2-e
i	1, 2, 3 …*M* strata

Incorporating rate uncertainty:

$$\text{Uncertainty}_{\text{BSL}} = \sqrt{\text{Uncertainty}_{\text{BSL,RATE}}^{\ 2} + \text{Uncertainty}_{\text{BSL,SS}}^{\ 2}} \quad (4)$$

Where:

$Uncertainty_{BSL}$	Uncertainty in baseline scenario in stratum *i*; %
$Uncertainty_{BSL,RATE}$	Percentage uncertainty in the rate of deforestation for areas through time; %

$Uncertainty_{BSL,SS}$	Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case; %
i	1, 2, 3 …M strata

Part 2 – Uncertainty *Ex-Post* in the With-Project Scenario

Relevant modules:

CP-AB	"Estimation of carbon stocks and changes in carbon stocks in the above-ground and below-ground biomass carbon pools"
CP-D	"Estimation of carbon stocks and changes in carbon stocks in the dead-wood carbon pool"
CP-L	"Estimation of carbon stocks in the litter carbon pool"
CP-S	"Estimation of carbon stocks in the soil organic carbon pool"
CP-W	"Estimation of carbon stocks and changes in carbon stocks in the wood products carbon pool"
E-BB	"Estimation of non-CO2 emissions from biomass burning"
E-FFC	"Estimation of emissions from fossil fuel combustion"
E-NA	"Estimation of direct N2O emissions from nitrogen application"

Relevant parameters:

$C_{AB\text{-}tree}$	CP-AB
$C_{BB\text{-}tree}$	CP-AB
C_{DW}	CP-D
C_{LI}	CP-L
C_{SOC}	CP-S
C_{WP}	CP-W
$E_{BiomassBurn}$	E-BB
E_{FC}	E-FFC
$N_2O_{direct\text{-}N}$	E-NA

Area of deforestation or degradation in the with-project scenario should be tracked directly using the same accuracy assessment criterion as used in the baseline (accuracy of 80% or more—see module BL-UP).

$$\text{Uncertainty}_{P,i} = \frac{\sqrt{\left(U_{P,SS1,i} * E_{P,SS1,i}\right)^2 + \left(U_{P,SS2,i} * E_{P,SS2,i}\right)^2 + \ldots + \left(U_{P,SSn,i} * E_{P,SSn,i}\right)^2}}{E_{P,SS1,i} + E_{P,SS2,i} + \ldots + E_{P,SSn,i}} \quad (5)$$

Where:

$Uncertainty_{P,i}$	Uncertainty in the combined carbon stocks and greenhouse gas sources in the with-project case in stratum *i*; %
$U_{P,SS,i}$	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions in the with-project case in stratum *i* (1,2…n represent different carbon pools and/or GHG sources); %
$E_{P,SS,i}$	Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning) in stratum *i* (1,2…n represent different carbon pools and/or GHG sources) in the with-project case; t CO_2-e
i	1, 2, 3 …*M* strata

To assess uncertainty across combined strata:

$$\text{Uncertainty}_{P} = \frac{\sqrt{\left(\text{Uncertainty}_{Pi1} * E_{P,i1}\right)^2 + \left(\text{Uncertainty}_{Pi2} * E_{P,i2}\right)^2 + \ldots + \left(\text{Uncertainty}_{P,iM} * E_{P,iM}\right)^2}}{E_{P,i1} + E_{P,i2} + \ldots + E_{P,iM}} \quad (6)$$

Where:

$Uncertainty_{P}$	Total uncertainty in project scenario; %
$Uncertainty_{P,i}$	Uncertainty in baseline project in stratum *i*; %
$E_{P,SS,i}$	Sum of combined carbon stocks and GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning in stratum *i* (1,2…n represent different carbon pools and/or GHG sources) multiplied by the area of stratum *i* (A_i) in the with-project case; t CO_2-e
i	1, 2, 3 …*M* strata

Part 3 – Total Error in REDD Project Activity

Calculation of leakage is conservative in all instances and therefore uncertainty is not considered here. Total project uncertainty is therefore equal to the combined uncertainty in baseline and with-project estimates:

$$C_{REDD\_ERROR} = \sqrt{\text{Uncertainty}_{BSL}^{2} + \text{Uncertainty}_{P}^{2}} \quad (7)$$

Where:

C_{REDD_ERROR}	Total uncertainty for REDD project activity; %
Uncertaint y_{BSL}	Total uncertainty in baseline scenario; %
Uncertainty$_P$	Total uncertainty in the with-project scenario; %

Part 4 – Implications for Project Accounting

The allowable uncertainty under this methodology is +/- 15% of $C_{REDD,t}$ at the 95% confidence level. Where this precision level is met then no deduction should result for uncertainty. Where uncertainty exceeds 15% of $C_{REDD,t}$ at the 95% confidence level then the deduction shall be equal to the amount that the uncertainty exceeds the allowable level.

adjusted value for $C_{REDD,\,t}$ to account for uncertainty shall be calculated as:

$$Adjusted\_C_{REDD,t} = C_{REDD,t} * (100\% - C_{REDD\_ERROR} + 15\%) \quad (8)$$

Where:

*Adjusted_* $C_{REDD,\,t}$	Cumulative total net GHG emission reductions at time *t* adjusted to account for uncertainty; t CO_2-e
$C_{REDD,\,t}$	Cumulative total net GHG emission reductions at time *t*; t CO_2-e
C_{REDD_ERROR}	Total uncertainty for REDD project activity; %

III. DATA AND PARAMETERS MONITORED

Data / parameter:	$E_{BSL\,SS}$
Data unit:	t CO_2-e
Used in equations:	2
Description:	Carbon stock or GHG sources (e.g. trees, dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in the baseline case
Source of data:	The terms denoting significant carbon stocks, GHG sources or leakage emissions from baseline modules (BL-DFW, BL-PL, BL-UP) used to calculate net emission reductions.
Measurement	

procedures (if any):	
Monitoring frequency:	Monitored at least once every ten years (or when the baseline is revisited)
Quality Assurance / Quality Control	
Any comment:	Baseline stocks and sources are estimated ex-ante for each baseline period

Data / parameter:	$E_{P,SS}$
Data unit:	t CO_2-e
Used in equations:	4
Description:	Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in the with-project case
Source of data:	The terms denoting significant carbon stocks, GHG sources or leakage emissions used in calculating net emission reductions from the following relevant modules: CP-AB, CP-D, CP-L, CP-S, CP-W, E-BB, E-FFC, E-NA.
Measurement procedures (if any):	
Monitoring frequency:	Monitored at least once every five years
Quality Assurance / Quality Control	
Any comment:	The *ex-ante* estimation shall be derived directly from the estimations originating in the relevant modules: CP-AB, CP-D, CP-L, CP-S, CP-W, E-BB, E-FFC, E-NA.

Data / parameter:	$U_{BSL,SS}$
Data unit:	%
Used in equations:	2
Description:	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case (1,2…n represent different carbon pools and/or GHG sources)
Source of data:	Calculations arising from field measurement data

Measurement procedures (if any):	Uncertainty in pools derived from field measurement with 95% confidence interval calculated as the standard error of the averaged plot measurements in each stratum multiplied by the t value for the 95% confidence level. For wood products the uncertainty should be the confidence interval around the volume of timber extracted from the forest. For emission sources conservative parameters should be used sufficient to allow the uncertainty to be set as zero.
Monitoring frequency:	Monitored at least once every ten years (or when the baseline is revisited)
Quality Assurance / Quality Control	
Any comment:	Baseline stocks and sources are estimated ex-ante for each baseline period

Data / parameter:	$U_{P,SS}$
Data unit:	%
Used in equations:	5
Description:	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the with-project case (1,2…n represent different carbon pools and/or GHG sources)
Source of data:	Calculations arising from field measurement data
Measurement procedures (if any):	Uncertainty in pools derived from field measurement with 95% confidence interval calculated as the standard error of the averaged plot measurements in each stratum multiplied by the t value for the 95% confidence level. For wood products the uncertainty should be the confidence interval around the volume of timber extracted from the forest. For emission sources conservative parameters should be used sufficient to allow the uncertainty to be set as zero.
Monitoring frequency:	Monitored at least once every five years
Quality Assurance / Quality Control	
Any comment:	*Ex-ante* the uncertainty in the with-project carbon stocks and sources

	shall be equal to the calculated baseline uncertainty

IV. PARAMETERS ORIGINATING IN OTHER MODULES

Data / parameter:	A_i
Data unit:	ha
Used in equations:	3, 6
Description:	Area of stratum *i*
Module parameter originates in:	X-STR
Any comment:	

Data / parameter:	$C_{REDD,\ t}$
Data unit:	t CO_2-e
Used in equations:	7
Description:	Net anthropogenic greenhouse emission reductions at time *t*; t CO_2-e
Module parameter originates in:	REDD-MF
Any comment:	

Data / parameter:	$D\%_{pn}$
Data unit:	%
Used in equations:	Uncertainty in baseline rate
Description:	Percent of deforestation in land parcel[2] *pn* etc of a proxy area as a result of planned deforestation as defined in this module; %
Module parameter originates in:	BL-PL
Any comment:	

Data / parameter:	r^2
Data unit:	dimensionless
Used in equations:	1

[2] Parcels are a unit of land area. A stratum may contain many parcels.

Description:	The r^2 value derived from the regression of historic deforestation against time
Module parameter originates in:	BL-UP
Any comment:	Must be ≥0.75 and be paired with a p ≤0.05

Data / parameter:	Yrs_{pn}
Data unit:	years
Used in equations:	Uncertainty in baseline rate
Description:	Number of years over which deforestation occurred in land parcel *pn* in proxy area; years
Module parameter originates in:	BL-PL
Any comment:	