

# Voluntary Carbon Standard

## Proposed Methodology

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## Section I: Summary and applicability of the baseline and monitoring methodology

### 1.1 Methodology title and history of submission

Title:	Adoption of sustainable agricultural land management (SALM)
Version:	5
Changes from previous version	Changes from the previous version are in response to the VCS guidance dated XXX 2010 included in Section 6.5.2 (of the VCS 2007.1) on quantification of GHG emissions and/or removals related to the methodology, as follows:
Date submitted:	2010-10-12
Acknowledgements:	The BioCarbon Fund acknowledges the lead author of this methodology: Neil Bird and all external and internal reviewers from the World Bank that contributed to the development of this methodology.

### 1.2 Brief description

This methodology proposes to estimate and monitor greenhouse gas emissions of project activities that reduce emissions in agriculture through adoption of sustainable land management practices (SALM) in the agricultural landscape. In this methodology, SALM is defined as any practice that increases the carbon stocks on the land. Examples of SALM are (but are not limited to) manure management, use of cover crops, and returning composted crop residuals to the field, and the introduction of trees into the landscape.. The methodology is applicable to areas where the soil organic carbon would remain constant or decrease in the absence of the project.

The methodology in its current form is applicable only for use of Roth C model. The estimates of uncertainty and Activity Baseline and Monitoring Survey (ABMS) in the current methodology are adapted for Roth C model only. Application of methodology for use of other models will require at a minimum, revisions to estimates of uncertainty and ABMS specific to the model applied. If however, the parameters used by another model correspond to some or all parameters included in this methodology, then the methodology is applicable, provided applicability conditions of the methodology are met

This methodology is based on the project “Western Kenya Smallholder Agriculture Carbon Finance project” in Kenya. The baseline study, monitoring and project document are being prepared by the Foundation Vi Planterar trad (“We plant trees”) with assistance from Unique Forestry Consultants Ltd., the Swedish International Agency (Sida) and the International Bank for Reconstruction and Development as Trustee of the Biocarbon Fund. The methodology is also based on a second project titled “Kenya Smallholder coffee carbon project”. This project will be implemented by ECOM Agroindustrial Corporation Ltd. in cooperation with the Komothai Farmers Cooperative Society (KFCS) and will be funded by the World Bank BioCarbon Fund with technical assistance from Unique Forestry Consultants Ltd.

### 1.3 Selected baseline approach for project activities

- Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary

#### Explanation / justification

The existing agricultural practices are likely to continue during the lifetime of the project.

## 1.4 Applicability conditions

This methodology is applicable to projects that introduce sustainable agriculture land management practices (SALM) into an agricultural landscape subject to the following conditions:

- a) Land is either cropland or grassland at the start of the project.
- b) The land is degraded and will continue to be degraded or continue to degrade;
- c) The area of land under cultivation in the region is constant or increasing in absence of the project
- d) Forest land, as defined by the national CDM forest definition, in the area is constant or decreasing over time;
- e) There is no significant<sup>1</sup> increase in greenhouse gas emissions as a result of an increase in the number of livestock;
- f) There is no significant displacement of agricultural residues or manure from outside the project boundary to within the project boundary
- g) There is no significant increase in the use of fossil fuels for agricultural management (i.e., use of farm machinery to cultivate, fertilize, harvest).
- h) There is no significant increase of use of fossil fuels for cooking and heating as a result of the displacement of manure and/or residuals from the household to the agricultural land as a result of the project.
- i) There must be studies (for example; scientific journals, university theses, local research studies or work carried out by the project proponents) that demonstrate that the use of the Roth C model<sup>2</sup> is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines<sup>1</sup> or (b) the agroecological zone (AEZ) in which the project is situated, using one of options presented below: <sup>3</sup>.

**Option 1:** The studies used in support of the project should meet the guidance on model applicability as outlined in IPCC, AFOLU 2006 guidelines in order to show that the model is applicable for the relevant IPCC climatic region. The guidance notes that an appropriate model should be capable of representing the relevant management practices and that the model inputs (i.e., driving variables) are validated from country or region-specific locations that are representatives of the variability of climate, soil and management systems in the country.

**Option 2:** Where available, the use of national, regional or global<sup>4</sup> level agroecological zone (AEZ) classification is appropriate to show that the model has been validated for similar AEZs. It is recognized that national level AEZ classifications are not readily available; therefore this methodology allows the use of the global and regional AEZ classification<sup>5</sup>.

Where a project area consists of multiple sites, it is recognized that studies demonstrating model validity using either Option 1 or Option 2 may not be available for each of the sites in

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<sup>1</sup> Significance is defined so that the sum of increase in greenhouse gas emissions from the increase in the number of livestock, displacement of manure, increase in fossil fuels from agricultural management and increase of fossil fuels for cooking as a result of the project is less than 5% of the emission reductions by the project. The significance of the emission will be tested using the latest version of the CDM EB approved "Tool for testing significance of GHG emissions in A/R CDM project activities" (<http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf>)

<sup>2</sup> For ROTH-C see <http://www.rothamsted.bbsrc.ac.uk/aen/carbon/rothc.htm>.

<sup>3</sup> The IPCC climatic regions are shown in Figure 3A.5.1 page 3.38.

<sup>4</sup> The agro-ecological zone (AEZ) methodology is standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production. Crop modeling and environmental matching procedures are used to identify crop-specific limitations of prevailing climate, soil and terrain resources, under assumed levels of inputs and management conditions.

<sup>5</sup> The details of global agroecological zones classification outlined by Food and Agricultural Organization of United Nations (FAO), Rome, Italy and International Institute for Applied Systems Analysis, Laxenburg, Austria are available at: <http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm>

the project area. In such cases the study used should be capable of demonstrating that the following two conditions are met:

- (i) The model is validated for at least 50% of the total project area where the project area covers up to 50,000 ha<sup>6</sup>; or at least 75% of the total project area where project area covers greater than 50,000 ha; and
- (ii) The area for which model is validated generates at least two-thirds of the total project emission reductions.

### **Explanation / justification**

Applicability conditions (a) - (c) allow for the simplification of the baseline. With these conditions we conservatively assume that the lands of a given land use type are degrading in absence of the project

Specifically it is likely that

- a) if the land is cropland, then it will remain croplands in absence of the project; otherwise
- b) the land is grasslands that will remain grassland or be converted to croplands in absence of the project.

Degradation shall be demonstrated using the latest version of the CDM EB approved tool “*Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities*”.<sup>2</sup>

Applicability condition (d) ensures that, in absence of the project, the land would likely not have been:

- a) abandoned and allowed to naturally regenerate to forest, or
- b) afforested or reforested.

With these applicability conditions we can conservatively assume that the soil organic carbon would remain constant or decrease with time in absence of the project.

Applicability condition (e) means that there is no increase in methane and nitrous oxide emissions from grazing animals as a result of the project.

Displacement of biomass from outside the project boundary to within the project boundary may cause the loss of carbon stocks outside the project boundary. This is a potential source of leakage.

Applicability condition (f) limits this leakage so that it does not need to be calculated.

Displacement of manure from outside the project boundary to within the project boundary may cause the loss of carbon stocks and/or increased use of nitrogen based fertilizers outside the project boundary. These are a potential source of leakage. Applicability condition (f) limits this leakage so that it does not need to be calculated.

SALM may cause, but generally does not cause, an increase in the use of fossil fuels due to management, harvesting, etc. Applicability condition (g) limits this increase so that emissions from fossil fuels need not be considered.

In some instances, manure and/or residuals used as an energy source for cooking and heating may be displaced as a result of the SALM. This displacement may cause an increase in the use of fossil fuels that has been limited by applicability condition (h). Leakage from the potential increase in the use of non-renewable biomass will be included in the ex-post calculations.

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<sup>6</sup> The project area of 50,000 ha is reasonable taking into account the wide range of soil carbon sequestration rates, which depend on climate, soil and land use characteristics. The project area is also influenced by the rates of SALM adoption that are in turn influenced by factors such as farmer awareness to SALM, institutional support and extension systems. Assuming a conservative soil sequestration rate of 0.5 tC/ ha/ yr applied in CDM A/R methodologies, a project of 50, 000 ha is likely to generate 25,000 tC/ ha/yr, and is considered reasonable taking into account the implementation, monitoring and verification costs. .

The insignificance of the emissions due to an increase in fossil fuel use for agricultural management and/or for cooking and heating shall be demonstrated using the latest version of the CDM EB approved tool “*Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*”<sup>3</sup>

Finally, the methodology relies on modelled soil organic carbon. To assure that the model results are reasonable, there must be studies (for example; scientific journals, university theses, local research studies or work carried out by the project proponents) that demonstrate the use of the selected model is valid for the project region. This is fulfilled with applicability condition (i) in accordance with the VCS guidance dated XXX included in Section 6.5.2 (of the VCS 2007.1) on quantification of GHG emissions and/or removals related to the methodology.

## 1.5 Selected carbon pools and emission sources

Table 1: Selected carbon pools

Carbon pools	Selected (answer with Yes or No)	Explanation / justification
Above ground	Yes	<p>A carbon pool covered by SALM practices. The increase in above ground biomass of woody perennials planted as part of the SALM practices is part of the methodology. The increase in above ground biomass of annual crops is not considered since in the IPCC accounting system, annual crops are ignored.</p> <p>The above ground biomass is calculated using the A/R Working Group Tool “<i>Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity</i>”<sup>4</sup> and <i>Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on grasslands or croplands AR-AMS0001</i><sup>5</sup></p>
Below ground	Yes	<p>Below-ground biomass stock is expected to increase due to the implementation of the SALM activities. The increase in below ground biomass of woody perennials planted as part of the SALM practices is part of the methodology. The increase in below ground biomass of annual crops is not considered since in the IPCC accounting system, annual crops are ignored.</p> <p>The below ground biomass is calculated using the A/R Working Group Tool “<i>Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity</i>”<sup>4</sup> and <i>Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on grasslands or croplands AR-AMS0001</i><sup>5</sup></p>
Dead wood	No	None of the applicable SALM practices decrease dead wood. Thus it can be conservatively ignored.
Litter	No	None of the applicable SALM practices decrease the amount of litter. Thus it can be conservatively ignored.

Soil organic carbon	Yes	A major carbon pool covered by SALM practices.
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**Table 2: Emissions sources included in or excluded from the project boundary**

Sources	Gas	Included/ excluded	Explanation / justification
Use of fertilizers	CO <sub>2</sub>	Excluded	Not applicable
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Included	Main gas for this source. These are calculated using the A/R Working Group Tool “ <i>Estimation of direct nitrous oxide emission from nitrogen fertilization (version 01)</i> ” <sup>6</sup>
Use of N-fixing species	CO <sub>2</sub>	Excluded	Not applicable
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Included	Main gas for this source. These are calculated using the tool “ <i>Estimation of direct nitrous oxide emission from n-fixing species and crop residues</i> ” (page 30)
Burning of biomass	CO <sub>2</sub>	Excluded	However, carbon stock decreases due to burning are accounted as a carbon stock change
	CH <sub>4</sub>	Included	Non-CO <sub>2</sub> emissions from the burning of biomass These are calculated using the tool “ <i>Estimation of non-CO2 emissions from the burning of crop residues</i> ” (page 32)
	N <sub>2</sub> O	Included	Non-CO <sub>2</sub> emissions from the burning of biomass These are calculated using “ <i>Estimation of non-CO2 emissions from the burning of crop residues</i> ” (page 32)

## **I.6 Summary description of major baseline and project methodological steps**

### **I.6.1 Baseline methodology**

The baseline emissions and removals are estimated using the following steps:

1. Identify and delineate the project boundary;
2. Identify the baseline scenario and demonstrate additionality
3. Estimate the annual emissions from the use of synthetic fertilizers;
4. Estimate the annual emissions from the use of n-fixing species
5. Estimate the annual emissions from the burning of agricultural residues;
6. Estimate the annual removals from existing woody perennials; and
7. Estimate the equilibrium soil organic carbon in the baseline assuming no changes in agricultural management or agricultural inputs.

### **I.6.2 Project methodology**

The project emissions and removals are estimated using the following steps:

1. Estimate the annual emissions from the use of synthetic fertilizers;

2. Estimate the annual emissions from the use of n-fixing species
3. Estimate the annual emissions from the burning of agricultural residues;
4. Estimate the annual emissions and removals from woody perennials;
5. Estimate the equilibrium soil organic carbon in the project based on estimated or measured changes in agricultural management or agricultural inputs;
6. Convert the equilibrium soil organic carbon in the project to transient soil organic carbon assuming a linear transition period;
7. Estimate the annual emissions and removals from soil organic carbon; and
8. Estimate the annual emissions from the increase in the use of non-renewable biomass that occurs from the displacement of biomass used for energy to agricultural inputs.

### **I.6.3 Monitoring methodology**

The following steps are required as part of the monitoring methodology:

1. Record the amount of synthetic fertilizers used in the project;
2. Estimate the amount of production of biomass by n-fixing species in the project;
3. Estimate the amount of agricultural residues burnt in the project;
4. Record the production from and areas of various types of agricultural land management;
5. Measure the changes in biomass in woody perennials;
6. Estimate the reduction in the amount of biomass used for energy that is a result of the project.

The summary description of major baseline and project methodological steps noted above has been elaborated in the sections II, III and IV of the methodology.

## Section II: Baseline methodology description

### II.1 Project boundary

The “project boundary” geographically delineates all lands that are:

1. directly affected by the proposed sustainable agricultural land management (SALM) activities and
2. under the control<sup>7</sup> of the project participants.

The SALM project activities may contain more than one discrete area of land.

#### Procedure

At the time the PDD is validated:

- Each discrete area of land shall have a unique geographical identification;
- The project participants shall describe legal title to the land, rights of access to the sequestered carbon, current land tenure, and land use for each discrete area of land;
- The project participants shall justify, that during the crediting period, each discrete area of land is expected to be subject to a SALM project activity under the control of the project participants

The project participants shall be allowed to increase or decrease area within the project boundary subject to the conditions described in “*Further Clarification On The Application Of The Definition Of Project Boundary To A/R Project Activities*”<sup>7</sup>

### II.2 Procedure for selection of most plausible baseline scenario

The baseline scenario is identified as existing or historical land management practices. Project participants shall use the most recent version of the “*Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities*”<sup>8</sup> ignoring the portions of the tool that make reference to eligibility of lands for A/R projects.

### II.3 Additionality

Project participants shall use the most recent version of the “*Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities*” ignoring the portions of the tool that make reference to eligibility of lands for A/R projects.

### II.4 Estimation of baseline GHG emissions and removals

#### II.4.1 Baseline emissions due to fertilizer use

The baseline emissions from synthetic fertilizer use,  $BEF_b$ , are calculated using the latest version of the CDM A/R Working Group Tool “*Estimation of direct nitrous oxide emission from nitrogen fertilization (version 01)*”<sup>6</sup>.

Emissions from manure application are not expected to change with the project, as applicability conditions limit the importing of manure from outside the project boundary and the change in the animal population. For this reason the baseline emissions from manure application can be ignored.

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<sup>7</sup> Control is defined by ownership, leasing of rights for agricultural use, or undisputed traditional right to use for agriculture.

#### II.4.2 Baseline emissions due to the use of N-fixing species

The baseline emissions from the use of N-fixing species,  $BEN_t$ , are not calculated, but project participants shall record the area under N fixing species prior to project implementation

#### II.4.3 Baseline emissions due to burning of biomass

The baseline emissions due to burning of biomass,  $BEBB_t$ , are calculated using the tool *Estimation of non-CO2 emissions from the burning of crop residues* (page 32).

#### II.4.4 Baseline removals from existing woody perennials

The baseline removals from woody perennials,  $BRWP_t$ , are calculated using the latest version of the CDM A/R Working Group Tool “*Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity*”<sup>4</sup>

#### II.4.5 Equilibrium soil organic carbon density in management systems

Using an analytic model that has been accepted in scientific publications (for example: RothC soil organic carbon model<sup>9</sup>) estimate the soil organic carbon (SOC) density to a depth of 30 cm, at equilibrium in identified management practices on cropland and grassland.

The SOC density should be estimated using area-weighted average values of model input parameters for each management practice identified in Step 4. The proponents should demonstrate that the standard deviation of the modelled SOC within each group is less than 10% of the average value.

The baseline soil organic carbon at equilibrium can be estimated using:

$$BS_{equil,t} = \sum_{m_C} BA_{C,m_C,t} \cdot SOC_{C,m_C} + \sum_{m_G} BA_{G,m_G,t} \cdot SOC_{G,m_G} \quad 1$$

Where

$BS_{equil,t}$	Baseline SOC in equilibrium year t, tC
$BA_{C,m_C,t}$	Baseline areas in cropland with management practice, $m_C$ , year t, ha
$SOC_{C,m_C}$	Soil organic carbon density at equilibrium for cropland with management practice, $m_C$ , tC/ha
$m_C$	An index for cropland management types, unit less
$BA_{G,m_G,t}$	Baseline areas in grassland with management practice, $m_G$ , year t, ha
$SOC_{G,m_G}$	Soil organic carbon density to a depth of 30 cm, at equilibrium for grassland with management practice, $m_G$ , tC/ha
$m_G$	An index for grassland management types, unit less

#### II.4.6 Baseline removals due to changes in soil organic carbon

Since the applicability conditions limit the project to lands that are under agricultural pressure and are degrading, it can be conservatively assumed that the baseline removals due to changes in SOC are zero. Therefore

$$BRS_t = 0 \quad 2$$

Where

$BRS_t$	Baseline removals due to changes in soil organic carbon in year t, t CO <sub>2</sub> e.
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## II.4.7 Total baseline emissions and removals

The total baseline emissions and removals are given by:

$$BE_t = BEF_t + BEBB_t - BRWP_t \quad 3$$

Where

$BE_t$  Baseline emissions in year t, t CO<sub>2</sub>e

$BEF_t$  Baseline emissions due to nitrogen fertilizer use in year t, t CO<sub>2</sub>e.

$BEBB_t$  Baseline emissions due to biomass burning in year t, t CO<sub>2</sub>e.

$BRWP_t$  Baseline removals due to changes in woody perennials in year t, t CO<sub>2</sub>e.

## Section III: Project methodology description

### III.1 Estimation of project GHG emissions and removals

#### III.1.1 Project emissions due to fertilizer use

The project emissions from synthetic fertilizer use,  $PEF_t$ , are calculated using the latest version of the CDM A/R Working Group Tool “*Estimation of direct nitrous oxide emission from nitrogen fertilization (version 01)*”<sup>6</sup>.

Emissions from manure application are not expected to change with the project, as applicability conditions limit the importing of manure from outside the project boundary and the change in the animal population. For this reason the project emissions from manure application can be ignored.

#### III.1.2 Project emissions due to the use of N-fixing species

Only the emissions due to increased area under N fixing species shall be accounted.

If the area cropped with N fixing species in the project is more than 50% larger than the area under N fixing species in the baseline then the project emissions from the use of N-fixing species,  $PEN_t$ , are calculated using the tool “*Estimation of direct nitrous oxide emission from n-fixing species and crop residues*” (page 30)

In all other cases estimation of emissions from N fixing species is not required.

This differentiation is based on the assumption that:

- a) the project does not occur on wet lands;
- b) the project occurs on degraded lands so that the lands are likely nitrogen deficient.

These assumptions mean that the nitrogen emissions tend to be smaller than estimated by the Tier 1 IPCC estimation methodology.

#### III.1.3 Project emissions due to burning of biomass

The project emissions due to burning of biomass,  $PEBB_t$ , are calculated using the tool *Estimation of non-CO2 emissions from the burning of crop residues* (page 32).

#### III.1.4 Project removals from woody perennials

The project removals from woody perennials,  $PRWP_t$ , are calculated using portions of CDM A/R *Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on grasslands or croplands AR-AMS001*<sup>5</sup>

#### III.1.5 Project equilibrium soil organic carbon density in management systems

Undertake an Activity Baseline and Monitoring Survey (ABMS) to identify the dominant agricultural management practices for croplands and grasslands. The ABMS should estimate or record details of each management practice. For example when using the Roth-C model, one should record;

1. its area;
2. the average annual biomass production;
3. the average biomass left on site or input;
4. the average number and type of grazing animals;
5. the amount of manure input; and

6. the amount of nitrogen fertilizers input.

Using an analytic model that has been accepted in scientific publications and validated for the project region (for example: RothC soil organic carbon model<sup>10</sup>) estimate the soil organic carbon (SOC) density, to a depth of 30 cm, at equilibrium in each of the identified management practices in each of the land use categories (cropland and grassland).

The details of each management practice that are recorded will depend on the choice of soil model selected and the type of activity being promoted. For example, if the activity is improving the use of crop residues then for use with the Roth-C model, the ABMS should record:

- Area of each crop (ha)
- Productivity of each crop (kg/ha)
- The amount of crop residues (kg/ha)<sup>8</sup>
- Existing crop residue management practices and their frequency
- Future crop residue management practices that will be implemented with the project

If the project activity includes improving the management of manure, then for use with the Roth-C model, the ABMS should also record:

- Area of grazing (ha)
- The number of livestock per animal type
- The amount of manure produced (kg/ha or kg/an)<sup>9</sup>
- Existing manure management practices and their frequency
- Future manure management practices that will be implemented with the project

If the project activity includes improved tillage practices, then for use with the Roth-C model, the ABMS should record:

- Area under tillage (ha)
- Type and depth of tillage
- Existing tilling practices and their frequency
- Future tilling practices that will be implemented with the project

If the project activity includes agroforestry, then, for use with the Roth-C model, the ABMS should record:

- Area of agroforestry (ha)
- Number and species of trees used
- Diameter at breast height (DBH) of trees
- Future numbers of trees that will be implemented with the project

The applicability of the selected model and parameters recorded for the various activities, and soil and climate types are dependent on the actual project. Since these are project specific and not methodology specific, they should be discussed in detail in the PD.

The SOC density should be estimated using area-weighted average values of model input parameters for each management practice identified. The proponents should demonstrate that the standard deviation of the modelled SOC within each group is less than 10% of the average value.

The project soil organic carbon at equilibrium can be estimated using:

$$PS_{equil,t} = \sum_{m_C} PA_{C,m_C,t} \cdot SOC_{C,m_C,t} + \sum_{m_G} PA_{G,m_G,t} \cdot SOC_{G,m_G,t} \quad 4$$

<sup>8</sup> Amount of crop residues need not be measured directly. It can also be estimated from the crop production using equations listed in Table 11.2 in Volume 4 of the 2006 IPCC Guidelines

<sup>9</sup> Amount of manure need not be measured directly. It can also be estimated from the number and type of animal using values from Table 10A-4 in Chapter 10 of the 2006 IPCC Guidelines.

Where

$PS_{equil,t}$	Project SOC in equilibrium year $t$ , tC
$PA_{C,m_C,t}$	Project areas in cropland with management practice, $m_C$ , year $t$ , ha
$SOC_{C,m_C,t}$	Soil organic carbon density at equilibrium for cropland, to a depth of 30 cm, with management practice, $m_C$ , at year $t$ , tC/ha
$m_C$	An index for cropland management types, unit less
$PA_{G,m_G,t}$	Project areas in grassland with management practice, $m_G$ , year $t$ , ha
$SOC_{G,m_G,t}$	Soil organic carbon density at equilibrium, to a depth of 30 cm, for grassland with management practice, $m_G$ , at year $t$ , tC/ha
$m_G$	An index for grassland management types, unit less

### III.1.6 Project estimate of soil organic carbon with transitions

The estimate of soil organic carbon with transitions can be estimated using:

$$PS_t = \frac{1}{D} \sum_{t-D+1}^t PS_{equil,t} \cdot \Delta t \quad 5$$

Where

$PS_t$	Estimate of the project SOC in year $t$ , tC
$PS_{equil,t}$	Estimate of the project SOC in equilibrium year $t$ , tC
$D$	The transition period required for SOC to be at equilibrium after a change in land use or management practice, year
$\Delta t$	Time increment = 1 year

For values of  $t-D+1$  less than zero (the start of the project) assume that  $PS_{equil,t} = BS_{equil,t=0}$ .

These values are required if one is trying to estimate the absolute soil organic carbon in the baseline. Since the ultimate goal of the methodology is the increase or decrease in SOC with the project these values are not required since they appear in both the baseline and project estimation technique.

Value of  $D$  may be chosen from published data from local or regional studies or the modelling exercise. In absence of such data, the IPCC Tier 1 methodology default factor of 20 years may also be used.

### III.1.7 Estimate of project removals due to changes in soil organic carbon

The estimate of project removals due to changes in soil organic carbon are given by:

$$PRS_t = (PS_t - PS_{t-1}) \cdot \frac{44}{12} \quad 6$$

Where

$PRS_t$	Estimate of project removals due to changes in soil organic carbon in year $t$ , t CO <sub>2</sub> e.
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$PS_t$  Estimate of the project SOC in year t, tC

### III.1.8 Actual net GHG emissions and removals by sinks

The actual net GHG emissions and removals by sinks are given by:

$$PE_t = PEF_t + PEN_t + PEBB_t - PRWP_t - PRS_t \quad 7$$

Where

$PE_t$  Estimate of actual net GHG emissions and removals by sinks in year t, t CO<sub>2</sub>e

$PEF_t$  Estimate of project emissions due to nitrogen fertilizer use in year t, t CO<sub>2</sub>e.

$PEN_t$  Estimate of project emissions due to the increase use of n-fixing species in year t, t CO<sub>2</sub>e.

$PEBB_t$  Estimate of project emissions due to biomass burning in year t, t CO<sub>2</sub>e.

$PRWP_t$  Estimate of project due to changes in biomass of woody perennials in year t, t CO<sub>2</sub>e.

$PRS_t$  Estimate of project removals due to changes in soil organic carbon in year t, t CO<sub>2</sub>e.

## III.2 Estimation of leakage

There are five potential sources of leakage:

- Displacement of biomass from outside to inside the project boundary causing the depletion of soil organic carbon outside the project boundary;
- Displacement of manure from outside to inside the project boundary causing an increase in the use of inorganic fertilizers or an increase in the amount of fossil fuel for cooking outside the project boundary;
- Increase in the use of fuel wood from non-renewable sources for cooking and heating purposes due to the decrease in the use of manure and/or residuals as an energy source;
- Increase in the use of fossil fuel for cooking and heating purposes due to the decrease in the use of manure and/or residuals as an energy source;
- Increase in the combustion of fossil fuel by vehicles due to an increase in agricultural produce shipped to market as a result of the adoption of sustainable land management practices.

Leakage due to displacement of biomass is limited by the applicability condition that only biomass that would have been burnt outside the project boundary can be brought into the project area. Otherwise, the project boundary needs to be increased to include these lands that source the additional biomass as the lands are directly affected by the project.

Leakage due to the displacement of manure is limited by the applicability condition that only biomass that would have been burnt outside the project boundary can be brought into the project area.

Leakage due to the increase in the use of fuel wood from non-renewable sources for cooking and heating purposes may be a significant source of leakage in manure or other agricultural residuals used for cooking and heating are transferred to the fields as part of the project. In the project, this will be minimized by the introduction of woody perennials for fuel in the landscape, and improvement of

energy efficiency of biomass for cooking and heating. Nevertheless, this form of leakage may occur. The leakage from a switch TO non-renewable biomass use,  $LNRB_t$ , are calculated using the small scale methodology AMS-I.E. *Switch from Non-Renewable Biomass for Thermal Applications by the User*<sup>11</sup>.

Leakage due to the increase in the use of fossil fuel use for cooking and heating purposes is limited by the applicability condition that landowners do not use fossil fuels for these purposes currently.

Leakage due to an increase in the amount of fossil fuels used by vehicles that ship agricultural produce to market is considered a form of market leakage and so can be ignored.

**Table 3: Emissions sources included in or excluded from leakage**

Sources	Gas	Included/ excluded	Justification / Explanation of choice
Soil organic carbon stock changes	CO <sub>2</sub>	Excluded	Applicability condition
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Excluded	Not applicable
Increase fertilizer use	CO <sub>2</sub>	Excluded	Not applicable
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Excluded	Applicability condition
Increase fossil fuel for cooking	CO <sub>2</sub>	Excluded	Applicability condition
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Excluded	Not applicable
Increase non-renewable biomass for cooking	CO <sub>2</sub>	Included	Managed
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Excluded	Not applicable
Combustion of fossil fuels by vehicles	CO <sub>2</sub>	Excluded	Market leakage
	CH <sub>4</sub>	Excluded	Not applicable
	N <sub>2</sub> O	Excluded	Not applicable

### III.3 Estimation of net anthropogenic GHG emissions and removals

The estimation of net anthropogenic GHG removal by sinks is made using:

$$\Delta R_t = BE_t - PE_t - LNRB_t \quad 8$$

Where

$\Delta R_t$  Estimate of net anthropogenic GHG emissions and removals in year t, t CO<sub>2</sub>e

$PE_t$  Estimate of actual net GHG emissions and removals in year t, t CO<sub>2</sub>e

$BE_t$  Baseline emissions and removals in year t, t CO<sub>2</sub>e

$LNRB_t$  The leakage from a switch TO non-renewable biomass use

## Section IV: Monitoring methodology description

### IV.1 Baseline GHG emissions and removals

#### IV.1.1 Sampling design

The project proponents should refer to CDM EB approved “*General Guidelines For Sampling And Surveys For Small-Scale CDM Project Activities*”<sup>12</sup> for sampling and survey design. At the start of the project, undertake an Activity Baseline and Monitoring Survey (ABMS) to identify the dominant agricultural management practices for croplands and grasslands. The ABMS should estimate or record details of each management practice. For example when using the Roth-C model, one should record;

1. its area;
2. the annual biomass production;
3. the annual biomass left on the fields;
4. the number and type of grazing animals;
5. the amount of manure input;
6. the amount of nitrogen fertilizers input;
7. the amount of n-fixing species;
8. the amount of biomass burnt; and
9. the existence and amount of woody perennials (trees and bushes).

The information recorded will depend on the choice of soil model selected and the type of activity being promoted. For example, if the project activity is improving the use of crop residues then for use with the Roth-C model, the ABMS should record in the baseline:

- Area of each crop (ha)
- Productivity of each crop (kg/ha)
- The amount of crop residues (kg/ha)<sup>10</sup>
- Existing crop residue management practices and their frequency
- Future crop residue management practices that will be implemented with the project

If the project activity includes improving the management of manure, then for use with the Roth-C model, the ABMS should record in the baseline:

- Area of grazing (ha)
- The number of livestock per animal type
- The amount of manure produced (kg/ha or kg/an)<sup>11</sup>
- Existing manure management practices and their frequency
- Future manure management practices that will be implemented with the project

If the project activity includes improved tillage practices, then for use with the Roth-C model, the ABMS should record in the baseline:

- Area under tillage (ha)
- Type and depth of tillage
- Existing tilling practices and their frequency
- Future tilling practices that will be implemented with the project

<sup>10</sup> Amount of crop residues need not be measured directly. It can also be estimated from the crop production using equations listed in Table 11.2 in Volume 4 of the 2006 IPCC Guidelines

<sup>11</sup> Amount of manure need not be measured directly. It can also be estimated from the number and type of animal using values from Table 10A-4 in Chapter 10 of the 2006 IPCC Guidelines.

If the project activity includes agroforestry, then for use with the Roth-C model, the ABMS should record in the baseline:

- Area of agroforestry (ha)
- Number and species of trees used
- Diameter at breast height (DBH) of trees
- Future numbers of trees that will be implemented with the project

The applicability of the selected model and parameters recorded for the various activities, and soil and climate types are dependent on the actual project. Since these are project specific and not methodology specific, they should be discussed in detail in the PD.

Other model input parameters that may be required by the selected model, such as climatic data, clay content and texture of soils<sup>13</sup> can be acquired from global or national data sets and do not need to be measured by the proponents.

It is recommended that the project proponents stratify by crop system, tillage system, use of crop residues, application of manure and clay content of soils as a minimum.

#### IV.1.2 Data to be collected and archived for baseline GHG emissions and removals

Section	Data / Parameter	Unit	Description	Recording frequency	Source
II.4.1	$BSN_{t=0}$	kg	Synthetic fertilizer use	Project start	ABMS
II.4.2	$Crop_{i,t=0}$	kg d.m./ha	Harvested annual dry matter yield for crop $i$	Project start	ABMS
II.4.2	$Area_{i,t=0}$	ha	total annual area harvested of crop $i$ or n-fixing trees $i$	Project start	ABMS
II.4.2	$Areaburnt_{i,t=0}$	ha	annual area of crop $i$ or n-fixing trees $i$ burnt	Project start	ABMS
II.4.3	$MB_{C,t=0}$	t d.m.	Mass of crop residues burnt	Project start	ABMS
II.4.3	$MB_{G,t=0}$	t d.m.	Mass of grasslands residues burnt	Project start	ABMS
II.4.3	$C_F$	unitless	Combustion factors that depend on vegetation type	Project start	National or regional studies
II.4.4	See A/R Methodological Tool “ <i>Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity</i> ” (Version 01) <sup>4</sup> for a complete list of data and parameters collected and archived.				
II.4.5	$BA_{C,m_C,t=0}$	ha	Baseline areas in cropland with management practice, $m_C$	Project start	ABMS
II.4.5	$SOC_{C,m_C,t=0}$	tC/ha	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, $m_C$	Project start	Modelled
II.4.5	$BP_{C,m_C,t=0}$	t/ha/month	Baseline production in cropland per month with management practice, $m_C$	Project start	ABMS

II.4.5	$BR_{C,m_C,t=0}$	t/t prod/ month	Baseline fraction of production returned as residuals per month in cropland with management practice, $m_C$	Project start	ABMS
II.4.5	$BM_{C,m_C,t=0}$	t/ha/m onth	Baseline manure input in cropland per month with management practice, $m_C$	Project start	ABMS
II.4.5	$BCC_{C,m_C,t=0}$		Baseline cover crop flag per month in cropland per month with management practice, $m_C$	Project start	ABMS
II.4.5	$BA_{G,m_G,t=0}$	ha	Baseline areas in grassland with management practice, $m_G$ ,	Project start	ABMS
II.4.5	$SOC_{G,m_G,t=0}$	tC/ha	Soil organic carbon density, to a depth of 30 cm, at equilibrium for grassland with management practice, $m_G$	Project start	Modelled
II.4.5	$BP_{G,m_G,t=0}$	t/ha/m onth	Baseline production in grassland per month with management practice, $m_G$	Project start	ABMS
II.4.5	$BR_{G,m_G,t=0}$	t/t prod/ month	Baseline fraction of production returned as residuals per month in grassland with management practice, $m_G$	Project start	ABMS
II.4.5	$BM_{G,m_G,t=0}$	t/ha/m onth	Baseline manure input in grassland per month with management practice, $m_G$	Project start	ABMS
II.4.5	$BCC_{G,m_G,t=0}$		Baseline cover crop flag per month in grassland per month with management practice, $m_G$	Project start	ABMS
II.4.5	$\overline{Temp}_m$	°C	Average temperature per month	Project start	National or regional studies
II.4.5	$\overline{Prec}_m$	mm	Average precipitation per month	Project start	National or regional studies
II.4.5	$\overline{Evap}_m$	mm/d ay	Average evapotranspiration per month	Project start	National, regional studies or calculated from solar radiation

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## **IV.2 Ex-ante and ex-post net anthropogenic GHG emissions and removals**

### **IV.2.1 Data to be collected and archived for *ex-ante* project GHG emissions and removals**

Record all assumptions and sources of assumptions

### **IV.2.2 Data to be collected and archived for *ex-ante* leakage**

The only source of leakage possible as a result of the project is the leakage from a switch TO non-renewable biomass use. As the project will attempt to manage the possibility of leakage through the addition of woody perennials for fuel wood use in the landscape; the *ex-ante* estimate of leakage is zero.

### **IV.2.3 Monitoring of project implementation**

The project participants should record when each farmer within the project area enters into agreement to adopt sustainable agricultural land management practices.

Each farmer should be given a unique ID. His name, location of his lands, and date of entering into the agreement and leaving the agreement should be recorded.

### **IV.2.4 Sampling design**

The project proponents should refer to CDM EB approved “*General Guidelines For Sampling And Surveys For Small-Scale CDM Project Activities*”<sup>14</sup> for sampling and survey design. They should undertake an Activity Baseline and Monitoring Survey (ABMS) on a regular basis (annually or bi-annually) to identify the actual agricultural management practices adopted on croplands and grasslands. The ABMS should estimate or record details of each management practice. For example when using the Roth-C model, one should record;

1. its area;
2. the annual biomass production;
3. the annual biomass left on the fields;
4. the number and type of grazing animals;
5. the amount of manure input;
6. the amount of nitrogen fertilizers input;
7. the amount of n-fixing species;
8. the amount of biomass burnt; and
9. the biomass of woody perennials (trees and bushes).

The following parameters need to be recorded annually.

1. Regional total biomass production;
2. Annual temperature, precipitation and evapotranspiration and
3. Fertilizer price.

The information recorded will depend on the choice of soil model selected and the type of activity being promoted. For example, if the activity is improving the use of crop residues then for use with the Roth-C model, the ABMS should record:

- Area of each crop (ha)
- Productivity of each crop (kg/ha)

- The amount of crop residues (kg/ha)<sup>12</sup>
- Existing crop residue management practices and their frequency
- Future crop residue management practices that will be implemented with the project

If the project activity includes improving the management of manure, then for use with the Roth-C model, the ABMS should record:

- Area of grazing (ha)
- The number of livestock per animal type
- The amount of manure produced (kg/ha or kg/an)<sup>13</sup>
- Existing manure management practices and their frequency
- Future manure management practices that will be implemented with the project

If the project activity includes improved tillage practices, then for use with the Roth-C model, the ABMS should record:

- Area under tillage (ha)
- Type and depth of tillage
- Existing tilling practices and their frequency
- Future tilling practices that will be implemented with the project

If the project activity includes agroforestry, then for use with the Roth-C model, the ABMS should record:

- Area of agroforestry (ha)
- Number and species of trees used
- Diameter at breast height (DBH) of trees
- Future numbers of trees that will be implemented with the project

It is recommended that the project proponents stratify by crop system, tillage system, use of crop residues, application of manure and clay content of soils as a minimum.

The applicability of the selected model and parameters recorded for the various activities, and soil and climate types are dependent on the actual project. Since these are project specific and not methodology specific, they should be discussed in detail in the PD.

Other model input parameters that may be required by the selected model, such as climatic data, clay content and texture of soils<sup>13</sup> can be acquired from global or national data sets and do not need to be measured by the proponents.

#### IV.2.5 Data to be collected and archived for project GHG emissions and removals

Section	Data / Parameter	Unit	Description	Recording frequency	Source
III.1.1	$PSN_t$	kg/yea r	Synthetic fertilizer use per year	Annually	ABMS
III.1.1	$PA_{C,t}$	ha/yea r	Areas in cropland	Annually	ABMS
III.1.1	$PA_{G,t}$	ha/yea r	Areas in grassland	Annually	ABMS
III.1.1	$PF_t$	USD/ kg	the price of inorganic	Annually	National or

<sup>12</sup> Amount of crop residues need not be measured directly. It can also be estimated from the crop production using equations listed in Table 11.2 in Volume 4 of the 2006 IPCC Guidelines.

<sup>13</sup> Amount of manure need not be measured directly. It can also be estimated from the number and type of animal using values from Table 10A-4 in Chapter 10 of the 2006 IPCC Guidelines.

			fertilizer		regional studies
III.1.2	$Crop_{i,t}$	kg d.m./ha	Harvested annual dry matter yield for crop $i$	Annually	ABMS
III.1.2	$Area_{i,t}$	Ha/year	total annual area harvested of crop $i$ or n-fixing trees $i$	Annually	ABMS
III.1.2	$Areaburnt_{i,t}$	Ha/year	annual area of crop $i$ or n-fixing trees $i$ burnt	Annually	ABMS
III.1.3	$MB_{C,t}$	t d.m./year	Mass of crop residues burnt	Annually	ABMS
III.1.3	$MB_{G,t}$	t d.m./year	Mass of grasslands residues burnt	Annually	ABMS
III.1.3	$C_F$	unitless	Combustion factors that depend on vegetation type	Project start	National or regional studies
III.1.4	See <i>Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on grasslands or croplands AR-AMS0001</i> <sup>5</sup> for a complete list of data and parameters collected and archived.				
III.1.5	$PA_{C,m_C,t}$	ha	Project areas in cropland with management practice, $m_C$	Annually	ABMS
III.1.5	$SOC_{C,m_C,t}$	tC/ha	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, $m_C$	Every five years	Modelled
III.1.5	$PP_{C,m_C,t}$	t/ha/month	Project production in cropland per month with management practice, $m_C$	Annually	ABMS
III.1.5	$PR_{C,m_C,t}$	t/t prod/month	Project fraction of production returned as residuals per month in cropland with management practice, $m_C$	Annually	ABMS
III.1.5	$PM_{C,m_C,t}$	t/ha/month	Project manure input in cropland per month with management practice, $m_C$	Annually	ABMS
III.1.5	$PCC_{C,m_C,t}$		Project cover crop flag per month in cropland per month with management practice, $m_C$	Annually	ABMS
III.1.5	$PA_{G,m_G,t}$	ha	Project areas in grassland with management practice, $m_G$	Annually	ABMS
III.1.5	$SOC_{G,m_G,t}$	tC/ha	Soil organic carbon density, to a depth of 30 cm, at equilibrium for grassland with management practice, $m_G$	Every five years	Modelled

			$m_G$		
III.1.5	$PP_{G,m_G,t}$	t/ha/month	Project production in grassland per month with management practice, $m_G$	Annually	ABMS
III.1.5	$PR_{G,m_G,t}$	t/t prod/month	Project fraction of production returned as residuals per month in grassland with management practice, $m_G$	Annually	ABMS
III.1.5	$PM_{G,m_G,t}$	t/ha/month	Project manure input in grassland per month with management practice, $m_G$	Annually	ABMS
III.1.5	$PCC_{G,m_G,t}$		Project cover crop flag per month in grassland per month with management practice, $m_G$	Annually	ABMS
III.1.5	$\overline{Temp}_m$	°C	Average temperature per month	Over the previous five years	National or regional studies
III.1.5	$\overline{Prec}_m$	mm	Average precipitation per month	Over the previous five years	National or regional studies
III.1.5	$\overline{Evap}_m$	mm/day	Average evapotranspiration per month	Over the previous five years	National, regional studies or calculated from solar radiation
III.1.6	$D$	Years	Transition period	Every five years	National or regional studies

#### IV.2.6 Data to be collected and archived for leakage

The only source of leakage possible as a result of the project is the leakage from a switch TO non-renewable biomass use attributable to the project. If the project plan includes the diversion of biomass used for cooking and heating to the fields (for example, manure or agricultural residuals) then the proponents should estimate the possible leakage.

The project proponents should record the amount of biomass used for heating and cooking purposes that is diverted to the agricultural system. It is conservatively assumed that this is replaced by non-renewable biomass or locally used fossil fuels.

Section	Data / Parameter	Unit	Description	Recording frequency	Source
III.2	$\Delta NRB_t$	kg/year	The amount of biomass used for heating and cooking that is diverted to the agricultural system.	Annually	ABMS
III.2	$f_{NRB,t} = 1$		Fraction of biomass that comes from non-renewable sources	Start of the project	

III.2	$NCV_{biomass}$	TJ/tonne	Net calorific value of the non-renewable biomass that is substituted	Start of the project	IPCC defaults, National or regional studies
III.2	$EF_{projected\_fossilfuel}$	tCO <sub>2</sub> /TJ	Emission factor for the projected fossil fuel consumption	Every five years	IPCC defaults, National or regional studies

#### IV.2.7 Conservative approach

Since emissions reduced are calculated as the baseline emissions minus project emissions, an approach means that:

- 1) ignores emissions in the baseline; and/or
- 2) ignores emission removals (sequestration) in the project

is conservative. Ignoring either of these two items will mean that emission reductions are underestimated.

The methodology uses a conservative approach because applicability conditions limit its use to:

- a) Land is either cropland or grassland at the start of the project
- b) The land is degraded and will continue to be degraded or continue to degrade;
- c) The area of land under cultivation is constant or increasing in absence of the project
- d) Forest land, as defined by the national CDM forest definition, in the area is constant or decreasing over time;

With these assumptions the methodology conservatively ignores emissions from SOC in the baseline.

The methodology uses a conservative approach because it assumes that leakage caused by the displacement of biomass used for cooking and heating purposes to the fields as the result of the project, causes an increase in the use of non-renewable biomass or fossil fuels.

#### IV.2.8 Uncertainty analysis

The project proponents should refer to CDM EB approved “*General Guidelines For Sampling And Surveys For Small-Scale CDM Project Activities*”<sup>Error! Bookmark not defined.</sup> with a view to reducing uncertainty of model input parameters. The generation of model parameters follows the standard procedures on surveys and quality assurance in the collection and organization of data.

The project proponent will estimate the uncertainty of the agricultural input parameters to the soil organic model using the ABMS. If the project area is stratified, the sampling effort should represent the relevant strata in the sample frame. Where there is no specific survey guidance from national institutions, the project proponents shall use a precision of 15% at the 95% confidence level as the criteria for reliability of sampling efforts. This reliability specification shall be applied to determine the sampling requirements for assessing parameter values. The sampling intensity could be increased to ensure that the model parameters estimated from the ABMS lead to the achievement of a desired precision of 15% at the 95% confidence level)for the estimate of greenhouse gas emission reductions from the project. The project proponent should calculate the soil model response using the model input parameters with the upper and lower confidence levels. The range of model responses demonstrates the uncertainty of the soil modelling.

##### Step 1: Calculate the values for all input parameters at the upper and lower confidence limit.

Calculate the mean,  $X_p$  and standard deviation,  $\hat{\sigma}_p$  for all parameters measured in ABMS, then the standard error in the mean is given by:

$$SE_p = \frac{\hat{\sigma}_p}{\sqrt{n_p}} \quad 9$$

Where

$SE_p$  Standard error in the mean of parameter,  $p$  in year  $t$

$\hat{\sigma}_p$  The standard deviation of the parameter  $p$  in year  $t$

$n_p$  Number of samples used to calculate the mean and standard deviation of parameter  $p$

Assuming that values of the parameter are normally distributed about the mean, the minimum and maximum values for the parameters are given by.

$$\begin{aligned} P_{\min} &= \bar{X}_p - 1.96 * SE_p \\ P_{\max} &= \bar{X}_p + 1.96 * SE_p \end{aligned} \quad 10$$

Where

$P_{\min}$  The minimum value of the parameter at the 95% confidence interval

$P_{\max}$  The maximum value of the parameter at the 95% confidence interval

$SE_p$  Standard error in the mean of parameter,  $p$  in year  $t$

1.96 The value of the cumulative normal distribution at 95% confidence interval

### Step 2: Calculate the project removals due to changes in soil organic carbon with the minimum and maximum values of the input parameters

The project removals due to changes in soil organic carbon using the minimum and maximum values of the parameters is given by

$$\begin{aligned} PRS_{\min,t} &= Model(P_{\min}, Temperature_{\max}, Precipitation_{\max}, ClayContent_{\min}) \\ PRS_{\max,t} &= Model(P_{\max}, Temperature_{\min}, Precipitation_{\min}, ClayContent_{\max}) \end{aligned} \quad 11$$

Where

$PRS_{\min,t}$  The minimum value of project removals due to changes in soil organic carbon at the 95% confidence interval

$PRS_{\max,t}$  The maximum value of project removals due to changes in soil organic carbon at the 95% confidence interval

### Step 3: Calculate the uncertainty in the model output

The uncertainty in the output model is given by:

$$UNC_t = \frac{|PRS_{\max,t} - PRS_{\min,t}|}{2 * PRS_t} \quad 12$$

### Step 4: Adjust the estimate of soil sequestration based on the uncertainty in the model output

If the uncertainty of soil models is less than or equal to 15% of the mean value then the project proponents may use the estimated value without any deduction for conservativeness or increase in sampling.

If the uncertainty of soil models is greater than 15% but less than or equal to 50% of the mean value, then the project proponents may use the estimated value subject to a deduction calculated as

$$PRS_{Deduction,t} = PRS_t * (UNC_t - 15\%) \quad 13$$

And the following term will be used in equation 7 in place of  $PRS_t$

$$PRS_{Adj,t} = PRS_t - PRS_{Deduction,t} \quad 14$$

Where

$PRS_t$  Estimate of project removals due to changes in soil organic carbon in year t, t CO<sub>2</sub>e.

$PRS_{Unc}$  Estimate of uncertainty in the mean of changes in soil organic carbon in year t, t CO<sub>2</sub>e.

$PRS_{Deduction,t}$  A calculated deduction to the estimate of the change in soil organic removals year t, t CO<sub>2</sub>e.

$PRS_{Adj,t}$  An adjusted estimate of project removals due to changes in soil organic carbon in year t, t CO<sub>2</sub>e.

In this way, when the uncertainty is 15% or less than 15% there is no deduction and when the uncertainty is between 15 and 30% a deduction as calculated in Step 4 above will apply.

If the uncertainty of soil models is greater than 30% of the mean value then the project proponents should increase the sample size of the input parameters until the soil model uncertainty is better than ± 30%.

#### IV.2.9 Other information

Every five years the means of parameters will be tested for significant difference using t-tests. If the are significantly different then the soil model shall be updated based on the new data and relevant data such as studies conducted in the region. It is not incumbent that the project proponents shall undertake such studies as part of the project activity but shall make use of data generated elsewhere as part of ongoing research/other efforts in the region for updating the model. Such data can be used to refine the model over time and decrease uncertainty.

## Section V: Lists of variables, acronyms and references

### V.1 Variables used in equations

#### Equation 1

$BSN_t$	baseline synthetic nitrogen fertilizer use in year t, kg
$BSN_{t=0}$	baseline synthetic nitrogen fertilizer use at the start of the project, kg
$BA_{C,t=0}$	Baseline areas in cropland at the start of the project, ha
$BA_{C,t}$	Baseline areas in cropland in year t, ha
$a$	a constant in the relation of national fertilizer use as a function of fertilizer price, kg/ha
$b$	a constant in the relation of national fertilizer use as a function of fertilizer price, kg/ha/USD
$PF_t$	the price of inorganic fertilizer in year t, USD/kg
$PF_{t=0}$	the price of inorganic fertilizer at the start of the project, USD/kg

#### Equation 2

$BS_{equil,t}$	Baseline SOC in equilibrium year t, tC
$BA_{C,m_C,t}$	Baseline areas in cropland with management practice, $m_C$ , year t, ha
$SOC_{C,m_C}$	Soil organic carbon density at equilibrium for cropland with management practice, $m_C$ , tC/ha
$m_C$	An index for cropland management types, unit less
$BA_{G,m_G,t}$	Baseline areas in grassland with management practice, $m_G$ , year t, ha
$SOC_{G,m_G}$	Soil organic carbon density at equilibrium for grassland with management practice, $m_G$ , tC/ha
$m_G$	An index for grassland management types, unit less

#### Equation 3

$BRS_t$	Baseline removals due to changes in soil organic carbon in year t, t CO <sub>2</sub> e.
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#### Equation 4

$BE_t$	Baseline emissions in year t, t CO <sub>2</sub> e
$BEF_t$	Baseline emissions due to nitrogen fertilizer use in year t, t CO <sub>2</sub> e.
$BEN_t$	Baseline emissions due to the use of N-fixing species in year t, t CO <sub>2</sub> e.
$BEBB_t$	Baseline emissions due to biomass burning in year t, t CO <sub>2</sub> e.
$BRWP_t$	Baseline removals due to changes in woody perennials in year t, t CO <sub>2</sub> e.

### Equation 5

$PS_{equil,t}$	Project SOC in equilibrium year $t$ , tC
$PA_{C,m_C,t}$	Project areas in cropland with management practice, $m_C$ , year $t$ , ha
$SOC_{C,m_C,t}$	Soil organic carbon density at equilibrium for cropland with management practice, $m_C$ , at year $t$ , tC/ha
$m_C$	An index for cropland management types, unit less
$PA_{G,m_G,t}$	Project areas in grassland with management practice, $m_G$ , year $t$ , ha
$SOC_{G,m_G,t}$	Soil organic carbon density at equilibrium for grassland with management practice, $m_G$ , at year $t$ , tC/ha
$m_G$	An index for grassland management types, unit less

### Equation 6

$PS_t$	Project estimate of the project SOC in year $t$ , tC
$PS_{equil,t}$	Project estimate of the project SOC in equilibrium year $t$ , tC
$D$	The transition period required for SOC to be at equilibrium after a change in land use or management practice, year
$\Delta t$	Time increment = 1 year

### Equation 7

$PRS_t$	Estimate of project removals due to changes in soil organic carbon in year $t$ , t CO <sub>2</sub> e.
$PS_t$	Estimate of the project SOC in year $t$ , tC

### Equation 8

$PE_t$	Estimate of actual net GHG emissions and removals by sinks in year $t$ , t CO <sub>2</sub> e
$PEF_t$	Estimate of project emissions due to nitrogen fertilizer use in year $t$ , t CO <sub>2</sub> e.
$PEN_t$	Estimate of project emissions due to the use of n-fixing species in year $t$ , t CO <sub>2</sub> e.
$PEBB_t$	Estimate of project emissions due to biomass burning in year $t$ , t CO <sub>2</sub> e.
$PRWP_t$	Estimate of project due to changes in biomass of woody perennials in year $t$ , t CO <sub>2</sub> e.
$PRS_t$	Estimate of project removals due to changes in soil organic carbon in year $t$ , t CO <sub>2</sub> e.

### Equation 9

$\Delta R_t$	Estimate of net anthropogenic GHG emissions and removals in year $t$ , t CO <sub>2</sub> e
$PE_t$	Estimate of actual net GHG emissions and removals in year $t$ , t CO <sub>2</sub> e
$BE_t$	Baseline emissions and removals in year $t$ , t CO <sub>2</sub> e
$LNRB_t$	The leakage from a switch TO non-renewable biomass use

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## **V.2 Acronyms**

A/R	Afforestation / reforestation
CDM	Clean Development Mechanism
ABMS	Activity Baseline and Monitoring Survey
SALM	sustainable agricultural land management
SOC	soil organic carbon

## Section VI: Tools

### VI.1 Estimation of direct nitrous oxide emission from n-fixing species and crop residues

This tool can be used for both ex ante and ex post estimation of the nitrous oxide emissions from the use of nitrogen fixing species and crop residues within the boundary of a CDM project activity. For ex post estimation purposes, activity data (quantities of crop residues) are monitored or estimated.

It is important to note that for the project emissions, it is only the new area under n-fixing crop that is input to the formulae.

As PPs may use various n-fixing species, it is important to identify and record the species type and estimate the amount of inputs from each species. The direct nitrous oxide emissions from the use of nitrogen-fixing species and crop residues can be estimated using equations as follows:

$$N_2O_{direct-N,t} = F_{CR,t} \cdot EF_1 \cdot MW_{N_2O} \cdot GWP_{N_2O} \cdot 10^{-3} \quad 15$$

$$F_{CR,t} = \sum_{i=1}^I Crop_{i,t} \cdot (Area_{i,t} - Area_{burnt_{i,t}} \cdot C_f) \cdot Frac_{Renew} \cdot [R_{AG,i,t} \cdot N_{AG,i,t} \cdot (1 - Frac_{Removed}) + R_{BG,i,t} \cdot N_{BG,i,t}] \quad 16$$

Where:

$N_2O_{direct-N,t}$	Direct N <sub>2</sub> O emission as a result of nitrogen application within the project boundary, t-CO <sub>2</sub> -e in year t
$F_{CR,t}$	Amount of N in crop residues (above and below ground), including N-fixing crops returned to soils annually, kg N yr <sup>-1</sup> in year t
$EF_1$	Emission Factor for emissions from N inputs, tonne-N <sub>2</sub> O-N (tonne-N input) <sup>-1</sup> As noted in IPCC 2006 Guidelines (table 11.1), the default emission factor ( $EF_1$ ) is 1% of applied N, and this value should be used when country-specific factors are unavailable. Project participants may use emission factors from the peer reviewed scientific literature that are specific for the project area.
$MW_{N_2O}$	Ratio of molecular weights of N <sub>2</sub> O and N (44/28), tonne-N <sub>2</sub> O (t-N) <sup>-1</sup>
$GWP_{N_2O}$	Global Warming Potential for N <sub>2</sub> O, kg-CO <sub>2</sub> -e (kg-N <sub>2</sub> O) <sup>-1</sup> (IPCC default = 310, valid for the first commitment period).
$Crop_{i,t}$	Harvested annual dry matter yield for crop i in year t, kg d.m. ha <sup>-1</sup> For n-fixing trees use the above ground biomass.
$Area_{i,t}$	total annual area harvested of n-fixing crop i or trees i in year t, ha yr <sup>-1</sup>
$Area_{burnt_{i,t}}$	annual area of n-fixing crop i or trees burnt in year t, ha yr <sup>-1</sup>
$C_f$	combustion factor (dimensionless) (see 2006 IPCC Guidelines, Table 2.6)
$Frac_{Renew}$	fraction of total area under crop that is renewed annually. For countries where pastures are renewed on average every X years, $Frac_{Renew} = 1/X$ . For annual crops $Frac_{Renew} = 1$ . For n-fixing trees assume that they shed their leaves every year are similar to annual crops

$R_{AG,i,t}$	<p>ratio of above-ground residues dry matter (<math>AG_{DM,i,t}</math>) to harvested yield for crop i in year t (<math>Crop_{i,t}</math>), kg d.m. (kg d.m.)<sup>-1</sup> (see 2006 IPCC Guidelines, Table 11.2)</p> <p>For n-fixing trees use the ratio of leaf biomass to above ground biomass. For deciduous trees 0.02 is a reasonable value</p>
$N_{AG,i,t}$	<p>N content of above-ground residues for crop i, kg N (kg d.m.)<sup>-1</sup> (see 2006 IPCC Guidelines, Table 11.2)</p> <p>For n-fixing trees assume 0.027 (default value for n-fixing forages) This value should be used when country-specific factors are unavailable.</p>
$Frac_{Removed}$	<p>fraction of above-ground residues of crop i removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)<sup>-1</sup>. Survey of experts in country is required to obtain data.</p> <p>If data for <math>Frac_{Removed}</math> are not available, assume no removal.</p>
$R_{BG,i,t}$	<p>Ratio of below-ground residues to harvested yield for crop i, kg d.m. (kg d.m.)<sup>-1</sup>. (see 2006 IPCC Guidelines, Table 11.2)</p> <p>For n-fixing trees assume 0.01 (assumes that fine roots are 7% of total root biomass, that total root biomass is 25% of above ground biomass and there is a 50% fine root turnover). This value should be used when country-specific factors are unavailable.</p>
$N_{BG,i,t}$	<p>N content of below-ground residues for crop i, kg N (kg d.m.)<sup>-1</sup>. (see 2006 IPCC Guidelines, Table 11.2)</p> <p>For n-fixing trees assume 0.022 (default value for n-fixing forages) This value should be used when country-specific factors are unavailable.</p>

## VI.2 Estimation of non-CO<sub>2</sub> emissions from the burning of crop residues

The CO<sub>2</sub> emissions from the burning of crop residues and grasslands are not included in the methodology as per IPCC convention. The non-CO<sub>2</sub> emissions burning this biomass,  $EBB_t$  are calculated using the following equations:

$$EBB_t = \left[ MB_{C,t} \cdot C_F \cdot (2.7 \cdot GWP_{CH_4} + 0.07 \cdot GWP_{N_2O}) + MB_{G,t} \cdot C_F \cdot (2.3 \cdot GWP_{CH_4} + 0.21 \cdot GWP_{N_2O}) \right] \cdot 10^{-3} \quad 17$$

Where

$EBB_t$  Emissions due to biomass burning in year t, t CO<sub>2</sub>e

$MB_{C,t}$  Mass of crop residues burnt in year t, tonnes

2.7, 0.07 Emissions factors for the burning of cropland, g CH<sub>4</sub> / kg and g N<sub>2</sub>O / kg, respectively  
From Table 2.5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories

$MB_{G,t}$  Mass of grasslands residues burnt in year t, tonnes

2.3, 0.21 Emissions factors for the burning of grassland, g CH<sub>4</sub> / kg and g N<sub>2</sub>O / kg, respectively  
From Table 2.5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories

$GWP_{CH_4}$  Global warming potential of CH<sub>4</sub> (IPCC default: 310 for the first commitment period of the Kyoto Protocol); t CO<sub>2</sub>e / t CH<sub>4</sub>

$C_F$  Combustion factors that depend on vegetation type (see Table 4), unit less

**Table 4: Combustion factor values for fires in a range of vegetation types**

Vegetation type	Subcategory	Mean Value
Savanna Grasslands/ Pastures (early dry season burns)	Tropical/sub-tropical grassland	0.74
	Grassland	-
<b>All savanna grasslands (early dry season burns)</b>		<b>0.74</b>
Savanna Grasslands/ Pastures (mid/late dry season burns)*	Tropical/sub-tropical grassland	0.92
	Tropical pasture~	0.35
	Savanna	0.86
<b>All savanna grasslands (mid/late dry season burns)</b>		<b>0.77</b>
Other vegetation types	Peatland	0.50
	Tropical Wetlands	0.70
Agricultural residues (Post harvest field burning)	Wheat residues	0.90
	Maize residues	0.80
	Rice residues	0.80
	Sugarcane	0.80

From Table 2.6, 2006 IPCC Guidelines for National Greenhouse Gas Inventories

## Section VII: References

- <sup>1</sup> IPCC. 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>
- <sup>2</sup> EB 41, Annex 15 <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-13-v1.pdf>
- <sup>3</sup> EB 33, Annex 14 <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-05-v1.pdf>
- <sup>4</sup> <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v1.pdf>
- <sup>5</sup> <http://cdm.unfccc.int/methodologies/SSCmethodologies/SSCAR/approved.html>
- <sup>6</sup> [http://cdm.unfccc.int/EB/033/eb33\\_repan16.pdf](http://cdm.unfccc.int/EB/033/eb33_repan16.pdf)
- <sup>7</sup> EB 44, Annex 16. [http://cdm.unfccc.int/EB/044/eb44\\_repan16.pdf](http://cdm.unfccc.int/EB/044/eb44_repan16.pdf)
- <sup>8</sup> EB 35, annex 19.  
[http://cdm.unfccc.int/methodologies/ARmethodologies/Tools/EB35\\_repan19\\_Combined\\_AR\\_Tool\\_ver01.pdf](http://cdm.unfccc.int/methodologies/ARmethodologies/Tools/EB35_repan19_Combined_AR_Tool_ver01.pdf)
- <sup>9</sup> <http://www.rothamsted.bbsrc.ac.uk/aen/carbon/rothc.htm>
- <sup>10</sup> <http://www.rothamsted.bbsrc.ac.uk/aen/carbon/rothc.htm>
- <sup>11</sup> [http://cdm.unfccc.int/UserManagement/FileStorage/CDM\\_AMSP4VBBO5G54RXDE9KQ6FJWMGHZLHFA5](http://cdm.unfccc.int/UserManagement/FileStorage/CDM_AMSP4VBBO5G54RXDE9KQ6FJWMGHZLHFA5)
- <sup>12</sup> [http://cdm.unfccc.int/EB/050/eb50\\_repan30.pdf](http://cdm.unfccc.int/EB/050/eb50_repan30.pdf)
- <sup>13</sup> Harmonized World Soil Database. 2009. <http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html>
- <sup>14</sup> [http://cdm.unfccc.int/EB/050/eb50\\_repan30.pdf](http://cdm.unfccc.int/EB/050/eb50_repan30.pdf)