PV CLIMATE MODULE

PU005

Estimation of uncertainty of carbon benefit estimates in Plan Vivo projects

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Developed by:

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1 Summary

This module is part of the Plan Vivo Agriculture and Forestry Project Carbon Benefit Assessment Methodologies (**PM001**). It can be used to provide values for the following parameters:

UD_T Uncertainty adjustment for the carbon benefits achieved in monitoring period *T* (from *t1* to *t2*; see Section 5.3)

2 Sources

This module refers to the following guidelines:

IPCC 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Chapter 3: Uncertainties.

IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Chapter 3: Uncertainties.

3 Definitions

Definitions used in this module follow the latest version of the Plan Vivo Glossary and **PM001**.

4 Applicability Conditions

This module is applicable to all Plan Vivo project interventions.

5 Procedures

For each carbon pool and emission source where a sampling approach or model is used to estimate baseline emissions, project emissions or leakage, the following steps must be followed.

- Step 1 Calculate the 90% confidence interval of carbon stock and GHG emission estimates made at the start and end of the measurement period and express as a percentage of the measured/modelled carbon stock/GHG emission
- Step 2 Calculate the uncertainty for each carbon pool and emission source as a percentage of the total estimated values
- Step 3 Combine all sources of uncertainty and express as a percentage of the total carbon benefit from the intervention
- Step 4 Combine uncertainty from all project interventions and determine an appropriate uncertainty adjustment

These steps are described below.

5.1 Calculation of uncertainty for each estimated value

5.1.1 Sampled values

For carbon stocks and GHG emissions estimated with sampling approaches, the percentage uncertainty at a 90% confidence level can be calculated with the following approaches:

i. Calculation with Equation 1.
ii. Monte Carlo simulation following procedures described in **IPCC 2006 and 2019**, with percentage uncertainty calculated as the average of upper and lower confidence intervals as a percentage of the estimated carbon density value.

Calculation of uncertainty of sampled values

$$U_x = z \cdot \frac{SD_{CDx}}{\sqrt{n}} \cdot \frac{1}{CD_x}$$

Equation 1

Where:

U_x Uncertainty of the carbon stock/GHG emission estimate *x* at a 90% confidence level (percent)

z Critical value for one-tailed test of significance at a 90% confidence level and *n* -1 degrees of freedom (from t distribution table)

SD_{CDx} Standard deviation of the estimated value (t CO_2e/ha)

n Sample size used to estimate the value

CD_x Carbon density or GHG emissions per hectare for estimated value *x* (t CO_2e/ha)

Confidence intervals must be calculated separately for each value (*x*) of carbon density/GHG emissions per hectare estimated with sampling approaches. Estimates from the start and end of the monitoring period, and project, baseline and leakage estimates are treated as separate values.

If a stratified sampling approach is used, carbon density or GHG emissions per hectare must be treated as a separate value for each stratum.

5.1.2 Modelled values

For carbon stocks and GHG emissions estimated with modelling approaches, the percentage uncertainty at a 90% confidence level must be calculated for each value (*x*) following the approaches described in the relevant methodology, module, or tool.

5.2 Calculation of uncertainty for each carbon pool/emission source

If more than one value estimated with sampling or modelling approaches is used to calculate net emissions or removals for a carbon pool or emission source, the uncertainty from all values estimated with sampling or modelling approaches must be combined for each carbon pool and emission source. Combined uncertainty can be calculated with either of the following approaches:

i. Error propagation
ii. Monte Carlo simulation following procedures described in **IPCC 2006 and 2019**

If using error propagation, the percentage uncertainty of net emissions or removals for the carbon pool/emission source is calculated with Equation 2.

Calculation of uncertainty of net GHG emission reduction/removals per carbon pool or emission source using error propagation

$$U_{p,T} = \sqrt{\sum_x (C_{x,p,T} \cdot U_{x,p})^2}$$

Equation 2

Where:

$U_{p,T}$ Uncertainty of net GHG emission reduction/removal estimate for carbon pool or emission source *p* in measurement period *T* (from *t1* to *t2*; t CO_2e)

$C_{x,p,T}$ Carbon stock or GHG emission estimated value *x* of carbon pool or emission source *p* in measurement period *T* (from *t1* to *t2* t CO_2e);

$U_{x,p}$ Uncertainty of the estimated carbon stock/GHG emission value (x) at a 90% confidence level, for carbon pool or emission source *p* (percent; see Section 5.1)Calculation of uncertainty for the project intervention

If calculation of carbon benefit from an intervention involves summing net GHG emission reductions/removals in multiple carbon stocks and emission sources with values estimated with sampling or modelling, the combined uncertainty from those carbon stocks and emission sources must be calculated. Combined uncertainty can be calculated with the following approaches:

i. Error propagation
ii. Monte Carlo simulation following procedures described in **IPCC 2006 and 2019**

If using error propagation, the percentage uncertainty of net emissions or removals for the intervention is calculated with Equation 3.

Calculation of uncertainty of net GHG emission reduction/removals per intervention using error propagation

$$U_{v,T} = \frac{\sqrt{\sum_p (U_{p,T}{}^2)}}{CB_{v,t2} - CB_{v,t1}}$$

Equation 3

Where:

$U_{v,T}$ Uncertainty of carbon benefit from project intervention *v* in monitoring period *T* (from *t1* to t2; percent)

$U_{p,T}$ Uncertainty of measured vales for carbon pool or emission source *p* in measurement period *T* (from *t1* to t2; percent; see Section 5.2)

$CB_{v,t2}$ Total carbon benefit for project intervention *v* up to *t2* (t CO_2e; see **PM001**)

$CB_{v,t1}$ Total carbon benefit for project intervention *v* up to *t1* (t CO_2e; see **PM001**)

5.3 Uncertainty Adjustment

To increase conservativeness and provide an incentive for greater precision, the Plan Vivo Methodology Requirements require the adjustment for uncertainty calculated with Equation 4. If Equation 4 returns a negative value, $UD_T = 0$. If Equation 4 returns a value greater than 1, $UD_T = 1$.

$$UD_T = 0.25 \cdot \left(\frac{\sqrt{\sum_v [(CB_{v,t2} - CB_{v,t1}) \cdot U_{v,T}]^2}}{(CB_{t2} - CB_{t1})} - 0.5 \right)$$

Equation 4

Where:

UD_T Uncertainty adjustment for the carbon benefits achieved in monitoring period *T* (from *t1* to *t2*)

$CB_{v,t2}$ Carbon benefit of project intervention *v* up to *t2* (t CO_2e; see **PM001**)

$CB_{v,t1}$ Carbon benefit of project intervention *v* up to *t1* (t CO_2e; see **PM001**)

$U_{v,T}$ Uncertainty of measured carbon benefit from project intervention *v* in monitoring period *T* (%; see Section 0)

CB_{t2} Carbon benefit of the project up to *t2* (t CO_2e)

CB_{t1} Carbon benefit of the project up to *t1* (t CO_2e)

6 Parameters

Data/Parameter	z
Units	Unitless
Description	Critical value for one-tailed test of significance at a 90% confidence level and *n* -1 degrees of freedom
Equations	Equation 1
Source	t-distribution table e.g. https://statscalculator.com/tcriticalvaluecalculator
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of 90% confidence interval
Comments	N/A

Data/Parameter	SD_{CDx}
Units	t CO_2e/ha
Description	Standard deviation of the estimated value
Equations	Equation 1
Source	Calculated from sample data e.g. using MS Excel STDEV function
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of 90% confidence interval
Comments	N/A

Data/Parameter	n
Units	Unitless
Description	Sample size used to estimate the value of CD_x
Equations	Equation 1
Source	Sample data
Value	N/A
Justification of choice of data or description of	N/A

measurement methods and procedures applied	
Purpose of Data	Calculation of 90% confidence interval
Comments	N/A

Data/Parameter	CD_x
Units	t CO_2e/ha
Description	Carbon density or GHG emissions per hectare for measurement *x*
Equations	Equation 1
Source	Estimated for each carbon pool or emission source measurement used to determine, project, baseline or leakage emissions or removals, following an approved methodology.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	An approved methodology must be used to estimate carbon density or GHG emissions per hectare.
Purpose of Data	Calculation of 90% confidence interval
Comments	N/A

Data/Parameter	$C_{x,p,T}$
Units	t CO_2e
Description	Carbon stock or GHG emission estimated for measurement *x* of carbon pool or emission source *p* in measurement period *T* (from *t1* to *t2.*
Equations	Equation 2
Source	Estimated for each carbon pool or emission source measurement used to determine, project, baseline or leakage emissions or removals, following an approved methodology. A value should be entered for all measurements used to determine project, baseline or leakage emissions or removals for the carbon pool within the measurement period. For example values for measurements at the start and end of the measurement period.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	An approved methodology must be used to estimate carbon density or GHG emissions per hectare.
Purpose of Data	Uncertainty estimation
Comments	N/A

Data/Parameter	$U_{x,p}$
Units	Percent
Description	Uncertainty of the estimated carbon stock/GHG emission at a 90% confidence level for measurement *x* of carbon pool or emission source *p*
Equations	Equation 2
Source	Equation 1 or Section 5.1.2

Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Uncertainty estimation
Comments	N/A

Data/Parameter	$CB_{v,t1}$; $CB_{v,t2}$
Units	t CO_2e
Description	Total carbon benefit for project intervention *v* up to *t1* or *t2*
Equations	Equation 3, Equation 4
Source	See PM001
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	An approved methodology must be used.
Purpose of Data	Uncertainty estimation and calculation of uncertainty adjustment
Comments	N/A

Data/Parameter	CB_{t1}; CB_{t2}
Units	t CO_2e
Description	Carbon benefit of the project up to *t1* or *t2*
Equations	Equation 4
Source	See PM001
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	An approved methodology must be used.
Purpose of Data	Calculation of uncertainty adjustment
Comments	N/A

7 References

IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Chapter 3: Uncertainties Available from: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Chapter 3: Uncertainties. Available from: https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

Plan Vivo Standard Glossary, Version 1.0. Available from: https://www.planvivo.org/standard-documents

PM001 Plan Vivo Agriculture and Forestry Project Carbon Benefit Assessment Methodology, Version 1.0. Available from: https://www.planvivo.org/methodologies