

VCS MODULE VMD0035

METHODS TO DETERMINE THE NET CHANGE IN
ATMOSPHERIC GHG RESULTING FROM
PROJECT ACTIVITIES

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Sectoral Scope 14



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1 SOURCES

VCS module *VMD0017 Estimation of Uncertainty for REDD Project Activities (X-UNC)*

2 SUMMARY DESCRIPTION OF THE MODULE

The module provides the methods required to sum up the estimated atmospheric GHG flux associated with the project area under either the baseline or project scenario for a given time period, and to estimate the uncertainty of project and baseline scenario carbon stock and emission calculations.

3 DEFINITIONS

- Baseline Scenario:** The most likely sequence of events and actions which would be expected to occur within the project area in the absence of the project.
- Livestock:** Domesticated animals including dairy cattle, non-dairy cattle, buffalo, sheep, goats, camels, horses, mules, asses, swine, poultry, alpacas and llamas.
- Project Scenario:** The actions and events which are expected to occur as a result of implementing the project.

4 APPLICABILITY CONDITIONS

None

5 PROCEDURES

Introduction:

Because GHG emissions are accounted as permanent, while GHG removals contained in pools have varying levels of impermanence risk, GHG pools and emissions are summarized separately in this module.

The uncertainty determination method may be used for project planning and must be used for GHG benefit determination. The method allows the project to determine whether the uncertainty of the atmospheric GHG benefit determination exceeds the appropriate level.

Summation of GHG pools:

$$PoolC_t = \sum_s (SoilC_s + B_s \cdot bf + Bl_s \cdot lf + Bdw_s \cdot dwf + Cwp_s) \cdot 44/12 \quad (19.1)$$

Where:

$PoolC_t$ = Total carbon in carbon pools at time t, tCO₂e

s	=	Strata
$SoilC_s$	=	The carbon content of the soil pool in stratum s at time t , tC
B_s	=	The living biomass content of stratum s at time t , t
bf	=	The conversion factor from living biomass to C = 0.5, tC/t
Bl_s	=	The litter biomass of stratum s at time t , t
lf	=	The conversion factor from litter biomass to C, tC/t
Bdw_s	=	The dead wood biomass of stratum s at time t , t
dwf	=	The conversion factor from deadwood biomass to C, tC/t
Cwp_s	=	The carbon content of long lived wood products resulting from the harvesting of wood in stratum s to time t , tC
$44/12$	=	Conversion factor from C to CO ₂ , tCO ₂ /tC

Notes on variables:

All variables: Any carbon pools not accounted must be set to 0 in this equation.

SoilC_s: Values are derived from estimations carried out using module *VMD0021 Estimation of Stocks in the Soil Carbon Pool*, or projections carried out using the *VMD0019 Methods to Project Future Conditions*, in the case of ex-ante projection of carbon pools.

B_s: Values are derived from estimations carried out using the *VMD0022 Estimation of Carbon Stocks in Living Plant Biomass*, or projections carried out using the *VMD0019 Methods to Project Future Conditions*, in the case of ex-ante projection of carbon pools.

Bf: The default conversion factor is 0.5 for conversion from dry biomass to mass of carbon.

Bl_s: Values are derived from estimations carried out using the *VMD0023 Estimation of Carbon Stocks in the Litter Pool*, or projections carried out using the *VMD0019 Methods to Project Future Conditions*, in the case of ex-ante projection of carbon pools.

Lf: Conversion factors from litter biomass to carbon must be determined using applicable literature, IPCC guidance, or testing of samples.

Bdws: Values are derived from estimations carried out using *VMD0024 Estimation of Carbon Stocks in the Dead Wood Pool*, or projections carried out using *VMD0019 Methods to Project Future Conditions*, in the case of ex-ante projection of carbon pools.

Dwf: Conversion factors from dead wood biomass to carbon must be determined using applicable literature, IPCC guidance, or testing of samples.

Cwps: Values are derived from estimations carried out using the *VMD0026 Estimation of Carbon Stocks in the Long-lived Wood Products Pool*, or projections carried

out using the *VMD0019 Methods to Project Future Conditions*, in the case of ex-ante projection of carbon pools.

Summation of GHG Emissions:

$$EmissionC_t = \sum_z (E_l + E_s + E_{ff}) + \sum_{fe} E_b \quad (19.2)$$

Where:

$EmissionC_t$	=	Total emissions from time t=0 to time t, tCO ₂ e
z	=	The years from time t=0 to time t, yr
E_l	=	Emissions from livestock management, tCO ₂ e/yr
E_s	=	Emissions from soil resulting from management activities, tCO ₂ e/yr
E_{ff}	=	Emissions from burning of fossil fuels in power equipment during project management, tCO ₂ e/yr
fe	=	Fire events within the selected time period
E_b	=	Emissions of non-CO ₂ gasses caused by fire events, tCO ₂ e/fire event

Notes on variables:

- Any emissions not accounted must be set to 0 in this equation.
- Only emissions due to livestock management and fire events may be accounted under the baseline scenario.
- Emissions due to livestock management may only be accounted under the baseline scenario if those emissions are less than the livestock emissions under the project scenario.
- Emissions due to fire events may only be accounted under the baseline scenario if those emissions are less than the fire emissions under the project scenario.

Summation of Leakage:

$$LeakageC_t = E_d + E_m \quad (19.3)$$

Where:

$LeakageC_t$	=	Quantified leakage of the project over the baseline over the selected period, tCO ₂ e
E_d	=	Emissions from displacement leakage over the selected period, tCO ₂ e
E_m	=	Emissions from market leakage over the selected period, tCO ₂ e

Summation of net change carbon stocks:

$$NetchangeCarbonstocks_{t=z} = PoolC_{t,P} - PoolC_{t,B} \quad (19.4)$$

Where:

$NetchangeCarbonstocks_{t=z}$ = Difference in carbon stocks in baseline and project scenario, tCO₂e

$PoolC_{t,P}$ = Total carbon in carbon pools at time t=z under the project scenario, tCO₂e

$PoolC_{t,B}$ = Total carbon in carbon pools at time t=z under the baseline scenario, tCO₂e

Summation of net change in GHG emissions:

$$NetGHGemissionchange_{t=z} = (EmissionC_{t,B} - EmissionC_{t,P}) \quad (19.5)$$

Where:

$NetGHGemissionchange_{t=z}$ = Net change in GHG emissions for a period ending at time t=z due to the project activity, tCO₂e

$EmissionC_{t,B}$ = Total emissions from time t=0 to time t= z, under the baseline scenario, tCO₂e

$EmissionC_{t,P}$ = Total emissions from time t=0 to time t= z, under the project scenario, tCO₂e

Summation of net change in atmospheric GHGs:

The net changes in GHGs due to the project activities at time t=z will be:

$$TotalGHGCreditsgenerated = (NetchangeCarbonstocks_{t=z} - NetGHGemissionchange_{t=z} - LeakageC_t) - (NetchangeCarbonstocks * Buffer\%_t) \quad (19.6)$$

Where:

$TotalGHGCreditsgenerated$ = GHG benefit of the project net of leakage and buffer.

$NetchangeCarbonstocks_{t=z}$ = Difference in carbon stocks in baseline and project scenario, tCO₂e

$NetGHGemissionchange_{t=z}$ = Net change in GHG emissions at time t=z due to the project activity, tCO₂e

$LeakageC_t$ = Quantified leakage of the project over the baseline over the selected period, tCO₂e

$Buffer\%_t$ = Percentage of required buffering as per latest *VCS AFOLU Non Permanence Tool* requirements

Project uncertainty:

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, or estimates based on sound statistical sampling. Alternatively, indisputably conservative estimates of values can also be used, which will allow proponents not to calculate uncertainties for those variables, provided that the values used are based on verifiable literature sources or expert judgment. In this case the uncertainty is assumed to be zero for that variable.

Associated modules include methods for adjusting estimated values of carbon pools where uncertainties exceed specified limits. However, this module provides a procedure to combine uncertainty information and conservative estimates allowing the estimation of overall ex-post project uncertainty.

The uncertainty across the baseline and project emissions and carbon stocks is determined through the following three steps. In Steps 1 and 2 the uncertainty of the various carbon stocks, and emissions in both the baseline (step 1) as well as the project scenario (step 2) will be determined. In Step 3 both uncertainties are summarized in one project uncertainty.

Step 1a: Estimation of the baseline uncertainty within the strata

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

$$\text{Uncertainty}_{BSL,SS,s} = \frac{\sqrt{(U_{BSL,SS1,s} * E_{BSL,SS1,s})^2 + (U_{BSL,SS2,s} * E_{BSL,SS2,s})^2 + \dots + (U_{BSL,SSn,s} * E_{BSL,SSn,s})^2}}{E_{BSL,SS1,s} + E_{BSL,SS2,s} + \dots + E_{BSL,SSn,s}} \quad (19.7)$$

Where:

Uncertainty_{BSL,SS,s} Percentage uncertainty in the combined carbon stocks and greenhouse gas emissions in the baseline scenario in stratum s, %

U_{BLS,SS,s} 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 scenario in stratum s (1,2,...s represents different carbon pool and/or GHG source,%

E_{BLS,SS,s} 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 s (1,2,...s represent different carbon pools and/or GHG sources) in the baseline case; tCO₂e

i 1,2,3,... s strata

In equation 19.7 the errors in each pool and emission are weighted according to the size of the pool or emission.

Step 1b: Total uncertainty of the baseline scenario is the square root of the sum of the squares of all the stratum uncertainties on a weighted basis.

$$\text{Uncertainty}_{\text{baseline}} = \sqrt{\frac{(\text{Uncertainty}_{\text{BLS,SS1}} * E_{\text{BLS,s1}})^2 + (\text{Uncertainty}_{\text{BLS,SS2}} * E_{\text{BLS,s2}})^2 + \dots + (\text{Uncertainty}_{\text{BLS,SSs}} * E_{\text{BLS,ss}})^2}{E_{\text{BLS,s1}} + E_{\text{BLS,s2}} + \dots + E_{\text{BLS,ss}}}} \quad (19.8)$$

Where:

Uncertainty _{Baseline}	Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline scenario, %
Uncertainty _{BLS,SS,s}	Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in stratum s in the baseline scenario, %
E _{BLS,SS,s}	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 s (1,2,...s represent different carbon pools and/or GHG sources) in the baseline scenario; tCO ₂ e
i	1,2,3,... s strata

Step 2a: Estimation of the project scenario uncertainty within the strata

$$\text{Uncertainty}_{P,s} = \sqrt{\frac{(U_{P,SS1,s} * E_{P,SS1,s})^2 + (U_{P,SS2,s} * E_{P,SS2,s})^2 + \dots + (U_{P,SSn,s} * E_{P,SSn,s})^2}{E_{P,SS1,s} + E_{P,SS2,s} + \dots + E_{P,SSn,s}}} \quad (19.9)$$

Where:

Uncertainty _{P,s} =	Uncertainty in the combines carbon stocks and greenhouse gas sources in the project scenario in stratum,%
U _{p,SS,s} =	Percentage uncertainty (expressed as 95% confidence interval as the percentage of the mean where appropriate) for the carbon stocks, Greenhouse gas emissions and leakage emissions in the project scenario in stratum s (1,2...s represents different carbon pools and/or GHG sources in the with-project case; tCO ₂ e)
E _{P,SS,s} =	Carbon stocks or GHG emission (Living biomass, Dead wood, Litter Soil carbon etc.) in stratum I (1,2...s represents different carbon pools and/or GHG sources) in the with-project case; tCO ₂ e
s=	1,2,3.. s strata

Step 2b: Total uncertainty of the project line scenario is the square root of the sum of the squares of all the stratum uncertainties on a weighted basis

$$\text{Uncertainty}_{\text{Project}} = \frac{\sqrt{(\text{Uncertainty}_{P_{s1}} * E_{P_{s1}})^2 + (\text{Uncertainty}_{P_{s2}} * E_{P_{s2}})^2 + \dots + (\text{Uncertainty}_{P_{sM}} * E_{P_{sM}})^2}}{E_{P_{s1}} + E_{P_{s2}} + \dots + E_{P_{sM}}} \quad (19.10)$$

Where:

Uncertainty_{Project} = Total uncertainty in project scenario, %

Uncertainty_{P,s} = Uncertainty in the combines carbon stocks and greenhouse gas sources in the project scenario in stratum, %

E_{P,sM} = Sum of combined carbon stocks and GHG sources (e.g. living biomass, dead wood, soil carbon, emissions from livestock and leakage in stratum s (1,2,3, ...s)

i, = 1,2,3, s strata

Step 3: Total project uncertainty:

$$\text{Uncertainty}_{\text{Total project}} = \sqrt{\text{Uncertainty}_{\text{Baseline}}^2 + \text{Uncertainty}_{\text{Project}}^2} \quad (19.11)$$

Where:

Uncertainty_{Total project} = total uncertainty of the projects atmospheric GHG benefit, %

Uncertainty_{Baseline} quantification, % = total uncertainty of the baseline scenario emissions and carbon stock

Uncertainty_{Project} quantification, % = total uncertainty of the project scenario emissions and carbon stock

6 PARAMETERS

Data Unit / Parameter:	<i>Bdw_s</i>
Data unit:	T
Description:	Deadwood biomass
Source of data:	<i>VMD0024 Estimation of Carbon Stocks in the Dead Wood Pool</i>
Justification of choice of data or description of measurement methods and procedures applied:	The dead wood biomass of stratum s at time t
Any comment:	

Data Unit / Parameter:	<i>bf</i>
Data unit:	tC/t
Description:	Carbon content of living biomass
Source of data:	IPCC
Justification of choice of data or description of measurement methods and procedures applied:	the conversion factor from living biomass to C = 0.5
Any comment:	

Data Unit / Parameter:	Bl_s
Data unit:	T
Description:	<i>VMD0023 Estimation of Carbon Stocks in the Litter Pool</i>
Source of data:	Module : Litter
Justification of choice of data or description of measurement methods and procedures applied:	the litter biomass of stratum s at time t
Any comment:	

Data Unit / Parameter:	B_s
Data unit:	T
Description:	Living biomass
Source of data:	<i>VMD0022 Estimation of Carbon Stocks in Living Plant Biomass</i>
Justification of choice of data or description of measurement methods and procedures applied:	The living biomass content of stratum s at time t
Any comment:	

Data Unit / Parameter:	Cwp_s
Data unit:	tC
Description:	Carbon in long lived wood products
Source of data:	<i>VMD0026 Estimation of Carbon Stocks in the Long-lived Wood Products Pool</i>
Justification of choice of data or description of measurement methods and procedures applied:	The carbon content of long lived wood products resulting from the harvesting of wood in stratum s to time t
Any comment:	

Data Unit / Parameter:	<i>d_{wf}</i>
Data unit:	tC/t
Description:	Carbon content of deadwood
Source of data:	<i>VMD0024 Estimation of Carbon Stocks in the Dead Wood Pool</i>
Justification of choice of data or description of measurement methods and procedures applied:	The conversion factor from deadwood biomass to C
Any comment:	

Data Unit / Parameter:	<i>E_b</i>
Data unit:	tCO ₂ e/yr
Description:	Fire event emissions
Source of data:	<i>VMD0031 Estimation of Emissions from Biomass Burning</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions of non-CO ₂ gasses caused by fire events
Any comment:	

Data Unit / Parameter:	<i>E_d</i>
Data unit:	tCO ₂ e/yr
Description:	Displacement leakage
Source of data:	<i>VMD0032 Estimation of Emissions from Activity Shifting Leakage</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from displacement leakage over the selected period
Any comment:	

Data Unit / Parameter:	<i>E_{ff}</i>
Data unit:	tCO ₂ e/yr
Description:	Fossil fuel emissions
Source of data:	<i>VMD0030 Estimation of Emissions from Power Equipment</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from burning of fossil fuels in power equipment during project management
Any comment:	

Data Unit / Parameter:	E_l
Data unit:	tCO ₂ e/yr
Description:	Livestock emissions
Source of data:	<i>VMD0028 Estimation of Emissions from Domesticated Animals</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from livestock management
Any comment:	

Data Unit / Parameter:	E_m
Data unit:	tCO ₂ e
Description:	Market leakage
Source of data:	<i>VMD0033 Estimation of Emissions from Market Leakage</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from market leakage over the selected period
Any comment:	

Data Unit / Parameter:	$EmissionC_{t,B}$
Data unit:	tCO ₂ e
Description:	Baseline emissions
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Total emissions from time t=0 to time t= z, under the baseline scenario
Any comment:	

Data Unit / Parameter:	$EmissionC_{t,P}$
Data unit:	tCO ₂ e
Description:	Project emissions
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Total emissions from time t=0 to time t= z, under the project scenario
Any comment:	

Data Unit / Parameter:	E_s
Data unit:	tCO ₂ e/yr
Description:	Soil emissions
Source of data:	VMD0021 <i>Estimation of Stocks in the Soil Carbon Pool</i>
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from soil resulting from management activities
Any comment:	

Data Unit / Parameter:	fe
Data unit:	#
Description:	Fire events
Source of data:	Field data
Justification of choice of data or description of measurement methods and procedures applied:	Fire events within the selected time period
Any comment:	

Data Unit / Parameter:	lf
Data unit:	tC/t
Description:	Carbon content of litter
Source of data:	Module : Litter
Justification of choice of data or description of measurement methods and procedures applied:	The conversion factor from litter biomass to C
Any comment:	

Data Unit / Parameter:	$NetGHG_{t=z}$
Data unit:	tCO ₂ e
Description:	Net GHG effects of the project
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Net change in atmospheric GHGs at time t=z due to the project activity
Any comment:	

Data Unit / Parameter:	$PoolC_t$
Data unit:	tCO ₂ e
Description:	Total carbon in pools
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Total carbon in carbon pools at time t,
Any comment:	

Data Unit / Parameter:	$PoolC_{t,B}$
Data unit:	tCO ₂ e
Description:	Baseline pools
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Total carbon in carbon pools at time t=z under the baseline scenario,
Any comment:	

Data Unit / Parameter:	$PoolC_{t,P}$
Data unit:	tCO ₂ e
Description:	Baseline pools
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Total carbon in carbon pools at time t=z under the project scenario,
Any comment:	

Data Unit / Parameter:	$SoilC_s$
Data unit:	tC
Description:	Soil pool carbon
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	The carbon content of the soil pool in stratum s at time t
Any comment:	

Data Unit / Parameter:	s
Data unit:	
Description:	Strata
Source of data:	Module : Stratification
Justification of choice of data or description of measurement methods and procedures applied:	Strata
Any comment:	

Data Unit / Parameter:	z
Data unit:	yr
Description:	Years in the selected period
Source of data:	<i>VMD0034 Methods for Developing a Monitoring Plan</i>
Justification of choice of data or description of measurement methods and procedures applied:	The years from time t=0 to time t
Any comment:	

Data Unit / Parameter:	$LeakageC_t$
Data unit:	Tonnes
Description:	Market leakage and activity shifting leakage
Source of data:	<i>VMD0032 Estimation of Emissions from Activity Shifting Leakage</i> <i>VMD0033 Estimation of Emissions from Market Leakage</i>
Justification of choice of data or description of measurement methods and procedures applied:	The years from time t=0 to time t
Any comment:	

Data Unit / Parameter:	$UncertaintyBSL,SS,s$
Data unit:	%
Description:	Percentage uncertainty in the combined carbon stocks and greenhouse gas emissions in the baseline scenario in stratum s,
Source of data:	calculated
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	<i>UBLS,SS,s</i>
Data unit:	%
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 scenario in stratum s (1,2,...s represents different carbon pool and/or GHG source
Source of data:	Calculated through data collected from appropriate modules
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	<i>EBSL,SS,s</i>
Data unit:	tCO ₂ e
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 stratum s (1,2,...s represent different carbon pools and/or GHG sources) in the baseline case;
Source of data:	Modules determining various variables
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	s
Data unit:	Dimensionless
Description:	1,2,3,... s strata
Source of data:	
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	<i>Up,SS,s</i>
Data unit:	%
Description:	Carbon stocks or GHG emission (Living biomass, Dead wood, Litter Soil carbon etc.) in stratum I (1,2...s represents different carbon pools and/or GHG sources) in the project scenario.
Source of data:	Modules determining various variables
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	<i>Ep,SS,s</i>
Data unit:	tCO ₂ e
Description:	Carbon stocks or GHG emission (Living biomass, Dead wood, Litter Soil carbon etc.) in stratum I (1,2...s represents different carbon pools and/or GHG sources) in the project scenario
Source of data:	Modules determining various variables
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	<i>UncertaintyProject</i>
Data unit:	%
Description:	Total uncertainty in project scenario
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

7 REFERENCES AND OTHER INFORMATION

None

DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 Nov 2012	Initial version released