AM 007

Module for Estimating Uncertainty of Carbon Benefits from Small-scale Agroforestry

Version 1.0 – October 2024

Acorn

Contents

1 Summary

The method described in this module implies that the adjustment factor is applied on an *Acorn project level*. The U values per plot are derived from Equation 1. Equation 6 is used to calculate the final project-based adjustment factor.

2 Sources

This module supports the following methodology:

- **AM-001** Methodology for Quantifying Carbon Benefits from Small-scale Agroforestry v2.0
- **AM-003** Module for Ground Truth Sampling v1.0
- **PU005** Estimation of Uncertainty of Carbon Benefits estimates in Plan Vivo Projects v1.1 2024

3 Definitions

Definitions used in this module follow the latest version of the Acorn Glossary available on the Acorn website.

4 Applicability Conditions

For this module, the applicability conditions of the Acorn Methodology **AM-001 v2.0** should be met. The method described in this module is applicable at an *Acorn project level*.

5 Procedures

If *Aboveground Biomass* in a plot is estimated using a modeling approach, the u*ncertainty* in the temporal change of the *Aboveground Biomass* in a plot can be calculated using Equation 1[1] to 5. The uncertainty per project includes both project variance and model error of the AGB derived from the Ground Truth Data, using Equation 6.

[1] Derived from equation 3.2 in **IPCC GPG** 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Chapter 3: Uncertainties.

$$U = \frac{\sqrt{\left(u \cdot AGB_{y-1}\right)^2 + \left(u \cdot AGB_y\right)^2}}{\left|\left(AGB_y - AGB_{y-1}\right)\right|}$$

Equation 1

Where:

U = *Uncertainty* per plot for *Aboveground Biomass* change estimated in *Measuring Period*

$AGB_{y,y-1}$ = *Aboveground Biomass* per *plot* in year *y* (tonne)

u = *Uncertainty* for *Aboveground Biomass* estimated per project (see Equation 2)

The variable u is calculated using Equation 2:

$$u = \frac{CI}{\overline{AGB}_{validation(m)}}$$

Equation 2

Where:

u = *Uncertainty* for *Aboveground Biomass* estimated per project

CI = Half-width of a 90% confidence interval derived from model residuals (tonne/ha)

$\overline{AGB}_{validation(m)}$ = Mean measured *Aboveground Biomass* of ground truth *plots in the validation set* (tonne/ha)

The confidence interval is calculated on the measured and predicted values of the validation dataset (see Module) using Equation 3:

$$CI = z \cdot \text{SEM}$$

Equation 3

Where:

CI = Half-width of a 90% confidence interval

SEM = Standard error of mean

z = 1.645 which is the critical point for a normal distribution on a 90% based on confidence interval

The standard error is calculated on the residual of the measured and predicted values of the validation plots using Equation 4[2]:

$$SEM = \frac{std\,\partial(e)}{\sqrt{n}}$$

Equation 4

Where:

SEM = Standard error of mean

$\text{std}\,\partial(\text{e})$ = Standard deviation of residual

n = Number of validation plots

The residual value, which is the difference between predicted and measured AGB of the validation dataset is calculated using Equation 5. The validation set are the "n" validation plots for each project. AGB is measured in the field following the GT data collection described in **AM-003.** ($AGB_{measured}$). The calibrated model is applied on the validation dataset and predicted values are produced ($AGB_{predicted.}$):

$$e = AGB_{validation(m)} - AGB_{validation(p)}$$

Equation 5

Where:

e = Residual value (tonne/ha)

[2] As used in: Stein, A., van der Meer, F.D. and Gorte, B. eds., 1999. *Spatial statistics for remote sensing* (Vol. 1). Springer Science & Business Media.

$AGB_{validation(p)}$ = Predicted *Aboveground Biomass* derived by the model on the validation set (tonne/ha)

$AGB_{validation(m)}$ = Measured *Aboveground Biomass* derived from ground truth data of the validation set (tonne/ha)

Finally, the U value (Equation 1) is matched against Table 1 containing the adjustment factor. Following AM-003 the plots are classified to the level of the smallest value of coefficient of variation. Plots are distributed into the classes and U value is calculated per class following the method below. The residual value (u) derived from Equation 2 is used as input for all classes.

Subsequently, equation 6 is applied to derive an adjustment factor value per plot. If Equation 6 results in a negative value, AdjUplot will be 'zero' and if the value is greater than 1 it will be 'one'.

$$AdjU_{plot} = 0.25\ (U - 0.5)$$

Equation 6

The adjustment factor is deducted from the carbon benefit per plot. The final adjustment per *project* is calculated by Equation 7, where the difference of the sum of all carbon benefit values before adjustment and the sum of all carbon benefit values after adjustment as ratio.

$$AdjU = 1 - \frac{\sum AdjU_{plot} \cdot (AGB_y - AGB_{y-1})}{\sum (AGB_y - AGB_{y-1})}$$

Equation 7

Where:

$AdjU$ = Adjustment factor for uncertainty on project level
$AdjU_{plot}$ = Adjustment factor for uncertainty on plot level
$AGB_{y,y-1}$ = *Aboveground Biomass* per *plot* in year *y* (tonne)

6 Parameters

Data/Parameter	$AdjU_{plot}$
Units	no unit
Description	Adjustment factor for uncertainty on plot level
Equations	Equation 7
Source	n/a
Value	Number
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Input for project level adjustment factor
Comments	-

Data/Parameter	$AGB_{y,y-1}$
Units	Tonne
Description	*Predicted Aboveground Biomass* of a plot in year y; Predicted *Aboveground Biomass* of a plot in year y-1
Equations	Equation 1
Source	n/a
Value	Number
Justification of choice of data or description of measurement methods and procedures applied	The change in biomass needs to be adjusted for the uncertainty of the predicted biomass in year y and year-1. Both these predictions have an uncertainty based on the model and project.
Purpose of Data	Calculating Uncertainty of the change in biomass per plot
Comments	-

Data/Parameter	$\overline{AGB}_{validation(m)}$
Units	Tonne/ha
Description	Mean measured Aboveground Biomass of all plots in validation set
Equations	Equation 2
Source	n/a
Value	Number
Justification of choice of data or description of	The confidence interval is based on the residuals between measured and predicted values of the validation set. The mean measured value is used to convert this in a relative value

measurement methods and procedures applied	
Purpose of Data	Calculating uncertainty per project
Comments	-

Data/Parameter	$AGB_{validation(m),(p)}$
Units	Tonne/ha
Description	Measured Aboveground Biomass of a validation plot; Predicted Aboveground Biomass of a validation plot;
Equations	Equation 5
Source	n/a
Value	Number
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculating residual between measured and predicted values
Comments	-

Data/Parameter	n
Units	n/a
Description	Number of plots in validation set
Equations	Equation 4
Source	General statistics
Value	Number
Justification of choice of data or description of measurement methods and procedures applied	Calculating half width of the confidence interval
Purpose of Data	
Comments	-

Data/Parameter	$\mathrm{std}(e)$
Units	n/a
Description	Standard deviation of residual
Equations	Equation 4
Source	General statistics
Value	Number

Justification of choice of data or description of measurement methods and procedures applied	Common statistics
Purpose of Data	Standard error
Comments	-

Data/Parameter	z
Units	n/a
Description	1.645 based on the 90 % confidence interval
Equations	Equation 3
Source	Student's t-distribution
Value	Number
Justification of choice of data or description of measurement methods and procedures applied	1.645 is the critical point for a normal distribution on a 90% based on confidence interval
Purpose of Data	Calculating half width of the confidence interval
Comments	-