Voluntary Carbon Standard

Proposed Methodology

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

I.1 Methodology title and history of submission

Title:	Adoption of sustainable agricultural land management (SALM) by landholders and farmers.
Version:	1
Date submitted:	23 September, 2009
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.

I.2 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

Agricultural practices can change very slowly with time as landowners learn new techniques and pass the information to neighbours. For this reason, the existing agricultural practices are likely to continue during the lifetime of the project.

I.3 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) There is constant or increasing agricultural pressure on lands in absence of the project;
c) There is constant or decreasing use of agricultural inputs such as fertilizers in absence of the project;
d) Forest land in the area is constant or decreasing over time;

e) Existing woody perennials are not removed during the first two years of project implementation.

f) There is no significant increase in greenhouse gas emissions as a result of an increase in the number of livestock;

g) Agricultural residuals from outside the project boundary may only be used as part of the project within the project boundary if they would have been burnt in absence of the project;
h) There is no significant displacement of manure from outside the project boundary to within the project boundary;

i) There is no significant increase in the use of fossil fuels for agricultural management (i.e., use of farm machinery to cultivate, fertilize, harvest)

j) 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.

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.

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 assume that the soil organic carbon would remain constant or decrease with time in absence of the project.

Applicability condition (e) ensures that there are no emissions as a result of the loss of biomass during the adoption of an SALM activity.

Applicability conditions (f) and (g) mean 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 if this biomass would not be burnt in absence of the project then. This is a potential source of leakage. Applicability condition (h) 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 conditions (i) 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 (j) 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 (k). Leakage from the potential increase in the use of non-renewable biomass will be included in the ex-post calculations.

I.4 Selected carbon pools and emission sources

Table 1: Selected carbon pools

Carbon pools	Selected (answer with Yes or No)	Explanation / justification
Above ground	Yes	A carbon pool covered by SALM practices. This methodology covers both tree and non-tree biomass.
Below ground	Yes	Below-ground biomass stock is expected to increase due to the implementation of the SALM activities.
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.

Table 2: Emissions sources included in or excluded from the project boundary

Sources	Gas	Included/ excluded	Explanation / justification
Use of fertilizers	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Included	Main gas for this source.
Use of N-fixing species	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Included	Main gas for this source.
Burning of biomass	CO_2	Excluded	However, carbon stock decreases due to burning are accounted as a carbon stock change
	CH_4	Included	Non-CO_2 emissions from the burning of biomass
	N_2O	Included	Non-CO_2 emissions from the burning of biomass

I.5 Summary description of major baseline and project methodological steps

I.5.1 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.5.2 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.5.3 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.

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[*] 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*"[1]

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*"[2] 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_t, are calculated using the A/R Working Group Tool "*Estimation of direct nitrous oxide emission from nitrogen fertilization (version 01)*"[3].

The baseline synthetic nitrogen fertilizer use is assumed to be proportional to the amount of area under cropland and is corrected for changes in the price of fertilizer based on national statistics. The future use is estimated as:

[*] Control is defined by ownership, leasing of rights for agricultural use, or undisputed traditional right to use for agriculture.

$$BSN_t = BSN_{t=0} \bullet \frac{BA_{C,t}}{BA_{C,t=0}} \bullet \frac{(a + b \bullet PF_t)}{(a + b \bullet PF_{t=0})} \qquad 1$$

Where

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

The constants, a and b, are estimated by performing a linear regression of the national fertilizer use to price of fertilizer.

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.

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 calculated using the tool "*Estimation of direct nitrous oxide emission from n-fixing species and crop residues"* (page 25)

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 27).

II.4.4 Baseline removals from existing woody perennials

The baseline removals from woody perennials, $BRWP_t$, are calculated using the 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*"[4]

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[5] or the CENTURY soil organic matter model[6]) estimate the soil organic carbon (SOC) density 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 proponents may, but are not required, to use a system similar to IPCC Tier 2 Soil methodology for but using locally derived parameters. This may reduce the number of models required to estimate all identified management practices. See the appendix for a detailed formulation of this technique.

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

$$BS_{equil,t} = \sum_{m_C} BA_{C,m_C,t} \bullet SOC_{C,m_C} + \sum_{m_G} BA_{G,m_G,t} \bullet SOC_{G,m_G} \qquad 2$$

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 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

$$BRS_t = 0 \qquad 3$$

Where

BRS_t	Baseline removals due to changes in soil organic carbon in year t, t CO_2e.

II.4.7 Total baseline emissions and removals

The total baseline emissions and removals are given by:

$$BE_t = BEF_t + BEN_t + BEBB_t - BRWP_t \qquad 4$$

Where

BE_t	Baseline emissions in year t, t CO_2e
BEF_t	Baseline emissions due to nitrogen fertilizer use in year t, t CO_2e.
BEN_t	Baseline emissions due to the use of N-fixing species in year t, t CO_2e.
$BEBB_t$	Baseline emissions due to biomass burning in year t, t CO_2e.
$BRWP_t$	Baseline removals due to changes in woody perennials in year t, t CO_2e.

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 A/R Working Group Tool "*Estimation of direct nitrous oxide emission from nitrogen fertilization (version 01)*"[7].

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

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 25)

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 27).

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-AMS0001[8]

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

Undertake a Farmer Self Assessment (FSA) to identify the dominant agricultural management practices for croplands and grasslands. The FSA should estimate or record details of each management practice. For example;

1. its area;
2. the average annual biomass production;
3. the average biomass left 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 cluster analysis or any other means, classify the management practices into groups that are similar. This step is equivalent to stratification in an afforestation / reforestation project. This reduces the number of strata or SOC models required.

Using an analytic model that has been accepted in scientific publications (for example: RothC soil organic carbon model[9] or the CENTURY soil organic matter model[10]) estimate the soil organic carbon (SOC) density at equilibrium in each of the identified management practices in each of the land use categories (cropland and grassland).

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 proponents may, but are not required, to use a system similar to IPCC Tier 2 Soil methodology for but using locally derived parameters. This may reduce the number of models required to estimate all identified management practices. See the appendix for a detailed formulation of this technique.

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

$$PS_{equil,t} = \sum_{m_C} PA_{C,m_C,t} \bullet SOC_{C,m_C,t} + \sum_{m_G} PA_{G,m_G,t} \bullet SOC_{G,m_G,t} \qquad 5$$

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 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

III.1.6 Project estimate of soil organic carbon with transitions

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

$$PS_t = \frac{1}{D} \sum_{t-D+1}^{t} PS_{equil,t} \bullet \Delta t \qquad 6$$

Where

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
Δt	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 the modelling exercise. The IPCC Tier 2 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:

$$PRS_t = (PS_t - PS_{t-1}) \bullet \frac{44}{12} \quad 7$$

Where

PRS_t Estimate of project removals due to changes in soil organic carbon in year t, t CO_2e.

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:

$$PE_t = PEF_t + PEN_t + PEBB_t - PRWP_t - PRS_t \quad 8$$

Where

PE_t Estimate of actual net GHG emissions and removals by sinks in year t, t CO_2e

PEF_t Estimate of project emissions due to nitrogen fertilizer use in year t, t CO_2e.

PEN_t Estimate of project emissions due to the use of n-fixing species in year t, t CO_2e.

$PEBB_t$ Estimate of project emissions due to biomass burning in year t, t CO_2e.

$PRWP_t$ Estimate of project due to changes in biomass of woody perennials in year t, t CO_2e.

PRS_t Estimate of project removals due to changes in soil organic carbon in year t, t CO_2e.

III.2 Estimation of leakage

There are five potential sources of leakage:

a) Displacement of biomass from outside to inside the project boundary causing the depletion of soil organic carbon outside the project boundary;
b) 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;
c) 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;
d) 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;
e) 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* [11].

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 from 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_2	Excluded	Applicability condition
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable
Increase fertilizer use	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Applicability condition
Increase fossil fuel for cooking	CO_2	Excluded	Applicability condition
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable
Increase non-renewable biomass for cooking	CO_2	Included	Managed
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable
Combustion of fossil fuels by vehicles	CO_2	Excluded	Market leakage
	CH_4	Excluded	Not applicable
	N_2O	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:

$$\Delta R_t = BE_t - PE_t - LNRB_t \quad 9$$

Where

ΔR_t Estimate of net anthropogenic GHG emissions and removals in year t, t CO_2e

PE_t Estimate of actual net GHG emissions and removals in year t, t CO_2e

BE_t Baseline emissions and removals in year t, t CO_2e

$LNRB_t$ 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

At the start of the project, undertake a Farmer Self Assessment (FSA) to identify the dominant agricultural management practices for croplands and grasslands. The FSA should estimate or record details of each management practice. For example;

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).

Using cluster analysis or any other means, classify the management practices into groups that are similar. This step is equivalent to stratification in an afforestation / reforestation project. This reduces the number of strata or SOC models required.

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	FSA
II.4.1	$BA_{C,t=0}$	ha	Areas in cropland	Project start	FSA
II.4.1	$BA_{G,t=0}$	ha	Areas in grassland	Project start	FSA
II.4.1	a	kg/ha	a constant in the relation of national fertilizer use as a function of fertilizer price	Project start	Calculated
II.4.1	b	kg/ha/ USD	a constant in the relation of national fertilizer use as a function of fertilizer price	Project start	Calculated
II.4.1	$PF_{t=0}$	USD/ kg	the price of inorganic fertilizer	Project start	National or regional studies
II.4.1	PF_t	USD/ kg	the price of inorganic fertilizer	Annually	National or regional studies
II.4.2	$Crop_{i,t=0}$	kg d.m./ha	Harvested annual dry matter yield for crop *i*	Project start	FSA
II.4.2	$Area_{i,t=0}$	ha	total annual area harvested of crop *i* or n-fixing trees *i*	Project start	FSA

II.4.2	$Areaburnt_{i,t=0}$	ha	annual area of crop *i* or n-fixing trees *i* burnt	Project start	FSA
II.4.3	$MB_{C,t=0}$	t d.m.	Mass of crop residues burnt	Project start	FSA
II.4.3	$MB_{G,t=0}$	t d.m.	Mass of grasslands residues burnt	Project start	FSA
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 *"Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity"(Version 01)*[12] 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	FSA
II.4.5	$SOC_{C,m_C,t=0}$	tC/ha	Soil organic carbon density 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	FSA
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	FSA
II.4.5	$BM_{C,m_C,t=0}$	t/ha/month	Baseline manure input in cropland per month with management practice, m_C	Project start	FSA
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	FSA
II.4.5	$BA_{G,m_G,t=0}$	ha	Baseline areas in grassland with management practice, m_G,	Project start	FSA
II.4.5	$SOC_{G,m_G,t=0}$	tC/ha	Soil organic carbon density at equilibrium for grassland with management practice, m_G	Project start	Modelled
II.4.5	$BP_{G,m_G,t=0}$	t/ha/month	Baseline production in grassland per month with management practice, m_G	Project start	FSA
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	FSA

II.4.5	$BM_{G,m_G,t=0}$	t/ha/month	Baseline manure input in grassland per month with management practice, m_G	Project start	FSA
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	FSA
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/day	Average evapotranspiration per month	Project start	National, regional studies or calculated from solar radiation

IV.2 Ex-ante net anthropogenic GHG emissions and removals

IV.2.1 Sampling design

At the start of the project, estimate the changes to the parameters listed in section IV.1.2 as a result of the project. This includes for example changes in;

1. area;
2. the annual biomass production;
3. the annual biomass residuals returned to 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 amount of woody perennials (trees and bushes).

Re-classify the management practices into groups that are similar may be required. This step is equivalent to stratification in an afforestation / reforestation project. This reduces the number of strata or SOC models required.

IV.2.2 Data to be collected and archived for project GHG emissions and removals

Record all assumptions and sources of assumptions

IV.2.3 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, and/or the introduction of wood stoves with improved efficiency, the ex-ante estimate of leakage is zero.

IV.3 Ex-post net anthropogenic GHG emissions and removals

IV.3.1 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.3.2 Sampling design

On the assumption that agricultural practices will change slowly with time, the proponents should undertake a Farmer Self Assessment (FSA) on a regular basis (every five years) to identify the actual agricultural management practices adopted on croplands and grasslands. The FSA should estimate or record details of each management practice. For example;

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;

Using cluster analysis or any other means, classify the management practices into groups that are similar. This step is equivalent to stratification in an afforestation / reforestation project. This reduces the number of strata or SOC models required.

IV.3.3 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/year	Synthetic fertilizer use per year	Annually	FSA
III.1.1	$PA_{C,t}$	ha/year	Areas in cropland	Annually	FSA
III.1.1	$PA_{G,t}$	ha/year	Areas in grassland	Annually	FSA
III.1.1	PF_t	USD/kg	the price of inorganic fertilizer	Annually	National or regional studies
III.1.2	$Crop_{i,t}$	kg d.m./h	Harvested annual dry matter yield for crop *i*	Annually	FSA

		a			
III.1.2	$Area_{i,t}$	Ha/year	total annual area harvested of crop *i* or n-fixing trees *i*	Annually	FSA
III.1.2	$Areaburnt_{i,t}$	Ha/year	annual area of crop *i* or n-fixing trees *i* burnt	Annually	FSA
III.1.3	$MB_{C,t}$	t d.m./year	Mass of crop residues burnt	Annually	FSA
III.1.3	$MB_{G,t}$	t d.m./year	Mass of grasslands residues burnt	Annually	FSA
III.1.3	C_F	unitless	Combustion factors that depend on vegetation type	Project start	National or regional studies
III.1.4	See *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[13] 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	FSA
III.1.5	$SOC_{C,m_C,t}$	tC/ha	Soil organic carbon density 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	FSA
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	FSA
III.1.5	$PM_{C,m_C,t}$	t/ha/month	Project manure input in cropland per month with management practice, m_C	Annually	FSA
III.1.5	$PCC_{C,m_C,t}$		Project cover crop flag per month in cropland per month with management practice, m_C	Annually	FSA
III.1.5	$PA_{G,m_G,t}$	ha	Project areas in grassland with management practice, m_G	Annually	FSA
III.1.5	$SOC_{G,m_G,t}$	tC/ha	Soil organic carbon density at equilibrium for grassland with management practice, m_G	Every five years	Modelled
III.1.5	$PP_{G,m_G,t}$	t/ha/month	Project production in grassland per month with management practice, m_G	Annually	FSA

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	FSA
III.1.5	$PM_{G,m_G,t}$	t/ha/m onth	Project manure input in grassland per month with management practice, m_G	Annually	FSA
III.1.5	$PCC_{G,m_G,t}$		Project cover crop flag per month in grassland per month with management practice, m_G	Annually	FSA
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/d ay	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.3.4 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	ΔNRB_t	kg/yea r	The amount of biomass used for heating and cooking that is diverted to the agricultural system.	Annually	FSA
III.2	$f_{NRB,t} = 1$		Fraction of biomass that comes from non-renewable sources	Start of the project	
III.2	$NCV_{biomass}$	TJ/ton ne	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_2/TJ	Emission factor for the projected fossil fuel consumption	Every five years	IPCC defaults, National or regional studies

IV.3.5 Conservative approach and uncertainties

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) There is constant or increasing agricultural pressure on lands in absence of the project;
c) There is constant or decreasing use of agricultural inputs such as fertilizers in absence of the project; and
d) Forest land 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.3.6 Other information

No other information

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_2e.

Equation 4

BE_t	Baseline emissions in year t, t CO_2e
BEF_t	Baseline emissions due to nitrogen fertilizer use in year t, t CO_2e.
BEN_t	Baseline emissions due to the use of N-fixing species in year t, t CO_2e.
$BEBB_t$	Baseline emissions due to biomass burning in year t, t CO_2e.
$BRWP_t$	Baseline removals due to changes in woody perennials in year t, t CO_2e.

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
Δt	Time increment = 1 year

Equation 7

PRS_t	Estimate of project removals due to changes in soil organic carbon in year t, t CO_2e.
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_2e
PEF_t	Estimate of project emissions due to nitrogen fertilizer use in year t, t CO_2e.
PEN_t	Estimate of project emissions due to the use of n-fixing species in year t, t CO_2e.
$PEBB_t$	Estimate of project emissions due to biomass burning in year t, t CO_2e.
$PRWP_t$	Estimate of project due to changes in biomass of woody perennials in year t, t CO_2e.
PRS_t	Estimate of project removals due to changes in soil organic carbon in year t, t CO_2e.

Equation 9

ΔR_t	Estimate of net anthropogenic GHG emissions and removals in year t, t CO_2e
PE_t	Estimate of actual net GHG emissions and removals in year t, t CO_2e
BE_t	Baseline emissions and removals in year t, t CO_2e
$LNRB_t$	The leakage from a switch TO non-renewable biomass use

V.2 Acronyms

A/R	Afforestation / reforestation
CDM	Clean Development Mechanism
FSA	Farmer Self Assessment
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. 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:

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

$$F_{CR,t} = \sum_{i=1}^{I} Crop_{i,t} \cdot \left(Area_{i,t} - Areaburnt_{i,t} \cdot C_f\right) \cdot Frac_{Renew} \cdot \left[R_{AG,i,t} \cdot N_{AG,i,t} \cdot \left(1 - Frac_{Removed}\right) + R_{BG,i,t} \cdot N_{BG,i,t}\right] \quad (11)$$

Where:

$N_2O_{direct-N,t}$	Direct N_2O emission as a result of nitrogen application within the project boundary, t-CO_2-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^{-1} in year t
EF_1	Emission Factor for emissions from N inputs, tonne-N_2O-N (tonne-N input)$^{-1}$ 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_2O and N (44/28), tonne-N_2O (t-N)$^{-1}$
GWP_{N2O}	Global Warming Potential for N_2O, kg-CO_2-e (kg-N_2O)$^{-1}$ (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^{-1} For n-fixing trees use the above ground biomass.
$Area_{i,t}$	total annual area harvested of crop i or n-fixing trees i in year t, ha yr^{-1}
$Areaburnt_{i,t}$	annual area of crop i or n-fixing trees burnt in year t, ha yr^{-1}
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
$R_{AG,i,t}$	ratio of above-ground residues dry matter ($AG_{DM,i,t}$) to harvested yield for crop i in year t ($Crop_{i,t}$), kg d.m. (kg d.m.)$^{-1}$ (see *2006 IPCC Guidelines*, Table 11.2)

	For n-fixing trees use the ratio of leaf biomass to above ground biomass. For deciduous trees 0.02 is a reasonable value
$N_{AG,i,t}$	N content of above-ground residues for crop i, kg N (kg d.m.) $^{-1}$ (see *2006 IPCC Guidelines*, Table 11.2) For n-fixing trees assume 0.027 (default value for n-fixing forages) This value should be used when country-specific factors are unavailable.
$Frac_{Removed}$	fraction of above-ground residues of crop i removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$. Survey of experts in country is required to obtain data. If data for FracRemove are not available, assume no removal.
$R_{BG,i,t}$	Ratio of below-ground residues to harvested yield for crop i, kg d.m. (kg d.m.)$^{-1}$. (see *2006 IPCC Guidelines*, Table 11.2) 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.
$N_{BG,i,t}$	N content of below-ground residues for crop i, kg N (kg d.m.)$^{-1}$. (see *2006 IPCC Guidelines*, Table 11.2) For n-fixing trees assume 0.022 (default value for n-fixing forages) This value should be used when country-specific factors are unavailable.

VI.2 Estimation of non-CO_2 emissions from the burning of crop residues

The CO_2 emissions from the burning of crop residues, and grasslands are not included in the methodology as per IPCC convention. The non-CO_2 emissions burning this biomass, EBB_t are calculated using the following equations:

$$EBB_t = \begin{bmatrix} MB_{C,t} \bullet C_F \bullet \left(2.7 \bullet GWP_{CH4} + 0.07 \bullet GWP_{N2O}\right) \\ + MB_{G,t} \bullet C_F \bullet \left(2.3 \bullet GWP_{CH4} + 0.21 \bullet GWP_{N2O}\right) \end{bmatrix} \bullet 10^{-3} \qquad 12$$

Where

EBB_t	Emissions due to biomass burning in year t, t CO_2e
$MB_{C,t}$	Mass of crop residues burnt in year t, tonnes
2.7, 0.07	Emissions factors for the burning of cropland, g CH_4 / kg and g N_2O / 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_4 / kg and g N_2O / kg, respectively From Table 2.5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories
GWP_{CH4}	Global warming potential of CH_4 (IPCC default: 310 for the first commitment period of the Kyoto Protocol); t CO_2e / t $_{CH4}$
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	-
All savanna grasslands (early dry season burns)		**0.74**
Savanna Grasslands/ Pastures (mid/late dry season burns)*	Tropical/sub-tropical grassland	0.92
	Tropical pasture~	0.35
	Savanna	0.86
All savanna grasslands (mid/late dry season burns)		**0.77**
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

[1] EB 44, Annex 16. http://cdm.unfccc.int/EB/044/eb44_repan16.pdf

[2] EB 35, annex 19. http://cdm.unfccc.int/methodologies/ARmethodologies/Tools/EB35_repan19_Combined_AR_Tool_ver01.pdf

[3] http://cdm.unfccc.int/EB/033/eb33_repan16.pdf

[4] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v1.pdf

[5] http://www.rothamsted.bbsrc.ac.uk/aen/carbon/rothc.htm

[6] http://www.nrel.colostate.edu/projects/century5/reference/html/Century/overview.htm

[7] http://cdm.unfccc.int/EB/033/eb33_repan16.pdf

[8] http://cdm.unfccc.int/methodologies/SSCmethodologies/SSCAR/approved.html

[9] http://www.rothamsted.bbsrc.ac.uk/aen/carbon/rothc.htm

[10] http://www.nrel.colostate.edu/projects/century5/reference/html/Century/overview.htm

[11] http://cdm.unfccc.int/UserManagement/FileStorage/CDM_AMSP4VBBO5G54RXDE9KQ6FJWMGHZLHFA5

[12] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v1.pdf

[13] http://cdm.unfccc.int/methodologies/SSCmethodologies/SSCAR/approved.html