PLAN VIVO

PV Climate Tool

PT001

Smallholder Agriculture Monitoring and Baseline Assessment

Version 2.1

16 February 2026

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PLAN VIVO

Contents

1 Summary

This tool is for the estimation of carbon benefits from Plan Vivo projects aiming to increase the carbon stocks in soils from agroforestry and conservation agriculture implemented by smallholders. It includes procedures for estimating values for the following parameters.

A Extent of the project area (ha)

BE_{SO_t} Baseline scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO_2e/ha)

PE_{SO_t} Project scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO_2e/ha)

The tool applies the SHAMBA Model (see Annex 1), which applies the Rothamstead Carbon Model (RothC)[1] to quantify the changes in soil organic carbon stocks under different management scenarios. It can be used by projects throughout Sub-Saharan Africa, and in other regions where the RothC model has been shown to make accurate predictions.

The tool quantifies changes in carbon stocks in soils under user defined project and baseline scenarios. A combination of process-based and empirical models are used to estimate changes in soil carbon stocks based on inputs from woody biomass and crops. For a full description of the modelling approaches and the data sources used in the SHAMBA Model see Annex 2.

Projects using this tool must provide all of the following:

- Copies of all inputs to and outputs from the SHAMBA Model
- Spreadsheets demonstrating that all calculations have been made according to the relevant equations
- A full description of all data and parameters used, with sufficient evidence to demonstrate that they meet the requirements described in Section 6.
- A copy of the SHAMBA Model version applied, with details of any amendments made to the Model from the version in Annex 1

The information used for estimates at the start of the verification period should be presented in a Project Design Document (PDD). Prior to verification, the relevant calculations and data used for verification of carbon benefits must be included in an annual report submitted to Plan Vivo.

[1] https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc

2 Sources

This tool can be used in conjunction with the following Plan Vivo methodology and modules:

PM001 Agriculture and Forestry Carbon Benefit Assessment Methodology, Version 1.0

PU001 Estimation of Baseline and Project GHG Removals by Carbon Pools in Plan Vivo Projects, Version 1.1

PU005 Estimation of Uncertainty of Carbon Benefit Estimates in Plan Vivo projects, Version 1.1

PT003 Guidance for the use of Models Validated With Measurements in PV Climate Projects V1.0

3 Definitions

Agroforestry

Agriculture incorporating the cultivation of trees

Conservation agriculture

Agricultural methods (for example, minimal soil disturbance, permanent soil cover and crop rotations) to achieve sustainable and profitable agriculture.

4 Applicability Conditions

4.1 Project Interventions

This tool is applicable to project areas that meet all of the following applicability conditions:

- The project area is cropland or grassland prior to the project intervention.
- The project area is located in Sub-Saharan Africa, or another area that the RothC Model has been validated for. If applying the tool to project areas outside Sub-Saharan Africa, evidence of RothC Model validation must be provided in the form of peer-reviewed publications or primary research.
- Project interventions involve tree planting, agroforestry or conservation agriculture.
- Project interventions will not increase GHG emissions or reduce carbon stocks in or around the project area, relative to the baseline scenario, by changing:
    - Manure application;
    - External organic inputs such as mulch;
    - Tillage, leaching or erosion of soil; or
    - Management of existing trees and woody vegetation.
- Project activities are not carried out in areas where tree planting is planned in the baseline scenario.

- Soils in the project area are not waterlogged or flooded regularly, and are at least 30 cm deep.

Projects must also be able to provide the inputs required by the SHAMBA Model (see Section 5.2), and to demonstrate that they meet the additional applicability criteria required for any default parameters used (see Section 5).

4.2 Default Parameters

The SHAMBA Model includes default factors that are applicable to all interventions that meet the applicability conditions in Section 4.1, with the following exceptions:

- Crops modelled must be either: grains, beans & pulses, tubers, root crops, N-fixing forages, non-N-fixing forages, perennial grasses, or grass-clover mixture.
- Trees modelled must be deciduous or have a leaf life span of <= 1 year.

If these criteria are not met, the relevant default values in the model must be replaced with suitable alternative values.

4.3 Certificate Types

This tool can be used by projects claiming fPVCs or vPVCs using the procedures described in Section 5. It cannot be used to claim rPVCs.

5 Procedures

5.1 Project Boundary

The boundary of each project area must be mapped using GPS to estimate the extent of the project area (A) in hectares. The geographical location (latitude, longitude) of centre of each project area must also be recorded in decimal degrees. Extent and location of the project area are used as inputs to the SHAMBA Model. Project area location is used to assign appropriate soil and environmental parameters.

5.2 Model Inputs

The SHAMBA Model (see Annex 1) provides an estimate of annual GHG emissions from the soil organic carbon pool by applying the procedures described in Annex 2. The following input parameters are required for each project area.

5.2.1 Soil inputs from woody biomass

Although the tool is not used to estimate changes in woody biomass, information relating to expected or actual woody biomass growth must be provided so that soil inputs from woody

biomass can be calculated. The inputs that must be specified to run the SHAMBA Model are listed below; other default values used for woody biomass model parameterisation are listed in Annex 2.

$B_{inc,y,i}$	Aboveground woody biomass increment of a single tree of cohort *i* in year *y* (kg C/ year)
$SD_{y=0,i}$	Initial stand or planting density of cohort *i* (trees/ha)
$th_{y,i}$	Proportion of stand density of cohort *i* thinned in year *y*
$thf_{stem,i}$	Proportion of thinned stems from cohort *i* left in the field
$thf_{branch,i}$	Proportion of thinned branches from cohort *i* left in the field
$tm_{y,i}$	Tree mortality of cohort *i* in year y as a proportion of stand density
$tmf_{stem,i}$	Fraction of dead stems from cohort *i* left in the field
$tmf_{branch,i}$	Fraction of dead branches from cohort *i* left in the field

5.2.2 Soil inputs from crops

Although the tool is not used to estimate changes in non-woody biomass, information relating to expected or actual crop growth must be provided so that soil inputs from crop biomass can be calculated. The inputs that must be specified to run the SHAMBA Model are listed below; other default values used for crop model parameterisation are listed in Annex 2.

$c_{yield,i}$	Annual mean crop yield for crop *i* (tonne of dry matter per hectare)
$c_{f,i}$	Aboveground crop residues removed from the field post-harvest as a proportion of the total dry matter of crop residues for crop *i*

5.2.3 Soil input adjustments from biomass burning

Although the tool is not used to estimate emissions from biomass burning, occurrence of crop/tree residue burning must be specified for each year of the crediting period so that soil inputs from tree and crop biomass can be adjusted accordingly. Other default values used for biomass burning model parameterisation are listed in Annex 2.

5.3 Model Outputs

The following outputs must be extracted from the SHAMBA Model for each project or baseline scenario.

BE_{SO_t} Baseline scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO_2e/ha)

PE_{SO_t} Project scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO_2e/ha)

5.4 Expected Baseline and Project Emissions

The model inputs described in Section 5.2 must be provided for the baseline scenario and project scenario for each project area. To estimate expected baseline and project scenario emissions from soil organic carbon stocks in each year of a verification period, input parameters should be based on planned management activities and expected growth rates and yields. If the project also quantifies carbon benefits from changes in woody biomass or crop biomass, the same tree and crop growth and mortality parameters must be applied to estimate expected changes in biomass and soil organic carbon pools. The model must be calibrated following the procedures in **PT003**.

The parameters applied for the first verification period must be specified in the PDD and justification provided for why they are appropriate for the project areas they are applied to.

The parameters applied for estimating expected changes in soil organic carbon stocks in the project scenario in subsequent verification periods must be specified in the final annual report of each verification period with justification based on observed management activities, growth rates and yields from previous verification periods.

5.5 Actual Project Emissions

At the end of each verification period, actual project scenario emissions from changes in soil carbon stocks must be estimated for each year of the verification period using monitoring data collected from each project area, or a representative sample of project areas implementing the same interventions under similar environmental conditions. The model must be calibrated and validated following the procedures described in **PT003**.

Monitoring data must include all inputs listed in Section 5.2. Monitoring approaches can include information reported by farmers and verified by project staff, and direct measurements and observations.

PDDs must include details of monitoring approaches that will be applied and procedures for calculating appropriate model input values.

The final annual report of each verification period must include full details of all monitoring results and calculations, and details of model input values used to estimate actual change in soil carbon stocks must be estimated for each year of the verification period.

5.6 Uncertainty

5.6.1 Expected Baseline and Project Emissions

Input parameters for modelling expected baseline and project emissions must be conservative, so uncertainty of expected baseline and project emissions is assumed to be zero, and the value U_x in **PU005** is set to zero.

5.6.2 Actual Project Emissions

If actual project emissions are modelled for each individual project area, using model inputs from monitoring data collected from the project area, model error is assumed to be zero, and the value U_x in **PU005** is set to zero.

If a sampling approach is used to collect monitoring data from a representative sample of project areas implementing the same interventions under similar environmental conditions, model uncertainty is estimated by calculating the upper and lower confidence limit, at a 90% confidence level, for each of the model inputs. The SHAMBA Model is then run three times, using: i) The average input values; ii) The upper or lower confidence limit values that generate the highest estimate of emissions from soil organic carbon; and iii) The upper or lower confidence limit values that generate the lowest estimate of emissions from soil organic carbon.

The value for U_x in **PU005** is then calculated with Equation 1.

Calculation of uncertainty of actual project emissions from soil organic carbon

$$U_{x,t} = \frac{(PE_{SO_{t,MAX}} - PE_{SO_{t,MIN}})}{PE_{SO_{t,AVE}}}$$

Equation 1

Where:

$U_{x,t}$	Uncertainty of the GHG emission estimate from soil organic carbon in year t
$PE_{SO_{t,MAX}}$	Maximum project scenario emissions from soil organic carbon in year t (t CO_2e)
$PE_{SO_{t,MIN}}$	Minimum project scenario emissions from soil organic carbon in year t (t CO_2e)
$PE_{SO_{t,AVE}}$	Average project scenario emissions from soil organic carbon in year t (t CO_2e)

6 Parameters

Data/Parameter	$B_{inc,y,i}$
Units	kg C/ year

Description	Aboveground woody biomass increment of a single tree of cohort *i* in year *y*
Equations	See Annex 2
Source	Tree growth modelling or measurements
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$SD_{y=0,i}$
Units	trees/ha
Description	Initial stand or planting density of cohort *i*
Equations	See Annex 2
Source	Planned or actual planting density
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$th_{y,i}$
Units	Unitless
Description	Proportion of stand density of cohort *i* thinned in year *y*
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees

Comments	None

Data/Parameter	$thf_{stem,i}$
Units	Unitless
Description	Proportion of thinned stems from cohort *i* left in the field
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$thf_{branch,i}$
Units	Unitless
Description	Proportion of thinned branches from cohort *i* left in the field
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$tm_{y,i}$
Units	Unitless
Description	Tree mortality of cohort *i* in year y as a proportion of stand density
Equations	See Annex 2

Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$tmf_{stem,i}$
Units	Unitless
Description	Proportion of dead stems from cohort *i* left in the field
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$tmf_{branch,i}$
Units	Unitless
Description	Proportion of dead branches from cohort *i* left in the field
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each cohort modelled
Justification of choice of data or description of measurement methods and procedures applied	Values used must match those applied for aboveground woody biomass carbon accounting.
Purpose of Data	Calculation of soil inputs from trees
Comments	None

Data/Parameter	$c_{yield,i}$
Units	Unitless
Description	Annual mean crop yield for crop *i* (tonne of dry matter per hectare)
Equations	See Annex 2
Source	Farmer surveys, regional data or project records
Value	Defined for each crop modelled
Justification of choice of data or description of measurement methods and procedures applied	For estimation of expected carbon benefits, past yields can be used. For estimation of carbon benefits achieved reported yield should be used.
Purpose of Data	Calculation of soil inputs from crops
Comments	None

Data/Parameter	$c_{f,i}$
Units	Unitless
Description	Aboveground crop residues removed from the field post-harvest as a proportion of the total dry matter of crop residues for crop *i*
Equations	See Annex 2
Source	Management plan or project records
Value	Defined for each crop modelled
Justification of choice of data or description of measurement methods and procedures applied	For estimation of expected carbon benefits, planned activities can be used. For estimation of carbon benefits achieved, reported activities should be used.
Purpose of Data	Calculation of soil inputs from crops
Comments	None

Data/Parameter	$PE_{SO_{t,MAX}}$
Units	t CO_2e
Description	Maximum project scenario emissions from soil organic carbon in year t
Equations	Equation 1

Source	Output from SHAMBA Model
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Model output based on the upper or lower confidence limit values for input parameters that generate the highest estimate of emissions from soil organic carbon.
Purpose of Data	Calculation of uncertainty
Comments	None
Data/Parameter	$PE_{SO_{t,MIN}}$
Units	t CO_2e
Description	Minimum project scenario emissions from soil organic carbon in year t
Equations	Equation 1
Source	Output from SHAMBA Model
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Model output based on the upper or lower confidence limit values for input parameters that generate the lowest estimate of emissions from soil organic carbon.
Purpose of Data	Calculation of uncertainty
Comments	None

Data/Parameter	$PE_{SO_{t,AVE}}$
Units	t CO_2e
Description	Average project scenario emissions from soil organic carbon in year t
Equations	Equation 1
Source	Output from SHAMBA Model
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Model output based on average input parameter values.
Purpose of Data	Calculation of uncertainty
Comments	None

7 References

PM001 Agriculture and Forestry Carbon Benefit Assessment Methodology, Version 1.0. PV Climate Methodology. Available from: https://www.planvivo.org/projects/certify-a-project/pvclimate/methodologies/approved-methodologies

PU001 Estimation of Baseline and Project GHG Removals by Carbon Pools in Plan Vivo Projects, Version 1.1. PV Climate Module. Available from: https://www.planvivo.org/projects/certify-a-project/pvclimate/methodologies/approved-modules

PU005 Estimation of Uncertainty of Carbon Benefit Estimates in Plan Vivo projects, Version 1.0. PV Climate Module. Available from: https://www.planvivo.org/projects/certify-a-project/pvclimate/methodologies/approved-modules

PT003 Guidance for the use of Models Validated With Measurements in PV Climate Projects V1.0. Available from: https://www.planvivo.org/projects/certify-a-project/pvclimate/methodologies/approved-tools

8 Annexes

Annex 1: SHAMBA Model v1.2, tagged version on the SHAMBA GitHub repository

Annex 2: SHAMBA Model v1.2 Description

Annex 3: Version Control

Version	**Active Date**	**Developer**	Approved by	Summary of Changes
1.0	03/03/2015	University of Edinburgh Tropical Land Use Team	Plan Vivo Technical Advisory Committee	N/A
2.0	08/11/2023	Landscapes and Livelihoods Group (TLLG) & Plan Vivo Technical Advisory Committee	Earthood Service Private Ltd., 409-410, Block B4, Spaze I-Tech Park, Sector 49, Sohna Road, Gurgaon-122018, India. https://www.earthood.in/	Alignment to PV Climate V5
2.1	16/02/2026	University of Edinburgh Land Team, with software support from Cirevo Ltd	Members of the Plan Vivo Technical Review Panel: Akshaya R. and Farai Chikomba	Alignment with the new SHAMBA Model v1.2. Further details: https://github.com/shamba-admin/shamba/releases/tag/V1.2