Plan Vivo Climate Benefit Quantification Methodology

Title	Small-holder Agriculture Mitigation Benefit Assessment (SHAMBA)
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Contents

Summary

This methodology can be used in conjunction with the SHAMBA tool (Version 1.0) to quantify the expected climate benefits of tree planting, agroforestry, and agricultural interventions that increase organic inputs to soils and/or reduce burning of fields and agricultural residues. It can be used by projects throughout the tropics.

The methodology quantifies changes in carbon stocks in soils and vegetation as well as greenhouse gas (GHG) emissions from plant nitrogen inputs to soils, fertiliser use and burning of biomass. The carbon stock changes and GHG emissions under the project scenario are compared to those under a baseline scenario to describe the expected climate benefit of the project intervention. The methodology does not quantify climate benefits from reduced tillage, GHG emissions from soil erosion or intense fires, or account for woody products or external organic inputs to soils. It is therefore not appropriate for projects where the main climate benefits are derived from changes to tillage, reductions in soil erosion, control of wild fires, production of long-lived woody products from timber, or increasing soil organic inputs from external (off-farm) sources.

The purpose of this methodology is to provide a description of the information that projects must provide to use the SHAMBA tool, and an overview of the approach to quantifying climate benefits used by the tool. The SHAMBA tool uses a combination of process based and empirical models to estimate climate benefits for individual project activity areas. For a description of these modelling approaches and the data sources used by the SHAMBA tool please refer to the SHAMBA model description.

Using this methodology

This methodology module can be used to estimate the emissions associated with a baseline and project scenarios so that expected climate benefits can be estimated. This information is required in Sections G4 and G5 of the PDD template.

Step 1 Applicability checks

Before using this methodology, projects should check that:

- Their project area, and project interventions meet the applicability conditions described in Section 1;
- They are able to provide the data listed in Section 4;
- Their project area and project interventions meet the applicability conditions for using the SHAMBA tool default values described in Section 5, or that they are able to provide alternative sources of information.

Step 2 Data collection

For each intervention gather the relevant data and information described in Section 4. Keep a record of the sources of information and data collected, as these will be checked in the project validation process.

Step 3 Use the SHAMBA tool to calculate expected climate benefits

The equations in Section 3 are provided for your information only. All calculations are carried out by the SHAMBA tool. You will need to enter the data and information for each intervention into the SHAMBA tool. A user guide is provided with the tool.

1. Applicability conditions

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

1. Project activity areas have not have been negatively altered, prior to the start of project activities for the purpose of increasing climate benefits
2. The baseline land use scenario in the project activity areas can be modelled using the SHAMBA tool, or can be conservatively assumed to be zero (for example if the baseline land use is expected to result in declining carbon stocks in soil and biomass)
3. Project activities involve tree planting, agroforestry, or conservation agriculture
4. Project activities will not increase GHG emissions or reduce carbon stocks in or around the project area, relative to the baseline scenario, by changing:
    a. Livestock management;
    b. Manure application;
    c. External organic inputs such as mulch;
    d. Tillage, leaching or erosion of soil; or
    e. Management of existing trees and woody vegetation
5. Project activities are not carried out in areas where tree planting is planned in the baseline scenario
6. 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 data required by the SHAMBA tool (see Section 4), and to demonstrate that they meet the additional applicability criteria required for any default parameters used (see Section 5).

2. Carbon pools and emission sources

The carbon pools and emission sources included in or excluded from the estimation of climate benefits are described in Tables 1 and 2.

Table 1. Carbon pools accounted for in this methodology

Carbon pool	Included?	Justification/Explanation
Above-ground woody biomass	Yes	This is a potentially significant pool and is considered for tree planting and agroforestry activities
Below-ground woody biomass	Yes	This is a potentially significant pool and is considered for tree planting and agroforestry activities
Non-tree biomass	No	Although not explicitly included in the accounting, crop residues are modelled and included as an input to the soil organic carbon pool where appropriate
Dead wood	No	Although not explicitly included in the accounting, dead wood is modelled and included as an input to the soil organic carbon pool where appropriate

Litter	No	Although not explicitly included in the accounting, tree litter inputs are modelled and included as an input to the soil organic carbon pool where appropriate
Soil organic carbon	Yes	This is a major pool affected by tree planting, agroforestry and agricultural activities
Wood products	No	Wood products are not accounted for, and are conservatively excluded

Table 2. Emission sources of greenhouse gases accounted for in this methodology

Emission source	Gas	Included?	Justification/explanation
Use of fertilisers	CO_2	No	Not applicable
	CH_4	No	Not applicable
	N_2O	Yes, if applicable	This is the primary gas from this source
Plant nitrogen inputs to soils	CO_2	No	Not applicable
	CH_4	No	Not applicable
	N_2O	Yes, if applicable	This is the primary gas from this source
Biomass burning	CO_2	No	Indirectly assessed through change in biomass carbon pools
	CH_4	Yes, if applicable	This is one of the primary non-CO_2 gases from this source
	N_2O	Yes, if applicable	This is one of the primary non-CO_2 gases from this source

3. Quantification of expected climate benefits

This methodology uses the SHAMBA tool (Version 1.0) to quantify changes to carbon stocks and GHG emissions in baseline and project scenarios. The SHAMBA tool models changes in carbon stocks and emissions using a combination of process-based and empirical approaches to estimate baseline, project and net emission reductions and removals, as outlined in Equations 1 to 4. The calculations in Equations 1 to 3 are made automatically by the SHAMBA tool based on the data provided by the projects summarised in Section 4.

3.1 Annual baseline emissions and removals

For each year of the baseline scenario GHG emissions or removals per hectare are calculated as:

$$BE_y = BE_{BB_y} + BE_{NI_y} + BE_{NF_y} + BE_{SO_y}$$

[Equation 1]

Where:

BE_y is the emissions under the baseline scenario for year *y* (tCO_{2e}/ha);

BE_{BB_y} is the emissions from biomass burning in year *y* of the baseline scenario (tCO_{2e}/ha);

BE_{NI_y} is the emissions resulting from the nitrogen inputs to soils from plants in year *y* of the baseline scenario (tCO_{2e}/ha);

BE_{NF_y} is the direct emissions resulting from the use of N fertilisers in year *y* of the baseline scenario (tCO_{2e}/ha); and
BE_{SO_y} is emissions from change in soil organic carbon stocks in year *y* of the baseline scenario (tCO_{2e}/ha).

Changes in carbon stocks of trees and woody vegetation are not quantified in the baseline scenario as the methodology is only applicable to areas where project activities do not increase emissions from harvesting or removal of existing trees and woody vegetation, and where tree planting is not planned in the baseline scenario.

3.2 Annual project emissions and removals

For each year of the project scenario GHG emissions or removals per hectare are calculated as:

$$PE_y = PE_{BB_y} + PE_{NI_y} + PE_{NF_y} + PE_{SO_y} + PE_{WB_y}$$

[Equation 2]

Where:

PE_y is the GHG emissions under the project scenario for year *y* (tCO_{2e}/ha);
PE_{BB_y} is the emissions from biomass burning in year *y* of the project scenario (tCO_{2e}/ha);
PE_{NI_y} is the emissions resulting from the nitrogen inputs to soils from plants in year *y* of the project scenario (tCO_{2e}/ha);
PE_{NF_y} is the direct emissions resulting from the use of N fertilisers in year *y* of the project scenario (tCO_{2e}/ha);
PE_{SO_y} is the emissions from change in soil organic carbon stocks in year *y* of the project scenario (tCO_{2e}/ha); and
PE_{WB_y} is the emissions from change in woody biomass of trees planted through project activities in year *y* of the project scenario (tCO_{2e}/ha).

3.3 Expected climate benefit

The expected climate benefit per hectare for each year of the project is calculated as:

$$CB_y = PE_y - BE_y$$

[Equation 3]

Where:

CB_y is the climate benefit in year *y* (tCO_{2e}/ha)

Total climate benefit expected for a defined project activity area over the project period *p* years is calculated as:

$$CB_{total} = (A \cdot \sum_{y=1}^{p} CB_y) \cdot (1 - LE)$$

[Equation 4]

Where:

CB_{total} is the expected total climate benefit of the project activities over the project period (tCO_{2e});

A is the area where project activities will be carried out (ha); and

LE is the % of the climate benefits that are expected to be negated by leakage (0-100%).

4. Data requirements

The calculations described in Equations 1 to 4 are made for each individual area where project activities are carried out – we refer to this as a 'project activity area'. This may be i) an individual field or ii) an idealised field, representative of the larger project area. Each area must have a prescribed baseline scenario that describes the most likely land use scenario in the absence of project interventions for the whole area, and a prescribed project scenario that will be applied across the whole of the area. If baseline conditions and/or project activities are different in different parts of the area it should be separated into distinct project activity areas.

Some of the parameters in Equations 1 to 4 must be supplied directly by the project, others are calculated using a combination of information provided and default values within the SHAMBA tool. This section lists the information that must be provided for the baseline and project scenario in each project activity area. For all parameters supplied directly by the project, justification for why the value adopted contributes to a conservative estimate of climate benefits must be provided.

4.1 Project activity area

Information that must be provided for all project activity areas:

Data	**Units**	**Data source/Measurement method**	**Relevant parameters**
Geographical location of the project activity area	Decimal degrees (latitude, longitude)	GPS or map location	BE_{SO}, PE_{SO}
Area of project activity area	Hectares	Directly measured or estimated with GPS or tape measure	A
Project period	Years	As described in the Technical Specification	p
Baseline scenario	Description of most likely future land use scenario in the absence of project interventions	Existing land use plans and/or results of participatory land use planning or scenario mapping exercises	BE_{BB}, BE_{NI}, BE_{NF}, BE_{SO}
Project scenario	Description of the land use scenario with the project activities	Developed with the land managers and project staff	PE_{BB}, PE_{NI}, PE_{NF}, PE_{SO}, PE_{WB}

4.2 Agricultural activities

Information that must be provided for baseline and project scenarios where crops are planted:

Data	**Units**	**Data source/Measurement method**	**Relevant parameters**
Crop type(s)	One of grains, beans & pulses, tubers, root crops, N-fixing forages, non-N-fixing forages, perennial grasses, grass-clover mixture	From description of baseline/project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}

Months of the year when ground is covered by crops, litter or other residues	Yes/ No for each month	From description of baseline/project scenario	BE_{SO}, PE_{SO}
Average annual crop yield for each crop type	Tonnes of dry matter per hectare	Determined from local information, or use country specific mean value from FAOSTAT[1] over the last 10 years	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are crop residues left in the field after harvest?	Yes/ No or % of crop residues left in the field	From description of baseline/project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}

Information that must be provided for baseline and project scenarios where synthetic and/or organic fertiliser is used:

Data	Units	Data source/Measurement method	Relevant parameters
Type of fertiliser	Synthetic/ Organic	From description of baseline/project scenario	BE_{NF}, PE_{NF}
Fertiliser application	Return interval for fertiliser application in years. For example, a return interval of 5 means fertiliser is applied every 5 years.	From description of baseline/project scenario	BE_{NF}, PE_{NF}
Mass of fertiliser applied	Tonnes per hectare for each application	From description of baseline/project scenario	BE_{NF}, PE_{NF}
Nitrogen content of fertiliser	Grams of nitrogen per 100 grams of fertiliser	From manufacturer or peer reviewed literature	BE_{NF}, PE_{NF}

Information that must be provided for baseline and project scenarios where crop or tree litter residues are burned on or off the project activity area:

Data	Units	Data source/Measurement method	Relevant parameters
Fire occurrence in fields	Return interval when fields will be burned. For example, a return interval of 1 means field is burnt every year.	From description of baseline/project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are crop residues that are removed from fields burnt elsewhere?	Yes/ No	From description of baseline/project scenario	BE_{BB}, PE_{BB},

Information that must be provided for baseline and project scenarios where additional plant litter inputs from trees or other woody vegetation are added to the field:

Data	Units	Data source/Measurement method	Relevant parameters
Additional litter application to fields	Return interval or year(s) in which application takes place. For example, return intervals of 1 means additional inputs were added every year	From description of baseline/project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Mass of additional inputs	Tonnes of dry matter per hectare for each application	From description of baseline/project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Nitrogen content of additional inputs	Proportion of dry matter that is nitrogen	Peer reviewed literature for appropriate source of plant inputs	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}

[1] http://faostat.fao.org/site/567/default.aspx#ancor

4.2 Tree planting activities

Information that must be provided for project scenarios that include tree planting:

Data	Units	Appropriate method for measurement, or data source, where applicable	Relevant parameters
Expected growth rates of tree diameter for each year of the accounting duration, for each species planted	Centimetres per year	This can be calculated using the SHAMBA tool if the diameter of trees with known ages are available for the area, from measurements made by the project or from literature values.	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
For each planted species, is the species a legume (i.e. a N-fixing species)?	Yes/No		BE_{NI}, PE_{NI}
Initial stand or planting density of each species planted	Trees per hectare	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Initial mean tree diameter of each species planted	Centimetres	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Years when thinning* event(s) will take place (if any)	Years since planting	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Fraction of stand density thinned	%	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are thinned tree stems removed from field?	Yes/ No or % of thinned stems left in the field	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are thinned tree branches removed from field?	Yes/ No or % of thinned branches left in the field	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Expected mortality rate of trees	% per year	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are dead tree stems removed from field?	Yes/ No or % of dead tree stems left in the field	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}
Are dead tree branches removed from field?	Yes/ No or % of dead tree branches left in the field	From description of the project scenario	BE_{BB}, BE_{NI}, BE_{SO}, PE_{BB}, PE_{NI}, PE_{SO}

* Thinning is the act of cutting down and removing trees or branches from the field

5. Applicability criteria for using default values in the SHAMBA tool

The SHAMBA tool provides default parameters (shown in the model description) which are only applicable if the following criteria are met by projects:

5.1 Agricultural activities

Crops must be either: grains, beans & pulses, tubers, root crops, N-fixing forages, non-N-fixing forages, perennial grasses, or grass-clover mixture.

5.2 Tree planting activities

The SHAMBA tool uses allometric equations to define the biomass for each tree, based on the tree diameter. The SHAMBA tool includes default allometry for the following trees or generic tree types:

- Miombo trees
- Generic tropical forest trees (not agroforestry spp)
- Agroforestry tree spp. *Markhamia lutea*, *Maesopsis eminii* and *Grevillea robusta*

If other trees or tree types are being planted, projects cannot use the default allometric equation, and will have to provide an alternative.

In addition:

- The tool default assumes allometry is not altered by pruning or other activities. If this is not the case projects may need to define the allometry of pruned trees.
- The tool default assumes that none of the biomass in the stems is returned to the soil as litter over the accounting period. Trees that shed their bark or other stem biomass will need to parameterise by the projects for stem turnover rates.
- The tool defaults assume that all trees are deciduous, or have a leaf life span of <= 1 year. For evergreen species, the leaf life span or turnover rates of the leaves will need to be known and parameterised.
- The default assumes that all woody biomass removed from the field is converted to CO_2 rapidly. Long-lived woody products are not accounted for in the current version of the tool.

5.3 Soil parameters

The SHAMBA tool makes assumptions about the past land use and its effect on soil carbon stocks. These assumptions can be altered, but this requires the user to specify the land use history. If this is not done, the tool assumes:

- Prior to clearance, soils carbon stocks were at equilibrium under forest/woodland cover
- Between the time of the first clearance and the start of the project period soil carbon stocks decreased by 25%
- The soil characteristics (soil carbon and clay content) at the start of the project are accurately characterised by the Harmonized World Soil Database[2]

If this does not reflect the land use history or soil characteristics, projects must provide alternative values of soil carbon stocks at equilibrium and at the start of project interventions, and justify how they were sourced (see SHAMBA model description for full details).

[2] http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/