VCS | VERIFIED CARBON STANDARD

A Global Benchmark for Carbon

Approved VCS Methodology VM0026

Version 1.1, 24 June 2021

Sectoral Scope 14

Sustainable Grassland Management

Copyright © FAO 2014

Methodology developed by:

Food and Argriculture Organization of the United Nations

Methodology prepared by:

Institute of Environment and Sustainable Development in Agriculture,
Chinese Academy of Agricultural Sciences

UNIQUE forestry and land use

World Agroforestry Center

Northwest Institute of Plateau Biology, Chinese Academy of Sciences

The views expressed in this publication are those of the authors and do not necessarily reflect the views or policies of the Food and Agriculture Organization of the United Nations.

Table of Contents

Acknowledgements 4
1 Sources 5
2 Summary Description of the Methodology 5
3 Definitions 6
3.1 Defined Terms 6
3.2 Acronyms 7
4 Applicability Conditions 7
5 Project boundary 8
6 Baseline Scenario 14
7 Additionality 16
8 Quantification of GHG Emission Reductions and Removals 16
8.1 Baseline Emissions 16
8.2 Project Emissions 25
8.3 Leakage Emissions 42
9 Monitoring 44
9.1 Data and Parameters Available at Validation 44
9.2 Data and Parameters Monitored 63
9.3 Description of the Monitoring Plan 73
10 References 77

ACKNOWLEDGEMENTS

This methodology was developed by the following contributors:

- Yue Li and Hongmin Dong, Institute of Environment and Sustainable Development and Agriculture, Chinese Academy of Agricultural Sciences
- Timm Tennigkeit, UNIQUE forestry and land use
- Andreas Wilkes, China & East Asia Node, World Agroforestry Center
- Shiping Wang, Northwest Institute of Plateau Biology, Chinese Academy of Sciences
- Benjamin Henderson and Pierre Gerber, Animal Production and Health Division, Food and Agriculture Organization of the United Nations
- Leslie Lipper, Agricultural Development Economics Division, Food and Agriculture Organization of the United Nations
- Neil Bird, Joanneum Research

1 SOURCES

The methodology was developed based on the requirements in the following documents :

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- IPCC 2003 Good Practice Guidelines for Land Use, Land Use Change and Forestry
- IPCC 2000 Good Practice Guidance for Uncertainty Management in National Greenhouse Gas Inventories

This methodology uses the latest versions of the follow modules and tools:

- CDM *General Guidelines for Sampling and Surveys for Small-scale CDM Project Activities*
- CDM *Tool for Calculation of the Number of Sample Plots for Measurements within A/R CDM Project Activities*
- CDM *Tool for Estimation of Carbon Stocks and Change in Carbon Stocks of Trees and Shrubs in A/R CDM Project Activities*
- CDM *Tool for Identification of Degraded or Degrading Lands for Consideration in Implementing CDM A/R Project Activities*
- CDM *Tool for Testing Significance of GHG Emissions in A/R CDM Project Activities*
- VCS *AFOLU Non-Permanence Risk Tool*
- VCS methodology module *VMD0033 Estimation of Emissions from Market Leakage*
- VCS methodology module *VMD0040 Leakage from Displacement of Grazing Activity*
- VCS *VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality	Project Method
Crediting Baseline	Project Method

The methodology provides procedures to estimate the GHG emissions reductions and removals from the adoption of sustainable grassland management practices, such as improving the rotation of grazing animals between summer and winter pastures, limiting the timing and number of grazing animals on degraded pastures, and restoration of severely degraded land by replanting with perennial grasses and ensuring appropriate management over the long-term.

The methodology quantifies emissions reductions and removals from increases in soil organic carbon (SOC) stocks and reduction of non-CO_2 GHG emissions. Where biogeochemical models

can be demonstrated to be applicable in the project region, they may be used in estimation of soil carbon pool changes. Where such models are not applicable, the methodology provides guidance for estimation of SOC pool changes using direct measurement methods. The methodology uses a project method to determine additionality and the crediting baseline.

3 DEFINITIONS

In addition to the definitions set out in VCS document Program Definitions, the following definitions and acronyms apply to this methodology:

3.1 Defined Terms

Baseline Period
A historical reference period over which the project's baseline emissions are calculated, which is representative of the most plausible baseline scenario and consists of five consecutive years occurring before the project start date

Baseline Year b
The year for which baseline emissions for a parameter are calculated as an average of emissions over the baseline period or as a result of sample surveys

Dry Matter (dm)
Biomass that has been dried to an oven-dry state, as defined by IPCC[1]

Grassland Parcel

A spatially discrete area of grassland that is owned and/or managed by a household or land user (and is identified by a unique geodetic polygon). Each household may have several parcels of land which may be categorized under the same land use stratum

Grazing Agent
An individual or organization responsible for decision-making regarding grazing management

Grazing Season
The period of time when a plot of grassland is available for grazing due to natural climatic and plant growth conditions and/or spatial and temporal management decisions of the grassland user[2]

Land Use Change
Conversion of land from one land use category to another. In this methodology, land use change is conversion of grassland to cropland, forest or wetland

[1] IPCC, 2003
[2] Grazing plans typically allocate individual plots to be grazed in different seasons, which may be identified differently in different locations (eg, two season systems, three season systems, four season systems) and some grazing plans may identify shorter periods of time when a specific plot is available for grazing.

Land Use Stratum (Stratum)
A distinct sub-type of land use. When land use is not homogeneous but instead consists of several sub-types which are known (or thought) to vary with reference to the indicator of interest (eg, with-project carbon stock change), then each sub-type may be treated separately as a land use stratum

Significance
A term used to determine whether an increase or decrease in carbon pool or GHG source can, or cannot, be deemed de minimis (ie, amounts to less than five percent of the total GHG emission reductions generated by the project)

Sustainable Grassland Management (SGM)
Activities on land that meets the definition for grassland under the VCS rules and that reduce net GHG emissions by increasing carbon stocks and/or reducing non-CO_2 GHG emissions

3.2 Acronyms

AEZ	Agroecological Zone
AFOLU	Agriculture, Forestry and Other Land Use
ALM	Agricultural Land Management
dm	dry matter
SGM	Sustainable Grassland Management
SOC	Soil Organic Carbon
VCS	Verified Carbon Standard

4 APPLICABILITY CONDITIONS

This methodology applies to Agricultural Land Management (ALM) project activities that introduce sustainable grassland management practices such as improving the rotation of grazing animals between grassland areas, limiting the number of grazing animals on degraded grassland, and restoring severely degraded grasslands by replanting with grasses and ensuring appropriate management over the long-term into a grassland landscape.

This methodology is applicable under the following conditions:

- The project area is grassland at the start of the project. The project area is land that is degraded at the start of the project and degradation will continue in the baseline scenario on the basis that degradation drivers or pressures are still present in the baseline scenario. The procedures outlined the latest version of the CDM *Tool for Identification of Degraded or Degrading Lands for Consideration in Implementing CDM A/R Project*

Activities must be used to determine both that the land is degraded at the start of the project and that in the baseline scenario the land will continue to degrade.[3]

- The project area is subject to livestock grazing, burning, and/or nitrogen fertilization in the baseline scenario.
- In the baseline scenario, more than 95 percent of animal dung from grazing animals deposited on grassland is allowed to lie as is, and is not managed, and in the project scenario no more than 5 percent of the animal dung from grazing animals within the project area is managed with alternative manure management systems.
- The project area must not have been cleared of native ecosystems within the 10 year period prior to the project start date.
- The project area is located in a region where precipitation is less than evapotranspiration for most of the year and leaching is unlikely to occur.
- If a biogeochemical model is selected for estimation of change in soil carbon stocks, the following conditions must be met:
    - The model must comply with the requirements for models as set out in the VCS rules.
    - The model must be appropriate for the region within which the project is situated. There must be studies by appropriately qualified experts (eg, scientific journals, university theses, local research studies or work carried out by the project proponent) that demonstrate that the use of the selected biogeochemical model is appropriate for the IPCC climatic regions (see *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, Chapter 3), or the agroecological zone (AEZ) in which the project is situated (see Section 9.3.2).
- Project activities must not include land use change. Note that seeding perennial grasses or legumes on degraded grassland is not considered a land use change activity.
- Project activities must not lead to an increase in the use of fossil fuels and fuel wood from non-renewable sources for cooking and heating.
- Project activities must not occur on wetlands or peatlands.

5 PROJECT BOUNDARY

The geographic project boundary delineates the location of grasslands where the project implements sustainable grassland management. The projectmay be implemented on more than one discrete areas of land. The following must be specified in the project description:

- Each discrete area of land must be identified by a unique geodetic polygon that must be recorded in a KML file.

[3] Such procedures were specified in Section II and III of version 1 of the tool which became inactive 3 Oct 2013

- Aggregation of grassland parcels with multiple landowners is permitted under the methodology, with aggregated areas treated as a single project area.

Table 1 and

Table 2 identify the GHG sources, sinks and reservoirs included or excluded from the project boundary.

Where the increases in greenhouse gas emissions from any project emissions or leakage source, and decreases in carbon stocks in carbon pools, is less than five percent of the total net anthropogenic GHG emission reductions and removals due to the project, such sources and pools may be deemed de minimis and may can be ignored (ie, their value may be accounted as zero). The significance of emissions and removals must be tested using the latest version of the CDM *Tool for Testing Significance of GHG Emissions in A/R CDM Project Activities*.

Table 1: Selected Carbon Pools under Baseline and Project

Carbon Pools	Included	Justification / Explanation
Aboveground woody biomass	Yes	SGM may reduce aboveground woody biomass.
Aboveground non-woody biomass	No	The increase of aboveground non-woody biomass resulting from SGM is transient in nature and can be conservatively excluded.
Belowground biomass	Optional	In calculating the baseline net greenhouse gas removals by sinks and/or actual net greenhouse gas removals by sinks, project proponent can choose not to account for below-ground biomass. This is subject to the provision of transparent and verifiable information that the choice will not increase the expected net anthropogenic greenhouse gas removals by sinks.
Dead wood	No	None of the applicable SGM practices decrease dead wood. Thus it can be conservatively excluded.
Litter	No	None of the applicable SGM practices decrease the amount of litter. Thus it can be conservatively excluded.
Soil organic carbon	Yes	A major carbon pool affected by grassland management practices that is expected to increase after adoption of SGM practices.
Wood products	No	None of the applicable SGM practices increases or decreases wood products. Because carbon changes in aboveground woody biomass is considered, it can be conservatively ignored.

Table 2: GHG Sources Included In or Excluded From the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Use of fertilizers	CO_2	No	Not applicable.
		CH_4	No	Not applicable.
		N_2O	Yes	Main gas for this source. This includes direct and indirect N_2O emissions from synthetic nitrogen fertilizer use. Indirect N_2O emissions from leaching and runoff a can be excluded from the project boundary, following guidance in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11* given that this methodology is only applicable in regions where annual precipitation is less than or equal to annual potential evapotranspiration.
		Other	No	Not applicable.
	Use of N-fixing species	CO_2	No	Not applicable.
		CH_4	No	Not applicable.
		N_2O	No	N_2O is the main gas for this source, but in the baseline N_2O emissions from this source are conservatively excluded.
		Other	No	Not applicable.
	Burning of biomass	CO_2	No	CO_2 emissions from biomass burning in grassland are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.
		CH_4	Yes	Non-CO_2 emissions from the burning of biomass.
		N_2O	Yes	Non-CO_2 emissions from the burning of biomass.
		Other	No	Not applicable.

	Manure deposition on grassland	CO_2	No	CO_2 emissions from biomass decomposition are not reported because net CO_2 emissions from this source are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2.
		CH_4	Yes	Significant emission source.
		N_2O	Yes	Main gas for this source.The baseline N_2O emissions from manure management include direct N_2O emissions from manure and urine deposited on grassland soil during the grazing season and indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season. Indirect N_2O emissions from leaching and runoff can be excluded from the project boundary, following guidance in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11* given that this methodology is only applicable in regions where annual precipitation is less than or equal to annual potential evapotranspiration.
		Other	No	Not applicable.
	Farming machine	CO_2	Yes	CO_2 emissions from fossil fuels used in farming machinery is the main gas for this source. Where project emissions from this source are larger than baseline emissions, project proponent may choose to account for this source in the baseline or may choose to conservatively exclude baseline emissions from this source.
		CH_4	No	Not main gas for this source. Excluded for simplification.
		N_2O	No	Not main gas for this source. Excluded for simplification.
		Other	No	Not applicable.
		CO_2	No	CO_2 emissions from animal respiration are not reported because net CO_2 emissions

	Animal respiration / Enteric fermentation			from this source are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2.
		CH_4	Yes	Main gas for this source.
		N_2O	No	No N_2O emission from enteric fermentation.
		Other	No	Not applicable.
Project	Use of fertilizers	CO_2	No	Not applicable.
		CH_4	No	Not applicable.
		N_2O	Yes	Main gas for this source. This includes direct and indirect N_2O emissions from synthetic nitrogen fertilizer use. Indirect N_2O emissions from leaching and runoff a can be excluded from the project boundary, following guidance in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11*, given that this methodology is only applicable in regions where annual precipitation is less than or equal to annual potential evapotranspiration.
		Other	No	Not applicable.
	Use of N-fixing species	CO_2	No	Not applicable.
		CH_4	No	Not applicable.
		N_2O	Yes	Main gas for this source. Where the area cropped with N-fixing species in the project is more than 50 percent larger than the area cropped with N-fixing species in the baseline, the project N_2O emissions from the use of N-fixing species must be calculated.
		Other	No	Not applicable.
	Burning of biomass	CO_2	No	CO_2 emissions from biomass burning in grassland are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.

		CH_4	Yes	Non-CO_2 emissions from the burning of biomass.
		N_2O	Yes	Non-CO_2 emissions from the burning of biomass.
		Other	No	Not applicable.
	Manure deposition on grassland	CO_2	No	CO_2 emissions from biomass decomposition are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.
		CH_4	Yes	Significant emission source.
		N_2O	Yes	Main gas for this source.The project emissions from manure and urine deposited on grassland soil during the grazing season include direct and indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season. Indirect N_2O emissions from leaching and runoff a can be excluded from the project boundary, following guidance in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11*, given that this methodology is only applicable in regions where annual precipitation is less than or equal to annual potential evapotranspiration.
		Other	No	Not applicable.
	Farming machine	CO_2	Yes	CO_2 emissions from fossil fuels used in farming machinery is the main gas for this source. Where project emissions from this source are larger than baseline emissions, project proponent must account for this source of project emissions.
		CH_4	No	Not main gas for this source. Excluded for simplification.
		N_2O	No	Not main gas for this source. Excluded for simplification.
		Other	No	Not applicable.

	Animal respiration / Enteric fermentation	CO_2	No	CO_2 emissions from enteric fermentation are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.
		CH_4	Yes	Main gas for this source.
		N_2O	No	No N_2O emissions from enteric fermentation.
		Other	No	Not applicable.

6 BASELINE SCENARIO

This methodology uses a project method to determine the baseline scenario. The following steps must be followed to identify the most plausible baseline scenario.

Step 1. Identification of alternative land use scenarios to the proposed SGM project

Sub-step 1a) Identify and list all credible alternative land use scenarios to the proposed SGM project: The project proponent must identify and list all realistic and credible land use scenarios that could have occurred within the project area in the absence of the SGM project. At a minimum, the identified land use scenarios must include:

1) Continuation of current land uses (ie, the land uses immediately prior to initiation of project activities); and

2) Any previous land use practiced within the project area in the ten years prior to initiation of project activities.

All current land uses c must be deemed realistic and credible. The project proponent must refer to the VCS *Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities* for guidance on identification of realistic and credible alternative land uses. The project proponent must justify that each of the identified alternative land uses is realistic and credible on the basis of verifiable information sources, such as documented management records of land users, agricultural statistics reports, published studies of grazing behavior in the project region, results of Participatory Rural Appraisals and other documented stakeholder discussions, and/or surveys conducted by or on behalf of the project proponent prior to the initiation of project activities.

Sub-step 1b) Check the consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations: The project proponent must check whether all alternative land use scenarios identified in sub-step 1a) are either:

1) In compliance with all mandatory applicable legal and regulatory requirements, or

2) Where an alternative does not comply with all mandatory applicable legal and regulatory requirements, it must be shown that on the basis of current practice in the region to which

the mandatory law or regulation applies that those laws or regulations are not systematically enforced or that non-compliance is widespread.

Where an alternative land use scenario identified does not meet either of these two criteria, the alternative land use scenario must be removed from the list. The resulting revised list is a list of credible alternative land use scenarios that are consistent with enforced mandatory applicable laws and regulations.

Step 2: Select the most plausible baseline scenario.

Sub-step 2a) Barrier analysis: Taking the list of credible alternative land use scenarios resulting from sub-step 1b, a barrier analysis must be conducted to identify realistic and credible barriers that prevent implementation of these land use scenarios following the procedures described in Step 3 of the VCS *Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities.* The project proponent must indicate which of the alternative land use scenarios would face which identified barrier, and provide verifiable information to support the presence of each particular barrier in relation to each alternative land use scenario.

Sub-step 2b) Eliminate alternative land use scenarios that face a barrier to implementation: All land use scenarios that face a barrier to implementation must be removed from the list.

Sub-step 2c) Select most plausible baseline scenario (if allowed by barrier analysis): Where there is only one alternative land use remaining in the list, this must be selected as the most plausible baseline scenario.

Where there is more than one alternative land use remaining in the list, and one of these alternatives includes continuation of current land use (ie, land use immediately prior to commencement of the project), continuation of current land use must be chosen as the most plausible baseline scenario where the following conditions are met:

1) The grazing agent(s) has not changed in the five years prior to initiation of project activities;
2) The current land uses have not changed in the five years prior to initiation of project activities; and
3) There have been no changes in mandatory applicable legal or regulatory requirements during this five year period and no such changes are currently under legal review by the relevant authorities.

Where there is more than one alternative land use remaining in the list and the most plausible land use has still not been chosen, then proceed to Step 2d.

Step 2d) Assess the profitability of alternative land use scenarios: Taking the list resulting from Step 2b of alternative land use scenarios that face no barriers to implementation, document the costs and revenues associated with each alternative land use and estimate the profitability of each alternative land use. The profitability of alternative land uses must be assessed in terms of the net present value of net incomes over the project crediting period. The key economic parameters and assumptions used in the analysis must be justified in a transparent manner.

Step 2e) Select the most plausible baseline scenario: The most profitable alternative land use among the land uses assessed in Step 2d must be selected as the most plausible baseline scenario.

Where, the most plausible baseline scenario selected conforms to the applicability conditions that pertain to the baseline scenario as specified in Section 4 of this methodology the project will be eligible to apply this methodology.

7 ADDITIONALITY

The project proponent must demonstrate the additionality of the project using the most recent version of the VCS *Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*. When applying Steps 2, 3 and 4 of that tool, the most plausible baseline scenario identified through application of procedures in Section 6 of this methodology must be assessed together with the project scenario.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

8.1.1 Baseline N_2O emissions due to fertilizer use

Baseline N_2O emissions due to fertilizer use equals baseline direct N_2O emission plus indirect N_2O emission, as described using the following:.

$$BE_{N_2O_{SN},b} = GWP_{N,O} \times (BE_{D,N_2O_{SN},b} + BE_{ID,N_2O_{SN},b}) \quad (1)$$

Where:

$BE_{N_2O_{SN}\,b}$	=	Baseline N_2O emissions due to fertilizer use in baseline year b (t CO_2e)
$BE_{D,N_2O_{SN}\,b}$	=	Baseline direct N_2O emissions from synthetic nitrogen fertilizer use in baseline year b (t N_2O)
$BE_{ID,N_2O_{SN}\,b}$	=	Baseline indirect N_2O emissions from synthetic nitrogen fertilizer use in baseline year b, (t N_2O)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2e/t N_2O)

1) Baseline direct N_2O emissions from synthetic nitrogen fertilizer use:

Baseline direct N_2O emissions from synthetic fertilizer use in year *b*, $BE_{D,N_2O_{SN},b}$, must be calculated following Chapter 11, Volume 4 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, as described using the following:

$$BE_{D,N_2O_{SN},b} = F_{SN,b} \times EF_{Nfert} \times 44/28 \quad (2)$$

Where:

$BE_{D,N_2O_{SN}\,b}$	=	Baseline direct N_2O emissions from synthetic nitrogen fertilizer use in baseline year b (t N_2O)

$F_{SN,b}$	=	Annual amount of synthetic fertilizer N applied to grassland soils in baseline year *b*, adjusted for volatilization as NH_3 and NO_x (t N)
EF_{Nfert}	=	N_2O emission factor for synthetic N fertilizer use (kg N_2O-N/kg N applied)
44/28	=	Conversion of N_2O-N to N_2O

$$F_{SN,b} = \sum_{i=1}^{I} M_{SNi,b} \times NC_{SNi,b} \times (1 - Frac_{GAS,F}) \quad (3)$$

Where:

$F_{SN,b}$	=	Annual amount of synthetic fertilizer N applied to grassland soils in baseline yearb, adjusted for volatilization as NH3 and NOx (t N)
$M_{SNi,b}$	=	Mass of synthetic N fertilizer type *i* applied in baseline year *b* (t fertilizer)
$NC_{SNi,b}$	=	Nitrogen content of synthetic N fertilizer type *i* applied in baseline year *b* (g N/g fertilizer)
$Frac_{GAS,F}$	=	Fraction of synthetic N fertilizer that volatilizes as NH_3 and NO_x (kg N volatilized/kg N applied)
I	=	Index of synthetic N fertilizer types

2) Baseline indirect N_2O emissions from synthetic N fertilizer use:

The N_2O emissions from the atmospheric deposition of N volatilized as NH_3 and NO_x after fertilizer is applied to grassland soils in baseline year b, is calculated using the below equation. Indirect N_2O emissions from leaching and runoff are excluded from the project boundary as described in Section 5:

$$BE_{ID,N_2O_{SN},b} = \sum_{i=1}^{I} (F_{SNi,b} \times Frac_{GAS,F}) \times EF_{4,SN} \times 44/28 \quad (4)$$

Where:

$BE_{ID,N_2O_{SN}b}$	=	Baseline indirect N2O emissions from synthetic nitrogen fertilizer use in baseline year b, (t N2O)
$F_{SNi,b}$	=	Annual amount of synthetic N fertilizer type *i* applied to grassland soils in baseline year b, adjusted for volatilization as NH_3 and NOx (t N)
$Frac_{GAS,F}$	=	Fraction of synthetic N fertilizer that volatilizes as NH_3 and NO_x (kg N volatilized/kg N applied)
$EF_{4,SN}$	=	N_2O emission factor for atmospheric deposition of synthetic N on soils and water surfaces (kg N_2O-N/(kg NH_3-N + NO_x-N volatilized)).

8.1.2 Baseline emissions due to the use of N-fixing species

N_2O emissions due to the use of N-fixing species in the baseline are excluded from the project boundary as described in Section 5.

8.1.3 Baseline emissions due to burning of biomass

The baseline emissions due to burning of biomass, $BE_{BB,b}$, include CH_4 emissions from biomass burning plus N_2O emissions from biomass burning in baseline year *b*, as described using the following:

$$BE_{BB,b} = BE_{CH_{4BB},b} + BE_{N_2O_{BB},b} \quad (5)$$

Where:

$BE_{BB,b}$	=	Baseline GHG emissions from biomass burning in baseline year *b* (t CO_2e)
$BE_{CH_{4BB},b}$	=	Baseline CH_4 emissions from biomass burning in baseline year *b* (t CO_2e)
$BE_{N_2O_{BB},b}$	=	Baseline N_2O emissions from biomass burning in baseline year *b* (t CO_2e)

1) CH_4 emissions from biomass burning:

CH_4 emissions from biomass burning in baseline year *b* must be calculated using the following:

$$BE_{CH_{4BB},b} = \frac{A_{B,b} \times M_{B,b} \times C_f \times EF_{CH_4} \times GWP_{CH_4}}{1000} \quad (6)$$

Where:

$BE_{CH_{4BB},b}$	=	Baseline CH_4 emissions from biomass burning in baseline year b (t CO_2e)
$A_{B,b}$	=	Area burned in baseline year *b* (ha)
$M_{B,b}$	=	Aboveground biomass burned in baseline year *b* (t biomass/ha)
C_f	=	Combustion factor (t dry matter burnt/t biomass)
EF_{CH_4}	=	CH_4 emission factor for biomass burning (g CH_4/kg dry matter burnt)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)

2) N_2O emissions from biomass burning:

N_2O emissions from biomass burning in baseline year *b* must be calculated using the following:

$$BE_{N_2O_{BB},b} = \frac{A_{B,b} \times M_{B,b} \times C_f \times EF_{N_2O} \times GWP_{N_2O}}{1000} \quad (7)$$

Where:

$BE_{N_2O_{BB},b}$	=	Baseline N_2O emissions from biomass burning in baseline year b (t CO_2e)
$A_{B,b}$	=	Area burned in baseline year *b* (ha)

$M_{B,b}$	=	Aboveground biomass burned in baseline year *b* (t biomass/ha)
C_f	=	Combustion factor (t dry matter burnt/t biomass)
EF_{N_2O}	=	N_2O emission factor (g N_2O/kg dry matter burnt)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2e/t N_2O)

8.1.4 Baseline CH_4 emissions due to enteric fermentation

Baseline CH_4 emissions from enteric fermentation must be calculated based on the approach in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, with the addition of a parameter to reflect the proportion of the year that livestock are present inside the project area, as described using the following:

$$BE_{CH_{4EF},b} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} P_{l,b} \times EF_l \times Days_{l,b}}{1000 \times 365} \quad (8)$$

Where:

$BE_{CH_{4EF},b}$	=	Baseline CH_4 emissions from enteric fermentation in baseline year *b* (t CO_2e)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
$P_{l,B}$	=	Population of grazing livestock type *l*, in baseline year *b* (head)
l	=	Index of livestock type
EF_l	=	Enteric CH_4 emission factor per head of livestock type *l* per year (kg CH_4/(head*year))
$Days_{l,b}$	=	Grazing days inside the project area for each livestock type *l* in baseline year *b* (days)

8.1.5 Baseline N_2O and CH_4 emissions due to manure management

Baseline emissions from manure management include N_2O and CH_4 emissions from manure and urine deposited on grassland soil during the grazing season.

$$BE_{GHG_{MD},b} = BE_{N_2O_{MD},b} + BE_{CH_{4MD},b} \quad (9)$$

Where:

$BE_{GHG_{MD},b}$	=	Baseline GHG emissions from manure management in baseline year *b* (t CO_2e)
$BE_{N_2O_{MD},b}$	=	Baseline N_2O emissions from manure and urine deposited on grassland soil in baseline year *b* (t CO_2e)
$BE_{CH_{4MD},b}$	=	Baseline CH_4 emissions from manure and urine deposited on grassland soil in baseline year *b* (t CO_2e)

1) Baseline N_2O emissions from manure management

Baseline N_2O emissions from manure and urine deposited on grassland soil in baseline year b are the sum of direct and indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season and is calculated as described using the following:

$$BE_{N_2O_{MD},b} = GWP_{N_2O} \times (BE_{D,N_2O_{MD},b} + BE_{ID,N_2O_{MD},b}) \quad (10)$$

Where:

$BE_{N_2O_{MD},b}$	=	Baseline N_2O emissions from manure and urine deposited on grassland soil in baseline year b (t CO_2e)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2e / t N_2O)
$BE_{D,N_2O_{MD},b}$	=	Direct N_2O emissions from manure and urine deposited on grassland soil during the grazing season in baseline year *b* (t N_2O)
$BE_{ID,N_2O_{MD},b}$	=	Indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season in baseline year *b* (t N_2O)

2) Baseline direct N_2O emissions from manure and urine deposited on grassland soil:

Baseline direct N_2O emissions from manure and urine deposited on grassland soil must be calculated using the methodology recommended in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, as described in the following equations. Equation 11 calculates direct N_2O emissions from livestock types classified as cattle (dairy, non-dairy and buffalo), poultry and pigs. Equation 12 calculates direct N_2O emissions .from livestock types classified as sheep and other animals. Where both kinds of livestock are present the following equations must be summed.

$$BE_{D,N_2O_{MD},b} = \sum_{l1=1}^{L1} F_{MD,l1,b} \times EF_{3,PRP,CPP} \times 44/28 \quad (11)$$

and/or

$$BE_{D,N_2O_{MD},b} = \sum_{l2=1}^{L2} F_{MD,l2,b} \times EF_{3,PRP,SO} \times 44/28 \quad (12)$$

Where:

$BE_{D,N_2O_{MD},b}$	=	Direct N_2O emissions from manure and urine deposited on grassland soil during the grazing season in baseline year b (t N_2O)
$F_{MD,l1,b}$	=	Annual amount of nitrogen in cattle, poultry and pigs manure and urine deposited on grassland soil during the grazing season in baseline year *b*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,l2,b}$	=	Annual amount of nitrogen in sheep and other animals manure and urine deposited on grassland soil during the grazing season in baseline year *b*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle, poultry and pigs manure and urine deposited on grassland soil during the grazing season (kg N_2O-N/kg N input)

$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on grassland soil during the grazing season (kg N_2O-N/kg N input)
L_1	=	Index of livestock cattle, poultry and pigs
L_2	=	Index of livestock sheep and other animals

$F_{MD,l1,b}$ and $F_{MD,l2,b}$ must be calculated using equation for each livestock type *l*.

$$F_{MD,l,b} = \frac{P_{l,b} \times W_{l,b} \times Nex_l \times H_{l,b} \times Days_{l,b} \times (1 - Frac_{GAS,MD})}{1000_a \times 24 \times 1000_b} \quad (13)$$

Where:

$F_{MD,l,b}$	=	Annual amount of manure and urine deposited on grassland soil from livestock type *l* during the grazing season in baseline year b, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{l,b}$	=	Population of livestock type *l* in baseline year *b* (head)
$W_{l,b}$	=	Average weight of livestock type *l* in baseline year *b* (kg livestock mass/head)
Nex_l	=	Nitrogen excretion of livestock type *l* (kg N deposited/(t livestock mass*day))
1000_a	=	Conversion factor for t livestock mass to kg livestock mass
$H_{l,b}$	=	Average grazing hours per day for livestock type *l* in baseline year *b* (hour)
24	=	Conversion factor for days to hours
$Days_{l,b}$	=	Grazing days for livestock type *l* inside the project area in baseline year *b* (days)
1000_b	=	Conversion factor for tonnes N to kg t N
$Frac_{GAS,MD}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
L	=	Index of grazing livestock types

3) Baseline indirect N_2O emissions from urine and manure N deposited on grassland soils:

The indirect N_2O emissions from the atmospheric deposition of N volatilized as NH_3 and NO_x after urine and manure N is deposited on grassland soils in baseline year *b,* are calculated using the following equation. Indirect N_2O emissions from urine and manure N deposited on grassland soils excludes N_2O emissions from leaching and runoff in regions.

$$BE_{IDV,N_2O_{MD},b} = \sum_{l=1}^{L} F_{MD,l,b} \times Frac_{GAS,MD} \times EF_{4,MD} \times 44/28 \quad (14)$$

Where:

$BE_{ID,N_2O_{MD},b}$	=	Indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season in baseline year b (t N_2O)

$F_{MD,l,b}$	=	Annual amount of manure and urine deposited on grassland soil from livestock type *l* during the grazing season in baseline year b, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
$EF_{4,MD}$	=	N_2O emission factor for atmospheric deposition of urine and manure N on soils and water surfaces, (kg N_2O-N/(kg NH_3-N + NO_x-N volatilized))
L	=	Index of grazing livestock types

4) **CH_4 emissions from manure management**:

The Tier 1 approach recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* must be used to calculate CH_4 emissions from manure management, as described using the following:

$$BE_{CH_{4MD},b} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{lM} \times P_{l,b} \times H_{l,b} \times Days_{l,b}}{24 \times 365 \times 1000} \quad (15)$$

Where:

$BE_{CH_{4MD},b}$	=	Baseline CH_4 emissions from manure and urine deposited on grassland soil in baseline year b (t CO_2e)
GWP_{CH_4}	=	Global warming potential for CH_4 (t CO_2e / t CH_4)
EF_{lM}	=	CH_4 emission factor from manure of livestock type *l* (kg CH_4/(head*year)
$P_{l,b}$	=	Population of grazing livestock type *l*, in baseline year *b*, head
$H_{l,b}$	=	Average grazing hours per day for livestock type *l* in baseline year *b* (hour)
$Days_{l,b}$	=	Grazing days for livestock type *l* inside the project area in baseline year *b* (days)
24	=	Conversion factor for days to hours
365	=	Conversion factor for years to days
1000	=	Conversion factor for t CH4 to kg CH4

8.1.6 Baseline CO_2 emissions due to the use of fossil fuels for grassland management

If project emissions from this source are larger than baseline emissions, the project proponent may choose to account for this source in the baseline or may choose to conservatively ignore baseline emissions from this source. The following is applied to calculate CO_2 emissions from consumption of fossil fuels for SGM in baseline year *b*.

$$BE_{FC,b} = \frac{\sum_{p=1}^{P} \sum_{j=1}^{J} \sum_{k=1}^{K} FC_{p,j,k,b} \times EF_{CO2,k} \times NCV_k}{1000} \quad (16)$$

Where:

$BE_{FC,b}$	=	Baseline CO_2 emissions from farming machine fossil fuel consumption in baseline year *b* (t CO_2)
$FC_{p,j,k,b}$	=	Fuel consumption by fuel type *k*, by machine type *j* , on parcel grassland *p*, in baseline year *b* (kg fuel/year)
$EF_{CO_2,k}$	=	CO_2 emission factor by fuel type *k* (t CO_2/GJ)
NCV_k	=	Thermal value of fuel type *k* (GJ/t fuel)
1000	=	Conversion factor for tonnes fuel to kg fuel
K	=	Index of fuel type
J	=	Index of machine type
P	=	Index of grassland parcel

8.1.7 Baseline emission removals from existing woody perennials

Where the project proponent includes above and below ground woody biomass pools as a selected carbon pool, baseline removals from existing woody perennials ($BRWP_b$) are calculated using the latest version of the CDM A/R tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*. Where the project proponent chooses not to include above and below ground woody biomass pools, baseline removals, $BRWP_b$, are assumed to be zero.

The carbon gain-loss approach must be applied to estimation of baseline removals from existing woody perennials.

Baseline removals by existing woody perennials in baseline year *b* ($BRWP_b$) must be calculated using the following:

$$BRWP_b = \sum_{j=1}^{J} \Delta C_{BG,j} - \Delta C_{BL,j} \qquad (17)$$

Where:

$BWRP_b$	=	Baseline removals from existing woody perennials in baseline year *b* (t CO_2)
$\Delta C_{BG,j}$	=	Average annual increase in carbon stocks of existing woody biomass for species *j*, under the baseline scenario (t CO_2)
$\Delta C_{BL,j}$	=	Average annual loss of carbon stocks of existing woody biomass for species *j*, under the baseline scenario (t CO_2)
J	=	Index of species

As noted under the assumptions used in developing this methodological tool, no explicit accounting of the term representing stock losses, $\Delta C_{BL,j}$, is included in this tool. That is, $\Delta C_{BG,j}$ is assumed to be a measure of net growth increment and thus to implicitly accounts for $\Delta C_{BL,j}$.

The average annual increase in carbon stocks in existing live woody biomass for each species must be calculated using the following:

$$\Delta C_{BG,j} = \sum_{s=1}^{S} A_{B,j,s} \times G_{B,j,s} \times CF_j \times \frac{44}{12} \quad (18)$$

Where:

$\Delta C_{BG,j}$	=	Average annual increase in carbon stocks of existing woody biomass for species *j*, under the baseline scenario (t CO_2)
$A_{B,j,s}$	=	Area of species *j* in stratum s under the baseline scenario (ha)
$G_{B,j,s}$	=	Average annual increase in existing woody biomass of species *j* in stratum *s*, under the baseline scenario (t dm/(ha)
CF_j	=	Carbon fraction for species *j* (t C/t dm)
S	=	Index of stratum
44/12	=	Ratio of molecular weights of CO_2 and C

The average annual increase in existing live woody biomass stocks for each species in a vegetation class in a stratum must be calculated from:

$$G_{B,j,s} = G_{AB,B,j,s}(1 + R_j) \quad (19)$$

Where:

$G_{B,j,s}$	=	Average annual increase in existing woody biomass of species *j* in stratum *s*, under the baseline scenario (t dm/ha)
$G_{AB,B,j,s}$	=	Average annual increase in existing above-ground woody biomass of species *j* in stratum *s* (t dm aboveground biomass/ha)
R_j	=	Root to shoot ratio of species *j* (t dm belowground biomass/t dm aboveground biomass)

Since below ground biomass is an optional carbon pool (Table 1), the term (1 + R_j) may be removed from the above equation if this carbon pool is not included in the project boundary.

8.1.8 Baseline emission removals due to changes in soil organic carbon

Since the applicability conditions limit the project to land that is degraded and is continuing to degrade, it can be conservatively assumed that the changes in SOC in the baseline scenario is zero. Therefore:

$$BRS = 0 \quad (20)$$

Where:

BRS	=	Baseline removals due to changes in SOC under the baseline scenario (t CO_2e)

8.1.9 Baseline emissions and removals

The emissions and removals in baseline year *b* are given by:

$$BE_b = BE_{N_2O_{SN},b} + BE_{BB,b} + BE_{CH_{4EF},b} + BE_{GHG_{MD},b} + BE_{FC,b} - BRWP_b \quad (21)$$

Where:

BE_b	=	Baseline emissions and removals in year *b* (t CO_2e)
$BE_{N_2O_{SN}b}$	=	Baseline N_2O emissions due to fertilizer use in baseline year b (t CO_2e)
$BE_{BB,b}$	=	Baseline GHG emissions from biomass burning in baseline year *b* (t CO_2e)
$BE_{CH_{4EF},b}$	=	Baseline CH_4 emissions from enteric fermentation in baseline year *b* (t CO_2e)
$BE_{GHG_{MD},b}$	=	Baseline GHG emissions from manure management in baseline year *b* (t CO_2e)
$BE_{FC,b}$	=	Baseline CO_2 emissions from farming machine fossil fuel consumption in baseline year *b*, (t CO_2)
$BWRP_b$	=	Baseline removals from existing woody perennials in baseline year *b* (t CO_2)

8.2 Project Emissions

8.2.1 Project N_2O emissions due to fertilizer use

Project N_2O emissions due to fertilizer use equals the sum of project direct and indirect N_2O emissions, as described using the following:

$$PE_{N_2O_{SN},t} = GWP_{N_2O} \times (PE_{D,N_2O_{SN},t} + PE_{ID,N_2O_{SN},t}) \quad (22)$$

Where:

$PE_{N_2O_{SN},t}$	=	Project N_2O emissions due to fertilizer use in year *t* (t CO_2e)
$PE_{D,N_2O_{SN},t}$	=	Project direct N_2O emissions from synthetic nitrogen fertilizer use in year *t* (t N_2O)
$PE_{ID,N_2O_{SN},t}$	=	Project indirect N_2O emissions from synthetic nitrogen fertilizer use in year *t* (t N_2O)
GWP_{N_2O}	=	Global-warming potential of N_2O

1) Project direct N_2O emissions from synthetic nitrogen fertilizer use:

Project direct N_2O emissions from synthetic fertilizer use is calculated using IPCC methodology recommended in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, as described using the following:

$$PE_{D,N_2O_{SN},t} = F_{SN,t} \times EF_{Nfert} \times 44/28 \quad (23)$$

Where:

$PE_{D,N_2O_{SN},t}$	=	Project direct N_2O emissions from synthetic nitrogen fertilizer use in year *t* (t N_2O)
$F_{SN,t}$	=	Annual amount of synthetic fertilizer N applied to grassland soils in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
EF_{Nfert}	=	N_2O emission factor for synthetic N fertilizer use (kg N_2O-N/kg N applied)
44/28	=	Conversion of N_2O-N to N_2O

$$F_{SN,t} = \sum_{i=1}^{I} M_{SNi,t} \times NC_{SNi,p} \times (1 - Frac_{GAS,F}) \quad (24)$$

Where:

$F_{SNi,t}$	=	Annual amount of synthetic fertilizer N applied to grassland soils in year t, adjusted for volatilization as NH_3 and NO_x (t N)
$M_{SNi,t}$	=	Mass of synthetic N fertilizer type *i* applied in year *t* (t fertilizer)
$NC_{SNi,p}$	=	Nitrogen content of synthetic N fertilizer type *i* applied (g-N/g fertilizer)
$Frac_{GAS,F}$	=	Fraction of synthetic N fertilizer that volatilizes as NH_3 and NO_x (kg N volatilized/kg of N applied)
I	=	Index of synthetic N fertilizer types

2) Project indirect N_2O emissions from the synthetic N fertilizer use:

The N_2O emissions from the atmospheric deposition of N volatilized as NH_3 and NO_x after fertilizer is applied to grassland soils under the project scenario in year t, is calculated using the below equation. Indirect N_2O emissions from leaching and runoff are excluded from the project boundary as described in Section 5.

$$PE_{ID,N_2O_{SN},t} = \sum_{i=1}^{I} (F_{SNi,t} \times Frac_{GAS,F}) \times EF_{4,SN} \times 44/28 \quad (25)$$

Where:

$PE_{ID,N_2O_{SN},t}$	=	Project indirect N_2O emissions from synthetic nitrogen fertilizer use in year t (t N_2O)
$F_{SNi,t}$	=	Annual amount of synthetic fertilizer N applied to grassland soils in year t, adjusted for volatilization as NH3 and NOx (t N)
$Frac_{GAS,F}$	=	Fraction of synthetic N fertilizer that volatilizes as NH_3 and NO_x (kg N volatilized/kg of N applied)

$EF_{4,SN}$	=	N_2O emission factor for atmospheric deposition of synthetic N on soils and water surfaces (kg N_2O-N/(kg NH_3-N + NO_x-N volatilized)$^{-1}$)
I	=	Index of synthetic N fertilizer types

8.2.2 Project emissions due to the use of N-fixing species

Project emissions from N-fixing species must only be accounted for. if the area cropped with N-fixing species in the project is more than 50 percent larger than the area cropped with N-fixing species in the baseline.

The project emissions from the use of N-fixing species, $PE_{N_2O_{NF},t}$, must be calculated using the following equations:

$$PE_{N_2O_{NF},t} = F_{CR,t} \times EF_{Nfix} \times 44/28 \times GWP_{N_2O} \quad (26)$$

Where:

$PE_{N_2O_{NF},t}$	=	Project N_2O emissions as a result of N-fixing species within the project area in year *t* (t CO_2e)
$F_{CR,t}$	=	Amount of N in N-fixing species (above and below ground) and from forage/pasture renewal, returned to soils under project in year *t* (t N)
EF_{Nfix}	=	Emission factor for N_2O emissions from N inputs of N-fixing species to grassland soil (kg N_2O-N/kg N input)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2/t N_2O)

$$F_{CR,t} = \sum_{g=1}^{G} Area_{g,t} \times Crop_{g,t} \times N_{content,g} \quad (27)$$

Where:

$F_{CR,t}$	=	Amount of N in N-fixing species (above and below ground) and from forage/pasture renewal, returned to soils under project in year t (t N)
$Area_{g,t}$	=	Annual area of N-fixing species *g* in year *t* (ha)
$Crop_{g,t}$	=	Annual dry matter, including aboveground and below ground, returned to grassland soils for N-fixing species *g* under project in year *t* (t dm/ha)
$N_{content,g}$	=	Fraction of N in dry matter for N-fixing species *g* (t N/t dm)
G	=	Index of N-fixing species

8.2.3 Project emissions due to burning of biomass

The project GHG emissions equals CH_4 emissions from biomass burning plus N_2O emissions from biomass burning under the project, as described using the following:

$$PE_{GHG_{BB},t} = PE_{CH_{4BB},t} + PE_{N_2O_{BB},t} \quad (28)$$

Where:

$PE_{GHG_{BB},t}$	=	Project GHG emissions from biomass burning in year *t* (t CO_2e)

$PE_{CH_{4BB},t}$ = Project CH_4 emissions from biomass burning in year *t* (t CO_2e)

$PE_{N_2O_{BB},t}$ = Project N_2O emissions from biomass burning in year *t* (t CO_2e)

1) CH_4 emissions from biomass burning under project:

CH_4 emissions from biomass burning must be calculated using the following:

$$PE_{CH_{4BB},t} = \frac{A_{B,t} \times M_{B,t} \times C_f \times EF_{CH_4} \times GWP_{CH_4}}{1{,}000} \quad (29)$$

Where:

$PE_{CH_{4BB},t}$ = Project CH_4 emissions from biomass burning in year *t* (t CO_2e)

$A_{B,t}$ = Area burned under project in year *t* (ha)

$M_{B,t}$ = Aboveground biomass burned, excluding litter and dead wood under project in year *t* (t biomass/ha)

C_f = Combustion factor (t dry matter burnt/t biomass)

EF_{CH_4} = CH_4 emission factor for biomass burning (g CH_4/kg dry matter burnt)

GWP_{CH_4} = Global-warming potential for CH_4 (t CO_2e/t CH_4)

2) N_2O emissions from biomass burning under project:

N_2O emissions from biomass burning must be calculated using the following:

$$PE_{N_2O_{BB},t} = \frac{A_{B,t} \times M_{B,t} \times C_f \times EF_{N_2O} \times GWP_{N_2O}}{1{,}000} \quad (30)$$

Where:

$PE_{N_2O_{BB},t}$ = Project N_2O emissions from biomass burning in year *t* (t CO_2e)

$A_{B,t}$ = Area burned under project in year *t* (ha)

$M_{B,t}$ = Aboveground biomass burned, excluding litter and dead wood under project in year *t* (t biomass/ha)

C_f = Combustion factor (t dry matter burnt/t biomass)

EF_{N_2O} = N_2O emission factor (g N_2O/kg dry matter burnt)

GWP_{N_2O} = Global-warming potential for N_2O (t CO_2e/t N_2O)

8.2.4 Project CH_4 emissions due to enteric fermentation

Project CH_4 emissions from enteric fermentation are calculated based on an IPCC methodology recommended in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, with the

addition of a parameter to reflect the proportion of the year that livestock are present inside the project area, as described using the following:

$$PE_{CH_{4EF},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} P_{l,t} \times EF_l \times Days_{l,t}}{1000 \times 365} \quad (31)$$

Where:

$PE_{CH_{4EF},t}$	=	Project CH_4 emissions from enteric fermentation in year *t* (t CO_2e)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
$P_{l,t}$	=	Population of grazing livestock type *l* in year *t* under project (head)
L	=	Index of livestock type
EF_l	=	Enteric CH_4 emission factor per head of livestock type *l* per year (kg CH_4 head*year)
$Days_{l,t}$	=	Grazing days inside the project area for each livestock type *l* in the project year *t* (days)
1000	=	Conversion factor for t CH_4 to kg t CH_4
365	=	Conversion factor for years to days

8.2.5 Project N_2O and CH_4 emissions due to manure management

The project emissions from manure management include N_2O and CH_4 emissions from manure and urine deposited on grassland soil during the grazing season.

$$PE_{GHG_{MD},t} = PE_{N_2O_{MD},t} + PE_{CH_{4MD},t} \quad (32)$$

Where:

$PE_{GHG_{MD},t}$	=	Project GHG emissions from manure management in year *t* (t CO_2e)
$PE_{N_2O_{MD},t}$	=	Project N_2O emissions from manure and urine deposited on grassland soil in year *t* (t CO_2e)
$PE_{CH_{4MD},t}$	=	Project CH_4 emissions from manure and urine deposited on grassland soil in year *t* (t CO_2e)

1) Project N_2O emissions from manure management

The project emissions from manure and urine deposited on grassland soil during the grazing season include direct and indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season. Project N_2O emissions from manure and urine deposited on grassland soil are calculated as described in the following:

$$PE_{N_2O_{MD},t} = GWP_{N_2O} \times (PE_{D,N_2O_{MD},t} + PE_{ID,N_2O_{MD},t}) \quad (33)$$

Where:

$PE_{N_2O_{MD},t}$	=	Project N_2O emissions from manure and urine deposited on grassland soil in year *t* (t CO_2e)
GWP_{N_2O}	=	Global warming potential for N_2O (t CO_2e/t N_2O)
$PE_{D,N_2O_{MD},t}$	=	Project direct N_2O emissions from manure and urine deposited on grassland soil during the grazing season in year *t* (t N_2O)
$PE_{ID,N_2O_{MD},t}$	=	Project indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season in year *t* (t N_2O)

2) Project direct N_2O emissions from manure and urine deposited on grassland soil

Project direct N_2O emissions from manure and urine deposited on grassland soil are calculated using IPCC methodology recommended by *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, as described using the following Equations 34 and 45. Equation 34 calculates direct N_2O emissions from livestock types classified as cattle (dairy, non-dairy and buffalo), poultry and pigs and Equation 35 calculates direct N_2O emissions from livestock types classified as sheep and other animals. Note that where both kinds of livestock are present the following equations must be summed.

$$PE_{D,N_2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,l1,t} \times EF_{3,PRP,CPP} \times 44/28 \quad (34)$$

and/or

$$PE_{D,N_2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,l2,t} \times EF_{3,PRP,SO} \times 44/28 \quad (35)$$

Where:

$PE_{D,N_2O_{MD},t}$	=	Project direct N_2O emissions from manure and urine deposited on grassland soil during the grazing season in year t (t N_2O)
$F_{MD,l1,t}$	=	Annual amount of nitrogen in cattle, poultry and pigs manure and urine deposited on grassland soil during the grazing season in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,l2,t}$	=	Annual amount of nitrogen in sheep and other animals manure and urine deposited on grassland soil during the grazing season in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle, poultry and pigs manure and urine deposited on grassland soil during the grazing season (kg N_2O-N/kg N input)
$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on grassland soil during the grazing season (kg N_2O-N/kg N input)
L_1	=	Index of livestock cattle, poultry and pigs
L_2	=	Index of livestock sheep and other animals

$F_{MD,l1,t}$ and $F_{MD,l2,t}$ must be calculated using the following equation for livestock type *l*.

$$F_{MD,l,t} = \frac{P_{l,t} \times W_{l,p} \times Nex_l \times H_{l,t} \times Days_{l,t} \times (1 - Frac_{GAS,MD})}{1000_a \times 24 \times 1000_b} \quad (36)$$

Where:

$F_{MD,l,t}$	=	Annual amount of manure and urine deposited on grassland soil from livestock type l during the grazing season in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{l,t}$	=	Population of grazing livestock type *l* in year *t* (head)
$W_{l,p}$	=	Average weight of livestock/under project (kg livestock mass/head)
Nex_l	=	Nitrogen excretion of livestock typ *l* (kg N deposited /(t livestock mass*day))
1000_a	=	Conversion factor for t livestock mass to kg livestock mass
$H_{l,t}$	=	Average grazing hours per day during grazing season in year *t* (hours)
24	=	Conversion factor for days to hours
$Days_{l,t}$	=	Grazing days for livestock type *l* inside the project area in year t (days)
1000_b	=	Conversion factor for t N to kg N
$Frac_{GAS,MD}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
L	=	Index of grazing livestock types

3) Project indirect N_2O emissions from urine and manure N deposited on grassland soils

Indirect N_2O emissions from rine and manure N deposited on grassland soils excludes N_2O emissions from leaching and runoff in regions as set out in Section 5.

Indirect N_2O emissions from the atmospheric deposition of N volatilized as NH_3 and NO_x after urine and manure N is deposited on grassland soils under the project in year t, are calculated using the following:

$$PE_{ID,N_2O_{MD},t} = \sum_{l=1}^{L} F_{MD,l,t} \times Frac_{GAS,MD} \times EF_{4,MD} \times 44/28 \quad (37)$$

Where:

$PE_{ID,N_2O_{MD},t}$	=	Project indirect N_2O emissions from manure and urine deposited on grassland soil during the grazing season in year t (t N_2O)
$F_{MD,l,t}$	=	Annual amount of manure and urine deposited on grassland soil from livestock type l during the grazing season in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
$EF_{4,MD}$	=	N_2O emission factor for atmospheric deposition of urine and manure N on soils and water surfaces, (kg N_2O-N/(kg NH_3-N + NO_x-N volatilized))

4) CH_4 emissions from manure management

Project CH_4 emissions from manure management must be calculated using the Tier 1 approach, recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, as described using the following:

$$PE_{CH_{4MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{lM} \times P_{l,t} \times H_{l,t} \times Days_{l,t}}{1000 \times 365 \times 24} \quad (38)$$

Where:

$PE_{CH_{4MD},t}$	=	Project CH_4 emissions from manure and urine deposited on grassland soil in year t (t CO_2e)
$P_{l,t}$	=	Population of livestock type *l* in year *t* (head)
EF_{lM}	=	CH_4 emission factor from manure of of livestock type *l* (kg CH_4/(head*year))
$H_{l,t}$	=	Average grazing hours per day during grazing season in year *t* (hours)
$Days_{l,t}$	=	Grazing days for livestock type *l* inside the project area in year t (days)
1000	=	Conversion factor for t CH_4 to kg CH_4
365	=	Conversion factor for years to days
24	=	Conversion factor for days to hours

8.2.6 Project CO_2 emissions due to the use of fossil fuels

If project emissions from this source are larger than baseline emissions, the project proponent must account for this source of project emissions. The following equation is applied to calculate CO_2 emissions from consumption of fossil fuels for management practices implemented as part of the project.

$$PE_{FC,t} = \frac{\sum_{p=1}^{P} \sum_{j=1}^{J} \sum_{k=1}^{K} FC_{p,j,k,t} \times EF_{CO_2,k} \times NCV_k}{1000} \quad (39)$$

Where:

$PE_{FC,t}$	=	Project CO_2 emissions from farming machine fossil fuel consumption in year *t* (t CO_2)
$FC_{p,j,k,t}$	=	Fuel consumption by fuel type *k*, by machine type *j*, on grassland parcel *p*, in year *t* (kg fuel/year)
$EF_{CO_2,k}$	=	CO_2 emission factor by fuel type *k* (t CO_2/GJ).
NCV_k	=	Thermal value of fuel type *k* (GJ/t fuel)
1000	=	Conversion factor for tonnes fuel to kg fuel

K	=	Index of fuel type
J	=	Index of machine type
P	=	Index of grassland parcel

8.2.7 Project removals from woody perennials

Where the project proponent chooses to include the aboveground woody biomass pool, project removals from woody perennials ($PRWP_t$) is calculated using CDM A/R tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*. Where the project proponent chooses not to include the aboveground woody biomass pool, with-project removals, $PRWP_t$, are assumed to be zero.

The carbon gain-loss approach must be applied to estimation of the project removals from woody perennials. Project removals from woody perennials must be calculated using the following:

$$PRWP_t = \sum_{j=1}^{J} \Delta C_{PG,j,t} - \Delta C_{PL,j,t} \quad (40)$$

Where:

$PRWP_t$	=	Project average net change in carbon stocks of existing woody biomass in year *t* (t CO_2)
$\Delta C_{PG,j,t}$	=	Project average increase in carbon stocks of existing woody biomass for species *j*, in year *t* (t CO_2)
$\Delta C_{PL,j,t}$	=	Project average loss in carbon stocks of existing woody biomass for species *j*, in year *t* (t CO_2)
J	=	Index of species

As noted under the assumptions used in developing this methodology, no explicit accounting of the term representing stock losses, $\Delta C_{PL,j,t}$, is included in this methodology. That is, $\Delta C_{PG,j,t}$ is assumed to be a measure of net growth increment and thus to implicitly account for $\Delta C_{PL,j,t}$.

The average increase in carbon stocks in existing live woody biomass for each species must be calculated using the following:

$$\Delta C_{PG,j,t} = \sum_{s=1}^{S} A_{P,j,s,t} \times G_{P,j,s,t} \times CF_j \times 44/12 \quad (41)$$

Where:

$\Delta C_{PG,j,t}$	=	Project average increase in carbon stocks of existing woody biomass for species *j*, for year *t* (t CO_2)
$A_{P,j,s,t}$	=	Area of species *j* in stratum *s* under project in year *t* (ha)

$G_{P,j,s,t}$	=	Project average increase in existing woody biomass for species *j* in grassland management stratum *s* in year *t* (t dm/ha)
CF_j	=	Carbon fraction for species *j* (t C/t dm)
S	=	Index of stratum
44/12	=	Ratio of molecular weights of CO_2 and C

The average annual increase in existing live woody biomass stocks for each species in a vegetation class in a stratum must be calculated using the following:

$$G_{P,j,s,t} = G_{AB,P,j,s,t}(1 + R_j) \quad (42)$$

Where:

$G_{P,j,s,t}$	=	Project average increase in existing woody biomass for species *j* in grassland management stratum *s* in year *t* (t dm/ha)
$G_{AB,P,j,s,t}$	=	Project average increase in existing above-ground woody biomass for species *j* in grassland management stratum *s*, in year *t* (t dm/ha)
R_j	=	Root to shoot ratio of species *j* (t dm belowground biomass/t dm aboveground biomass)

Since below ground biomass is an optional carbon pool (see Table 1), the term $(1 + R_j)$ may be removed from the above, Equation 42, if this carbon pool is not included in the project boundary.

8.2.8 Project removals due to changes in soil organic carbon

Soil carbon is a major pool affected by changes in grassland management practices. In this methodology, proponents may either make direct measurements of SOC, or use a modeling approach. If there are peer-reviewed studies (eg, scientific journals, university theses, or work carried out by the project proponent) that demonstrates that the use of the selected model is valid for the project region, the model can be applied for estimating of carbon stock changes (Option 1 below). Otherwise, direct measurement of carbon stocks will be carried out (Option 2 below).

Option 1: Estimate of project removals due to changes in SOC using a validated model

Using a biogeochemical model that has been accepted in peer-reviewed scientific publications and validated for the project region (eg, CENTURY soil organic matter model[4]) estimate the annual change in SOC stocks during each year of the project under each of the identified management practices of stratum s. The details of each management practice that are recorded will depend on the choice of the soil model selected and the type of activity being promoted.

tiThe annual changes of SOC stock ($\Delta SOC_{m_G,s,t}$) and project removals due to changes in SOC (PR_t) in year t must be calculated using the following:

[4] Parton et. al., 1987

$$\Delta SOC_{m_G,s,t} = \Delta SOC_{model,m_G,s,t}\ (model\ parameters) \tag{43}$$

Where:

$\Delta SOC_{m_g,s,t}$	=	Change in SOC stock under management practice *mg* in stratum *s* during year *t* (tonnes C/(ha*yr))
$\Delta SOC_{model,m_G,s}$ $(model\ parameters)$	=	Modelled change in SOC stock under management practice *mg* in stratum *s* during year *t.*

The annual project removals due to changes in SOC in year *t* must be calculated using area-weighted average values of model input parameters for each management practice identified.

$$PR_t = \sum_{m_G} \sum_s PA_{m_G,s,t} \bullet \Delta SOC_{m_G,s,t} \times \frac{44}{12} \tag{44}$$

Where:

PR_t	=	Project removals due to changes in SOC in year *t* (t CO_2e)
$PA_{m_G,s,t}$	=	Project areas with management practice m_G in stratum s in year *t* (ha)
$\Delta SOC_{m_G,s,t}$	=	Change in SOC stock under management practice *mg* in stratum *s* during year *t* (tonnes C/(ha*yr))
S	=	Index of stratum
m_G	=	Index for grassland management types

The applicability of the selected model and parameters recorded for the various activities, 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 project document. However, data used to parameterize the selected model must be based on measurements of soil properties including bulk density and organic carbon concentrations to the full depth of affected soil layers, or a minimum depth of 30 cm where the full depth of affected soil layers is not known in advance.The required procedures for the sampling and measurement of these soil properties are outlined in Option 2 immediately below.

Option 2: Estimate of project removals due to changes in SOC using a measurement approach

For measuring soil organic carbon stock changes, soil sampling must follow a scientifically established method (eg, methods described in Carter and Gregoroch, 2006), or a nationally-approved standard (eg, the soil sampling protocol used to certify the changes of organic carbon stock in mineral soil of the European Union[5]). The frequency of SOC monitoring must be at least once every five years. Handling, storage, processing, measurement, and quality control of soil samples must follow scientifically established procedures such as the procedures described in

[5] Stolbovoy et al., 2007

Carter and Gregoroch, 2006, OECD, 1998, or nationally approved standards. Procedures should ensure that the presence of carbonates is adequately accounted for. Soil properties including bulk density and organic carbon concentration must be measured to the full depth of affected soil layers, or a minimum depth of 30 cm where the full depth of affected soil layers is not known in advance.

The below Equation 45 is used to calculate the SOC stock in stratum s, sampling site *i*, under project in year *t*. Sampling procedures should be designed such that the statistical significance of soil carbon stock changes between the baseline carbon stock and the carbon stock in time *t* can be determined with a 95 percent confidence interval. The *General Guidelines for Sampling and Surveys for Small-Scale CDM Project Activities* should be followed to determine the sampling procedure and sample size.

$$P_{SOC_{m_G,s,i,t}} = SOC_{m_G,s,i,t} \times BD_{m_G,s,i,t} \times Depth \times (1 - FC_{m_G,s,i,t}) \times 0.1 \qquad (45)$$

Where:

$P_{SOC_{m_G,s,i,t}}$	=	SOC stock in the top 30 cm (or greater depth if required) of soil for management practice m_G, stratum *s*, sampling site *i* under project in year *t* (t C/ha)
$SOC_{m_G,s,i,t}$	=	SOC content in the top 30 cm of soil (or greater depth if required) for management practice m_G, stratum s, sampling site *i*, under project in year *t* (g C/kg soil)
$BD_{m_G,s,i,t}$	=	Soil bulk density in the top 30 cm of soil (or greater depth if required) for management practice m_G, stratum *s*, sampling site *i*, under project in year *t* (g soil/cm^3)
$Depth$	=	Top soil depth, for calculating grassland SOC stock in the top 30 cm of soil (or greater depth if required) (cm)
$FC_{m_G,s,i,t}$	=	Percentage of rocks larger than 2mm, roots, and other dead residues with a diameter in the top 30 cm of soil (or greater depth if required), for management practice m_G, stratum *s*, sampling site *i* under project in year *t* (percent)
0.1	=	Conversion factor for SOC to t C/ha
m_G	=	Index of management practice
s	=	Index of stratum
i	=	Index of sampling site

Among the laboratory methods available to determination of TC and OC in soils, the total combustion method described in Nelson and Sommers (1996) is the most widely accepted and is therefore recommended for this purpose.

Calculate average carbon stock of all monitored sites in management practice m_G, stratum s, under project using the following:

$$P_{SOC_{m_G,s,t}} = \frac{\sum_{i=1}^{I} P_{SOC_{m_G,s,i,t}}}{I} \quad (46)$$

Where:

$P_{SOC_{m_G,s,t}}$	=	Average carbon stock in stratum *s* under project (t C/ha)
$P_{SOC_{m_G,s,i,t}}$	=	SOC stock in the top 30 cm (or greater depth if required) of soil for management practice m_G, stratum *s*, sampling site *i* under project in year *t* (t C/ha)
I	=	Monitored sites in stratum *s*, under project

The following is used to calculate the difference between the carbon stock for management practice m_G under project in year *t,* and the carbon stock under the baseline scenario, for all strata.

$$P_{m_G,t} = \sum_{s=1}^{S} (P_{SOC_{m_G,s,t}} - SOC_{s,Baseline}) \times PA_{m_G,s,t}) \quad (47)$$

Where:

$P_{m_G,t}$	=	Difference in the carbon stock between the project in year *t* and the baseline scenario (t C)
$PA_{m_G,s,t}$	=	Project areas with management practice m_G in stratum *s* in year *t* (ha)
$P_{SOC_{m_G,s,t}}$	=	Average carbon stock in stratum *s* under project in year *t* (t C / ha)
$SOC_{s,Baseline}$	=	Baseline SOC stock of stratum *s*, in the top 30 cm soil layer (or greater depth if required) (t C / ha)
S	=	Strata under project
s	=	Index of stratum

The following is applied to calculate average carbon stock of all management practice, under project in year *t*.

$$P_t = \sum_{m_G=1}^{M} P_{mG,t} \quad (48)$$

Where:

P_t	=	Carbon stock under project in year t (t C)
$P_{m_G,t}$	=	Difference in the carbon stock between the project in year *t* and the baseline scenario (t C)
M	=	Number of management practice

For the first monitoring of SOC stock, the annual project removals due to changes in SOC stock in year t must be calculated using the following:

.

$$PR_t = \frac{(P_t)}{n} \bullet \frac{44}{12} \quad (49)$$

Where:

PR_t	=	Project removals due to changes in SOC in year *t* (t CO_2e)
P_t	=	Carbon stock under project in year t (t C)
n	=	Number of years from the project start date to year t (years)

For the second and subsequent monitoring of SOC stock, the annual project removals due to changes in SOC stock in year t must be calculated using the following:

$$PR_t = \frac{(P_t - P_{t-f})}{f} \bullet \frac{44}{12} \quad (50)$$

Where:

PR_t	=	Project removals due to changes in SOC in year *t* (t CO_2e)
P_t	=	Carbon stock under project in year *t* (t C)
P_{t-f}	=	Carbon stock under project in year *t-f* (t C)
f	=	SOC monitoring frequency (years)

8.2.9 Uncertainty analysis

The methodology requires that all parameters used to estimate emissions and removals are conservative. Where conservative estimates are used that are based on verifiable literature sources or expert judgment, for the purposes of calculating uncertainty, it is not required to estimate a confidence interval for the parameter and uncertainty may be considered to be zero. Guidance on conservativeness of default parameters is given in the CDM EB *Guidelines on Conservative Choice and Application of Default Data in Estimation of the Net Anthropogenic GHG Removals by Sinks.* Where parameter values are derived from sample surveys undertaken within the project area, and the sample size is large (ie, >30), a conservative estimate of baseline carbon sequestration by carbon pools or project emissions by GHG sources is given by adopting a value that represents the upper bound of the 95 percent confidence interval (ie, sample mean + 1.96 × standard error), while a conservative estimate of baseline emissions by GHG sources or carbon sequestration by carbon pools in the project scenario is given by adopting a value that

represents the lower bound of the 95 percent confidence interval (ie, sample mean - 1.96 × standard error).[6]

Where Option 1 (use of a validated SOC model) is adopted to estimate changes in soil carbon stocks, quantification of uncertainty is required, and deductions for uncertainty must be applied following the procedures set out in this section. In addition to ex post deductions for uncertainty, the project proponent should also plan to diminish uncertainty in the process of planning data collection. The project proponent should refer to CDM EB approved *General Guidelines For Sampling And Surveys For Small-Scale CDM Project Activities* 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 must estimate the uncertainty of agricultural input parameters to the soil organic model selected. The project area should be stratified, and the sampling effort should represent the relevant strata in the sample frame. Where there is no specific survey guidance from national institutions, the project proponent must use a precision of 15 percent at the 95 percent confidence level as the criteria for reliability of sampling efforts. This reliability specification must 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 SGM lead to the achievement of a precision of ±15 at the 95 percent 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 modeling.

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

Calculate the mean, X_p and standard deviation, ∂_p for all parameters measured in SGM, then the standard error in the mean is given by:

$$SE_p = \frac{\partial_p}{\sqrt{n_p}} \tag{51}$$

Where:

SE_p	=	Standard error in the mean of parameter, *p* in year *t*
∂_p	=	Standard deviation of the parameter p in year *t*

[6] This approach assumes a large sample size and a normal distribution. Where sample size is small, and/or where the assumption of a normal distribution is not appropriate, alternative methods to derive a conservative estimate may be adopted following the guidance provided in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* Vol. 1, Chapter 3.

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 in the following:

$$P_{\min} = \overline{X_p} - 1.96 * SE_p$$
$$P_{\max} = \overline{X}_p + 1.96 * SE_p \quad (52)$$

Where:

$P_{\min}$	=	Minimum value of the parameter at the 95 percent confidence interval
$P_{\max}$	=	Maximum value of the parameter at the 95 percent confidence interval
SE_p	=	Standard error in the mean of parameter, *p* in year *t*
1.96	=	Value of the cumulative normal distribution at 95 percent 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 bin the following:

$$PR_{\min,t} = Model(P_{\min}, Temperature_{\max}, Precipitation_{\max}, ClayContent_{\min})$$
$$PR_{\max,t} = Model(P_{\max}, Temperature_{\min}, Precipitation_{\min}, ClayContent_{\max}) \quad (53)$$

Where:

$PR_{\min,t}$	=	Minimum value of project removals due to changes in soil organic carbon at the 95 percent confidence interval in year *t*
$PR_{\max,t}$	=	Maximum value of project removals due to changes in soil organic carbon at the 95 percent confidence interval in year *t*

Step 3: Calculate the uncertainty in the model output

The uncertainty in the output model must be calculated as described in the following:

$$UNC_t = \frac{\left| PR_{\max,t} - PR_{\min,t} \right|}{2 * PR_t} \quad (54)$$

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 percent of the mean value then the project proponent may use the estimated value without any deduction for conservativeness or increase in sampling.

If the uncertainty of soil models is greater than 15 percent but less than or equal to 30 percent of the mean value, then the project proponent may use the estimated value subject to a deduction calculated as described in the following:

$$PR_{Deduction,t} = PR_t * (UNC_t - 15\%) \quad (55)$$

And the following term will be used for calculation of net GHG emission reductions in Equation 60 in place of PR_t:

$$PR_{Adj,t} = PR_t - PR_{Deduction,t} \quad (56)$$

Where:

PR_t	=	Estimate of project removals due to changes in soil organic carbon in year *t* (t CO_2e)
PR_{Unc}	=	Estimate of uncertainty in the mean of changes in soil organic carbon in year *t* (t CO_2e)
$PR_{Deduction,t}$	=	Calculated deduction to the estimate of the change in soil organic removals year *t* (t CO_2e)
$PR_{Adj,t}$	=	Adjusted estimate of project removals due to changes in soil organic carbon in year *t* (t CO_2e)

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

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

8.2.10 Project net GHG emissions by sources and removals by sinks

The net GHG emissions and removals by sinks in project year *t* are given by:

$$PE_t = PE_{N_2O_{SN},t} + PE_{N_2O_{NF},t} + PE_{GHG_{BB},t} + PE_{CH_{4EF},t} + PE_{GHG_{MD},t} + PE_{FC,t} - PRWP_t - PR_t \quad (57)$$

Where:

PE_t	=	Project net GHG emissions by sources and removals by sinks in year *t* (t CO_2e)
$PE_{N_2O_{SN},t}$	=	Project N_2O emissions due to fertilizer use in year t (t CO_2e)
$PE_{N_2O_{NF},t}$	=	Project N_2O emissions as a result of N-fixing species within the project area in year *t* (t CO_2e)
$PE_{GHG_{BB},t}$	=	Project GHG emissions from biomass burning in year *t* (t CO_2e)
$PE_{CH_{4EF},t}$	=	Project CH_4 emissions from enteric fermentation in year *t* (t CO_2e)

$PE_{GHG_{MD},t}$	=	Project GHG emissions from manure management in year *t* (t CO_2e)
$PE_{FC,t}$	=	Project CO_2 emissions from farming machine fossil fuel consumption in year *t* (t CO_2)
$PRWP_t$	=	Project average net change in carbon stocks of existing woody biomass in year *t* (t CO_2)
PR_t	=	Project removals due to changes in SOC in year *t* (t CO_2e)

8.3 Leakage Emissions

Under this methodology, project activities must not involve increase in use of fossil fuels or fuel wood and must not include significanlty different manure management practices. Therefore the only potential sources of leakage in this methodology are the following:

1) Market leakage due to reduction in the production of livestock products within the project boundary;

2) Displacement of grazing beyond the project boundary.

Market leakage must be assessed and quantified using VCS Module *VMD0033 Estimation of Emissions from Market Leakage*. The result of applying the module is estimation of the parameter $LE_{M,t}$. Leakage from displacement of grazing activities to outside the project boundary must be assessed and quantified using VCS module *VMD0040 Leakage from Displacement of Grazing Activities*. The result of applying that module is estimation of the parameter $LE_{GD,t}$. Leakage emissions must be calculated as:

$$LE_t = LE_{M,t} + LE_{GD,t} \quad (58)$$

Where:

LE_t	=	Leakage emissions in year *t* (t CO_2e)
$LE_{M,t}$	=	Leakage emissions due to market leakage in year *t* (t CO_2e)
$LE_{GD,t}$	=	Leakage emissions due to grazing displacement in year *t* (t CO_2e)

8.4 Summary of GHG Emission Reduction and/or Removals

The amount of emission reductions achieved by the project in project year *t* must be calculated using the following Equation 59. Where relevant, emission reductions must be adjusted for uncertainty, as described in Section 8.2.9.

$$ER_t = BE_b - PE_t - LE_t \quad (59)$$

Where:

ER_t	=	Emission reductions in year *t* (t CO_2e)

BE_b	=	Baseline emissions and removals in year *b* (t CO_2e)
PE_t	=	Project emissions and removals in year *t* (t CO_2e)
LE_t	=	Leakage emissions in year *t* (t CO_2e)

The amount of emission reductions that can be issued as credits during the monitoring period must be calculated using the Eqauation 60. The emissions reductions generated during the monitoring period should be summed from the first year of the monitoring period, t_f, to the final year of the monitoring period, t_m.

AFOLU buffer credits must be deposited into the AFOLU pooled buffer account when the project requests issuance of VCUs, in accordance with the procedures in the VCS document *Registration and Issuance Process*. AFOLU buffer credits must be deducted from the total emission reducitons achieved to determine the total number of emission reductions elibile to be issued as VCUs, as calculated in the following:

$$VCU_t = ER_t - BC_t \tag{60}$$

Where:

VCU_t	=	Emission reductions eligible to be issued as VCUs in year *t* (t CO_2e)
ER_t	=	Emission reductions in year *t* (t CO_2e)
BC_{tm}	=	AFOLU buffer credits in year *tm* (t CO_2e)

The amount of AFOLU buffer credits that must be depositied into the AFOLU pooled buffer account must be calculated by multiplying the non-permanence risk rating by the change in carbon stocks in a given monitoring period. The non-permanence risk rating must be determined using the VCS *AFOLU Non-Permanence Risk Tool*. The amount of AFOLU buffer credits required for the monitoring period can be determined for the first monitoring period using Equation 61 or subsequent monitoring periods using Equation 62.

$$BC_t = RR_t * (PRWP_t + PR_t - BRWP_b) \tag{61}$$

or

$$BC_t = RR_t * (PRWP_t + PR_t - PRWP_{tp} - PR_{tp}) \tag{62}$$

Where:

BC_{tm}	=	AFOLU buffer credits in year *tm* (t CO_2e)
RR_t	=	Non-permanence risk rating in year *t* (percent)
$PRWP_t$	=	Project average net change in carbon stocks of existing woody biomass for species *j*, in year *t* (t CO_2)

PR_t	=	Project removals due to changes in SOC in year *t* (t CO_2e)
$BWRP_b$	=	Baseline removals from existing woody perennials in baseline year *b* (t CO_2)
$PRWP_{tp}$	=	Project average net change in carbon stocks of existing woody biomass at the end of the previous monitoring period *tp* (t CO_2)
PR_{tp}	=	Project removals due to changes in SOC at the end of the previous monitoring period *tp* (t CO_2e)

9 MONITORING

The purpose of the monitoring plan is to define a series of monitoring tasks to be conducted in order to ensure that the GHG emissions reductions claimed by the proposed project are real, additional and measurable. Subject to the specific requirements and guidance below, procedures specified in monitoring plans should meet the requirements of the most recent version of the *VCS Standard* and other VCS rules, and be consistent with guidance in internationally accepted guidance documents such as Volume 4 (Agriculture, Forestry and Other Land Use (AFOLU)) of the *2006 IPCC Guidelines on National Greenhouse Gas Inventories*.

Where sampling is conducted, procedures must attain a precision of 15 percent at the 95 percent confidence level.

Monitoring plans must include procedures for managing data quality that are consistent with internationally accepted guidance documents such as IPCC (2003) Chapter 5, or IPCC (2000) Chapter 8.

9.1 Data and Parameters Available at Validation

Data/Parameter	GWP_{N_2O}
Data unit	t CO_2e/t N_2O
Description	Global-warming potential for N_2O
Equations	1, 7, 10, 21, 26, 30 and 33
Source of data	GWP_{N_2O} must be obtained from the IPCC Second Assessment Report
Value applied	310
Justification of the choice of data or description of measurement methods and procedures applied	
Purpose of data	Calculation of baseline emissions Calculation of project emissions

Comments	

Data / Parameter	EF_{Nfert}
Data unit	kg N_2O-N/kg N applied
Description	N_2O emission factor for synthetic N fertilizer use
Equations	2 and 23
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	Project-specific value or IPCC default value
Justification of the choice of data or description of measurement methods and procedures applied	Where detailed emission factors from peer-reviewed scientific studies, specific to the project area or country, taking into account specific environmental, climatic and soil management conditions, are available, such data must be applied. Where detailed emission factors are unavailable, the default Tier 1 N_2O emission factor recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.1, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followedAFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comments	

Data Unit / Parameter	EF_{Nfix}
Data unit	kg N_2O-N/kg N input
Description	N_2O emission factor for N from N-fixing species
Equations	26
Source of data	Peer-reviewed scientific studies or default values from I*PCC Guidelines for National Greenhouse Gas Inventorie*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed emission factors from peer-reviewed scientific studies, specific to the project area or country, taking into account specific environmental, climatic and soil management conditions, are available, such data must be applied. Where detailed emission factors are unavailable, the default Tier 1 N2O emission factor recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table

	11.1, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of project emissions
Comment	

Data Unit / Parameter	EF_{Nfix}
Data unit	kg N_2O-N/kg N input
Description	N_2O emission factor for N from N-fixing species
Equations	26
Source of data	Peer-reviewed scientific studies or default values from I*PCC Guidelines for National Greenhouse Gas Inventorie*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed emission factors from peer-reviewed scientific studies, specific to the project area or country, taking into account specific environmental, climatic and soil management conditions, are available, such data must be applied. Where detailed emission factors are unavailable, the default Tier 1 N2O emission factor recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.1, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of project emissions
Comment	

Data Unit / Parameter	$M_{SNi,b}$
Data unit	t fertilizer
Description	Mass of synthetic N fertilizer type i applied in baseline year *b*
Equations	3
Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	The mass of synthetic N fertilizer must be based on documented management records of all synthetic N fertilizer types applied during the baseline period. Documented management records may include fertilizer application records or fertilizer purchase records. For new management entities or where such records are unavailable, a conservative estimate of the mass of synthetic N fertilizer applied per ha must be provided based on a sample

	survey conducted in the project area provide a conservative estimate of baseline N fertilizer application over the baseline period. Where data from sample surveys are used, a conservative estimate must be made following the guidance in Section 8.2.9. The total mass of synthetic N fertilizer applied must be estimated by multiplying the mass of synthetic N fertilizer applied per ha by the total grassland area involved in the project.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$NC_{SNi,b}$
Data unit	g N/g fertilizer
Description	Nitrogen content of synthetic N fertilizer type i applied in baseline year *b*
Equations	3
Source of data	Manufacturer product label or other manufacturer data
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	The nitrogen content must be recorded for each synthetic N fertilizer type i that has been applied in the baseline scenario. The value must be obtained from the product description stated by the manufacturer on the product label.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$Frac_{GAS,F}$
Data unit	kg N volatilized/kg N applied
Description	Fraction of synthetic N fertilizer that volatilizes as NH_3 and NO_x
Equations	3, 4, 24 and 25
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied.

	Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$EF_{4,SN}$
Data unit	kg N2O-N/(kg NH_3-N + NOx-N volatilized)
Description	N_2O emission factor for atmospheric deposition of synthetic N on soils and water surfaces
Equations	4 and 25
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$EF_{4,MD}$
Data unit	kg N_2O-N/(kg NH_3-N + NOx-N volatilized)
Description	N_2O emission factor for atmospheric deposition of urine and manure N on soils and water surfaces
Equations	14 and 37
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	

Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$A_{B,b}$
Data unit	Ha
Description	Area burned in baseline year *b*
Equations	6 and 7
Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Area burned in each year during the baseline period must be based on documented fire management records averaged over the five year period prior to the project start date. For new management entities or where such records are unavailable, a conservative estimate of the area burned during the baseline period must be provided based on a sample survey conducted in the project area. The sample survey must provide a conservative estimate of the area burned in each year during the baseline period. Where sample survey data are used, a conservative estimate of the area burned must be made following the guidance in Section 8.2.9. The annual area burned must be equal to the percentage area burned times the total grassland area involved in the project.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$M_{B,b}$
Data unit	t biomass dm/ha
Description	Aboveground biomass in terms of dry matter burned in baseline year *b*

Equations	6 and 7
Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Aboveground biomass burned under baseline must be based on documented fire management records averaged over the baseline period. For new management entities or where such records are unavailable, aboveground biomass burned under the baseline scenario must be conservatively estimated based on sample surveys conducted before the project start date. Where sample survey data are used, the mean aboveground biomass burned under the baseline scenario must be converted to a conservative estimate following the guidance on conservative parameter estimates presented in Section 8.2.9.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	C_f
Data unit	t dry matter burnt/t biomass
Description	Combustion factor
Equations	6, 7, 29 and 30
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.6, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.peer-reviewed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	EF_{CH_4}
Data unit	g CH_4/kg dry matter burnt

Description	CH_4 emission factor for biomass burning
Equations	6 and 29
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.6, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.peer-reviewed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	GWP_{CH_4}
Data unit	t CO_2e/t CH_4
Description	Global-warming potential for CH_4
Equations	6, 8, 15, 29 and 31
Source of data	GWP_{CH_4} must be obtained from the IPCC Second Assessment Report
Value applied	21
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$P_{l,b}$
Data unit	Head
Description	Population of grazing livestock type l, in baseline year *b*
Equations	8, 13 and 15

Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Population of grazing livestock must be based on documented management records, averaged over the baseline period. For new management entities or where such records are unavailable, a conservative estimate of the animal population must be provided based on a sample survey of the animal population grazing in the project area year prior to the project start dateduring the baseline period. The design of the sample survey must consider the annual livestock population during the baseline period, which may not be the same as the population present at the time of the survey. Where data from sample surveys are used, a conservative estimate of the baseline livestock population must be made following the guidance on using conservative parameter estimates derived from sample surveys, presented in Section 8.2.9.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	EF_l
Data unit	kg CH_4/(head * year)
Description	Enteric CH_4 emission factor per head of livestock type l per year
Equations	8 and 31
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. When data from IPCC sources are used, the project proponentmust refer to the tables in Annex 10A.1 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the value selected reflects the underlying animal characteristics appropriate to the selected value.

Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$EF_{3,PRP,CPP}$
Data unit	kg N_2O-N/kg N input
Description	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on of applied to grassland
Equations	11 and 34
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. When data from IPCC sources are used, the project proponent must refer to the tables in Annex 10A.1 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the value selected reflects the underlying animal characteristics appropriate to the selected value.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$EF_{3,PRP,SO}$
Data unit	kg N_2O-N/kg N input
Description	N_2O emission factor for sheep and other animals manure and urine deposited on of applied to grassland
Equations	12 and 35
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	

Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. When data from IPCC sources are used, the project proponentmust refer to the tables in Annex 10A.1 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the value selected reflects the underlying animal characteristics appropriate to the selected value.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	Nex_l
Data unit	kg N deposited/(t livestock mass * day)
Description	Nitrogen excretion of livestock type *l*
Equations	13 and 36
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. When data from IPCC sources are used, the project proponentmust refer to the tables in Annex 10A.1 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the value selected reflects the underlying animal characteristics appropriate to the selected value.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$W_{l,b}$
Data unit	Kg
Description	Average weight of livestock *l*, in baseline year *b*
Equations	
Source of data	Peer reviewed scientific literature or expert judgment.
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Data from the peer-reviewed scientific literature or expert judgement that are specific to the project area.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$W_{l,p}$
Data unit	Kg
Description	Average weight of livestock under project
Equations	
Source of data	Peer reviewed scientific literature or expert judgment.
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Data from the peer-reviewed scientific literature or expert judgment that are specific to the project area. To ensure that the estimated N2O emission reductions from manure and urine deposited on grassland soil are conservative, the value selected for the average weight of livestock l under project ($W_{l,p}$) must be greater than the average weight of livestock l, in baseline year b ($W_{l,p}$). Moreover, the project proponent must justify why the values selected for these parameters results in emission reductions that are conservative.
Purpose of data	Calculation of project emissions
Comment	

Data Unit / Parameter	$Days_{l,b}$
Data unit	Days
Description	Grazing days for livestock type *l* in baseline year *b*
Equations	8, 13 and 15

Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Grazing days inside the project area in the baseline must be based on documented management records, averaged over the baseline period. For new management entities or where such records are unavailable, grazing days must be based on the average annual grazing days from a sample survey of livestock grazing in the project area in the year prior to the project start date. Where data from sample surveys are used, a conservative estimate must be made to enable conservative estimates of livestock enteric fermentation and manure management emissions.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$H_{l,b}$
Data unit	Hours
Description	Average grazing hours for livestock type *l* per day during the grazing season in baseline year *b*
Equations	13 and 15
Source of data	Documented management records or sample surveys
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	The average grazing hours per day in the baseline must be based on documented management records, averaged over the baseline period. For new management entities or where such records are unavailable, a conservative estimate of average grazing hours must be provided based on the average grazing hours in each grazing season taken from a sample survey of livestock grazing in the project area in the year prior to the project start date. Where data from sample surveys are used, a conservative estimate must be made to enable a conservative estimate of livestock manure management emissions.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$Frac_{GAS,MD}$
Data unit	kg N volatilized/kg of N deposited
Description	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x
Equations	13, 14, 36 and 37
Source of data	Peer reviewed scientific studies or default values from I*PCC Guidelines for National Greenhouse Gas Inventoriespeer-reviewed*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	EF_{lM}
Data unit	kg CH_4/(head * year)
Description	CH_4 emission factor from manure of livestock type *l*
Equations	15 and 38
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10,

	Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$FC_{p,j,k,B}$
Data unit	kg fuel/year
Description	Fuel consumption by type *k*, machine type *j*, parcel grassland *p*, in baseline
Equations	16
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Documented management records or sample surveys. Fuel consumption for grassland management under the baseline scenario must be estimated on the basis of management records , such as fuel consumption logs, averaged over the baseline period. For new management entities or where such records are unavailable, a conservative estimate of fuel consumption must be provided based on a sample survey conducted in the project area regarding fuel consumption during the baseline period. Where data from sample surveys are used, a conservative estimate must be made following the guidance in Section 8.2.9. A sample survey mean may be converted to a conservative estimate by subtracting 1.96 × the standard error from the mean.
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$EF_{CO_2,k}$
Data unit	t CO_2/GJ
Description	CO_2 emission factor by fuel type *k*
Equations	16 and 39
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	

Justification of choice of data or description of measurement methods and procedures applied	Where detailed emissions factors from peer-reviewed scientific studies, specific to the country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	NCV_k
Data unit	GJ/t fuel
Description	Thermal value of fuel type *k*
Equations	16 and 39
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed emissions factors from peer-reviewed scientific studies, specific to the country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$A_{B,j,s}$
Data unit	Ha
Description	Area of trees and shrubs under baseline, for species j in stratum *s*
Equations	18
Source of data	Documented management records or sample surveys
Value applied	

Justification of choice of data or description of measurement methods and procedures applied	Area of trees and shrubs under the baseline scenario must be obtained from a field survey before the project start date.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	CF_j
Data unit	t C/t dm
Description	Carbon fraction for species *j*
Equations	18 and 41
Source of data	Default values in the CDM A/R Methodological Tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
Value applied	0.50 for tree species; 0.49 for shrub species.
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	R_j
Data unit	t dm belowground biomass/t dm aboveground biomass
Description	Root to shoot ratio of species *j*
Equations	19 and 42
Source of data	Default values in the CDM A/R Methodological Tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities.*
Value applied	0.26 for tree species; 0.4 for shrub species
Justification of choice of data or description of measurement methods and procedures applied	

Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$G_{AB,B,j,s}$
Data unit	t dm/ha
Description	Average annual increase in existing aboveground woody biomass of species *j* in stratum *s*, under baseline.
Equations	19
Source of data	Use one of the methods for the estimation of carbon stocks and change in carbon stocks in trees and shrubs in the baseline outlined in the latest version of the CDM tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*. Follow the measurement, sampling, modeling and default estimation procedures specified in this tool.
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of data	Calculation of baseline emissions
Comment	

Data Unit / Parameter	$SOC_{s,Baseline}$
Data unit	t C/ha
Description	Baseline SOC stock in the top 30 cm of soil layer (or greater depth if required) in stratum *s*
Equations	43
Source of data	Results from biogeochemical model or project measurements
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where Option 1, outlined in Section 8.2.8, is applied to estimate project removals due to changes in SOC, the project proponent must use the biogeochemical model selected under Option 1 to conservatively determine $SOC_{s,Baseline}$, by setting the value of this parameter to the computed maximum carbon stocks that

	occurred in the designated project area and stratum within the previous 10 years. Where Option 2 is applied to estimate project removals due to changes in SOC, the project proponent must follow the procedures for the sampling and measurement of soil properties, including bulk density and organic carbon concentrations, that are outlined in Option 2 in Section 8.2.8to determine the value of $SOC_{s,Baseline}$, less than two years prior to the project start time. The General Guidelines for Sampling and Surveys for Small-Scale CDM Project Activities should be followed to determine the sampling procedures and the sample size.
Purpose of data	Calculation of project emissions
Comment	

Data Unit / Parameter	EF_{N_2O}
Data unit	g N_2O/kg dry matter burnt
Description	N_2O emission factor for biomass burning
Equations	7 and 30
Source of data	Peer reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.5, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.peer-reviewed.
Purpose of data	Calculation of baseline emissions Calculation of project emissions
Comment	

Data Unit / Parameter	$\Delta SOC_{model,m_G,s,t(model\ parameters)}$
Data unit	t C/(ha*yr)

Description	Modelled change in SOC stock under management practice *mg* in stratum *s* during year *t*.
Equations	43
Source of data	Model
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Methods used to measure and/or monitor model parameters must be outlined either as Data and Parameters Available at Validation or Data and Parameters Monitored.
Purpose of data	Calculation of project emissions
Comment	

Data Unit / Parameter	f
Data unit	Year
Description	SOC monitoring frequency
Equations	50
Source of data	Project records
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Where the project applies option 2 to directly measure SOC, the frequency of SOC measurements must be at least once every five years.
Purpose of data	Calculation of project emissions
Comment	

9.2 Data and Parameters Monitored

Data Unit / Parameter	$M_{SNi,t}$
Data unit	t fertilizer
Description	Mass of synthetic N fertilizer type *i* applied in year *t*
Equations	24
Source of data	Project records
Description of measurement methods and procedures to be applied	The mass must be recorded just after the application of synthetic N fertilizer for each fertilizer type applied for each year.

Frequency of monitoring/recording	Each application of fertilizer during year t
QA/QC procedures to be applied	Guidelines provided in IPCC, 2003 Chapter 5 or IPCC, 2000 Chapter 8
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$NC_{SNi,p}$
Data unit	g N/g fertilizer
Description	Nitrogen content of synthetic N fertilizer type *i* applied under project
Equations	24
Source of data	Manufacturer product label or other manufacturer data
Description of measurement methods and procedures to be applied	The nitrogen content must be recorded for each synthetic N fertilizer type *i* that has been applied in the baseline scenario or project. The value must be obtained from the product description stated by the manufacturer on the product label.
Frequency of monitoring/recording	Each application during project crediting period in year t
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$Area_{g,t}$
Data unit	ha
Description	Annual area of N-fixing species *g* in year t
Equations	27
Source of data	Project records
Description of measurement methods and procedures to be applied	Record the area of N-fixing species by all households involved in the project.
Frequency of monitoring/recording	Annually, at the beginning of growing season.
QA/QC procedures to be applied	Where the difference between the recorded and the new reading is more than 10 percent, reasons for the difference

	must be discussed with the staff responsible for taking both measurements, and if necessary the $Area_{g,p,t}$ should be re-measured.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$Crop_{g,t}$
Data unit	t dm/ha
Description	Annual dry matter, including aboveground and below ground, returned to grassland soils for N-fixing species *g* in year t.
Equations	27
Source of data	Project records
Description of measurement methods and procedures to be applied	Measure annual dry matter, including aboveground and below ground, returned to grassland soils for N-fixing species g in year t. The sample size of household number must ensure precision at 95±15 precision.
Frequency of monitoring/recording	Annually, at the end of growing season.
QA/QC procedures to be applied	The sample collection should be carried out by experts or well-trained staff. Where the difference between the recorded and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the $Crop_{g,t}$ should be re-measured.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$N_{content,g}$
Data unit	t N/t dmt N
Description	Fraction of N in dry matter for N-fixing species g under project
Equations	27
Source of data	Project records
Description of measurement methods and procedures to be applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied.

	Where detailed data are unavailable, an peer-reviewedexpert survey within the project area must be performed before the start of the project. Data must be surveyed by collecting biomass (aboveground and below ground) from at least three plots (1m*1m) of each N-fixing species in each sampled household. Send the samples to a qualified laboratory to analyze the N content in the biomass.
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	A sufficient number of plots for sampling $N_{content,\mathrm{p},g}$ must be used to ensure that a precision of 15 percent at the 95 percent confidence level is attained. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be applied for guidance on sampling methods and QA/QC procedures. The sample collection must be carried out by appropriately trained staff. The measurement of the N content in the biomass must be carried out by a laboratory that can demonstrate adherence to the principles of good laboratory practices, outlined in OECD (1998).
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$A_{B,t}$
Data unit	Ha
Description	Area burnt in year t during the project crediting period
Equations	29 and 30
Source of data	Project records
Description of measurement methods and procedures to be applied	Measure and record the area burnt after the fire occurrence
Frequency of monitoring/recording	Each burning activity in year t during project crediting period
QA/QC procedures to be applied	Where the difference between the recorded burnt area and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the burnt area should be re-measured.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$M_{B,t}$
Data unit	t biomass/ha
Description	Aboveground biomass burnt, excluding litter and dead wood under project in year t.
Equations	29 and 30
Source of data	Project records
Description of measurement methods and procedures to be applied	Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the aboveground biomass is the aboveground biomass burnt.
Frequency of monitoring/recording	Each burning activity in year t during the project crediting period
QA/QC procedures to be applied	A sufficient number of plots for sampling $M_{B,p,t}$ must be used to ensure that a precision of 15 percent at the 95 percent confidence level is attained. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be used for guidance on sampling methods and QA/QC procedures.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$P_{l,t}$
Data unit	*head*
Description	Population of livestock type *l* under project in year t
Equations	31, 36 and 38
Source of data	Project records
Description of measurement methods and procedures to be applied	Record numbers of grazing livestock by type. The sample size of household number must ensure that a precision of 15 percent at the 95 percent confidence level is attained. The value must be based on the grazing numbers; annual or seasonal average population of grazing livestock by type.
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied

Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$H_{l,t}$
Data unit	Hours
Description	Average grazing hours per day of livestock type l during grazing season in year t
Equations	36 and 38
Source of data	Project records
Description of measurement methods and procedures to be applied	Record the average number of grazing hours per day during grazing season in year t. The sample size of household number must ensure that a precision of 15 percent at the 95 percent confidence level is attained.
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$Days_{l,t}$
Data unit	Days
Description	Grazing days of livestock l in year t under project
Equations	31, 36 and 38
Source of data	Project records
Description of measurement methods and procedures to be applied	Record the grazing days in year t. The sample size of household number must ensure that a precision of 15 percent at the 95 percent confidence level is attained.
Frequency of monitoring/recording	At the end of every grazing season in year t
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$G_{AB,j,s,t}$
Data unit	t dm/ha
Description	Average increase in existing aboveground woody biomass of species *j*, in stratum *s*, under project for year *t*.
Equations	42
Source of data	Project records
Description of measurement methods and procedures to be applied	Use one of the methods for estimating changes in carbon stock of trees and shrubs between two points in time for project activities outlined in the latest version of the CDM tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*. Follow the sampling, measurement, modeling, and monitoring procedures specified in this tool.
Frequency of monitoring/recording	At the end of every monitoring period
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory must be applied. Where such procedures are not available, QA/QC procedures from published handbooks, or from the IPCC, 2003 *Good Practice Guidance for Land Use, Land Use Change and Forestry* (or the most recent version of IPCC good practice guidance for AFOLU) must be applied.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$FC_{p,j,k,t}$
Data unit	Kg fuel
Description	Fuel consumption by type k, machine type *j*, parcel grassland *p*, in year t under project
Equations	39
Source of data	Project records
Description of measurement methods and procedures to be applied	Record fuel consumption by type *k*, machine type *j*, parcel grassland *p* of each household.
Frequency of monitoring/recording	Record fuel consumption just after the application of machine.
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied

Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$A_{P,j,s,t}$
Data unit	Ha
Description	Area of trees and shrubs of species *j* in stratum *s* under project in year *t*
Equations	41
Source of data	Project records
Description of measurement methods and procedures to be applied	Maps, orthorectified images, or field-based GPS measurements must be applied. Horizontal projected area required.
Frequency of monitoring/recording	Annually, at the beginning of growing season in year t
QA/QC procedures to be applied	Where the difference between the recorded area of trees and shrubs and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the area of trees and shrubs should be re-measured.
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$PA_{m_G,s,t}$
Data unit	Ha
Description	Project areas of grassland with management practice *Mg* in stratum *s* in year *t*
Equations	44 and 47
Source of data	Project records
Description of measurement methods and procedures to be applied	Record the area of grassland with management practice *Mg* in stratum *s*.
Frequency of monitoring/recording	Record the area and management practice just after the management practice has taken place and report annually
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Purpose of data	Calculation of project emissions

Comments	

Data Unit / Parameter	$SOC_{m_G,s,i,t}$
Data unit	g C/kg soil
Description	SOC stock in the top 30 cm of soil (or greater depth if required) for management practice m_G, stratum *s* (or greater depth if desired), sampling site *i*
Equations	45
Source of data	Project records
Description of measurement methods and procedures to be applied	Measurement methods and procedures described in Section 8.2.8 of this methodology must be applied.
Frequency of monitoring/recording	At least once every five years, at the end of growing season in the year measured, until the end of the project crediting period
QA/QC procedures to be applied	Soil sampling, sampling intensity, handling and storage, processing and measurement of $SOC_{m_G,s,i,t}$, and quality control must follow the guidance, methods and procedures as described in Section 8.2.8 of this methodology.The collection of soil samples for measuring SOC must be carried by suitably trained staff. The measurement of SOC must be carried out by a laboratory that can demonstrate adherence to the principles of good laboratory practices, outlined in OECD (1998).
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$BD_{m_G,s,i,t}$
Data unit	g soil/cm^3
Description	Soil bulk density in the top 30 cm of soil (or greater depth if required) for management practice m_G, stratum *s* (or greater depth if desired), sampling site *i*
Equations	45
Source of data	Project records
Description of measurement methods and procedures to be applied	Measurement methods and procedures described in Section 8.2.8 of this methodology must be applied.

Frequency of monitoring/recording	At least once every five years, at the end of growing season in the year measured, until the end of the project crediting period
QA/QC procedures to be applied	Soil sampling, sampling intensity, handling and storage, processing and measurement of $BD_{m_G,s,i,t}$, and quality control must follow the guidance, methods and procedures as described in Section 8.2.8 of this methodology. The collection of soil samples for measuring soil bulk density must be carried by suitably trained staff. The measurement of soil bulk density must be carried out by a laboratory that can demonstrate adherence to the principles of good laboratory practices, outlined in OECD (1998).
Purpose of data	Calculation of project emissions
Comments	

Data Unit / Parameter	$FC_{m_G,s,i,t}$
Data unit	percent
Description	Percentage of rocks with a diameter larger than 2mm, roots, and other dead residues in the top 30 cm of soil (or greater depth if desired), for management practice m_G, stratum *s*, sampling site *i*
Equations	45
Source of data	Project records
Description of measurement methods and procedures to be applied	Measurement methods and procedures described in Section 8.2.8 of this methodology must be applied.
Frequency of monitoring/recording	At least once every five years, at the end of growing season in the year measured, until the end of the project crediting period
QA/QC procedures to be applied	Soil sampling, sampling intensity, handling and storage, processing and measurement of $FC_{m_G,s,i,t}$, and quality control must follow the guidance, methods and procedures as described in Section 8.2.8 of this methodology. The collection of soil samples for measuring $FC_{m_G,s,i,t}$ must be carried by suitably trained staff. The measurement of $FC_{m_G,s,i,t}$ must be carried out by a laboratory that can demonstrate adherence to the principles of good laboratory practices, outlined in OECD (1998).
Purpose of data	Calculation of project emissions

Comments	

Data Unit / Parameter	*Depth*
Data unit	cm
Description	Total soil depth, for calculating grassland SOC stock in the top 30 cm of soil (or greater depth if required)
Equations	45
Source of data	Project records
Description of measurement methods and procedures to be applied	The value for soil depth must be consistent with the measurements taken. Soil properties must be measured to the full depth of affected soil layers. Where the full depth of affected soil layers is not known, a minimum depth of 30 cm must be applied.
Frequency of monitoring/recording	Recorded with each measurement taken
QA/QC procedures to be applied	
Purpose of data	Calculation of project emissions
Comments	

9.3 Description of the Monitoring Plan

The monitoring plan must include a statement of the purpose(s) of monitoring, and describe monitoring procedures adequate for obtaining, recording, compiling and analyzing data and information important for quantifying and reporting GHG emissions and/or removals relevant for the project (including leakage) and baseline scenario and for meeting any other stated purposes of monitoring. All data collected as part of monitoring must be archived electronically and be kept at least for two years after the end of the project crediting period.

9.3.1 Monitoring of Project Implementation

Information must be provided, and recorded in the project description to establish:

- A record of the grazing agents (eg, herder households) involved the project.
  - The project proponent should record each household involved in the sustainable grassland management project.
  - Each household should be given a unique ID. Their name, location of their land, and date of entering into the agreement and leaving the agreement should be recorded.
- A record of the geographic location of the project area for all areas of grassland;

  - The geodetic coordinates of the project area (and any stratification inside the area) must be established, recorded and archived. This can be achieved by field survey (eg, using GPS), or by using geo-referenced spatial data (eg, maps, GIS datasets).

- A record of grassland management
  - The grassland management plan, together with a record of the plan as actually implemented during the project crediting period must be available for validation and verification.

9.3.2 Validation of Biogeochemical Model

As set out in the applicability conditions, if a biogeochemical model is selected for estimation of change in soil carbon stocks, the model must meet with the requirements for models as set out in the VCS rules.

If a biohgeochemical model is used, it must be validated for the region within which the project is situated based on studies by appropriately qualified experts (eg, scientific journals, university theses, local research studies or work carried out by the project proponent) that demonstrate that the use of the selected biogeochemical model is appropriate. This can be done using one of the approaches described below:

- Approach 1: The studies used in support of the project must meet the guidance on model applicability as set out in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* 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 (ie, driving variables) are validated from country or region-specific locations that are representative of the variability of climate, soil and management systems in the country.
- Approach 2: Where available, national, regional or global level agroecological zone (AEZ) classification can be used to to show that the model has been validated for similar AEZs. It is recognized that national level AEZ classifications are not readily available, and therefore this methodology allows the use of the global and regional AEZ classification.
- Approach 3: Where a project area consists of multiple sites, it is recognized that studies demonstrating model validity using either Approach 1 or Approach 2 may not be available for each of the sites in the project area. In such cases the study used must be capable of demonstrating that the following two conditions are met:
  - The model is validated for at least 50 percent of the total project area where the project area covers up to and including 50,000 ha; or at least 75 percent of the total project area where project area covers greater than 50,000 ha; and
  - The area for which the model is validated generates at least two-thirds of the total project emission reductions.

9.3.3 Sampling Design and Stratification (Option 2)

Stratification of the project area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit.

The project proponent must present in the project description an ex-ante stratification of the project area or justify the lack of stratification. The number and boundaries of the strata defined ex-ante may change during the project crediting period (ex-post). Four main requirements should be met before the stratified sampling is chosen:

- Population must be stratified in advance of the sampling.
- Classes must be exhaustive and mutually exclusive (ie, all elements of the population must fall into exactly one class).
- Classes must differ in the attribute or property under study, otherwise there is no gain in precision over simple random sampling.
- Selection of items to represent each class (ie, the sample drawn from each class) must be random.

<u>Updating of strata</u>

The ex-post stratification must be updated due to the following reasons:

- Unexpected disturbances occurring during the project crediting period (eg, due to fire, pests or disease outbreaks), affecting differently various parts of an originally homogeneous stratum;
- Grassland management activities (planting) may be implemented in a way that affects the existing stratification.

Established strata may be merged if reasons for their establishment have disappeared.

<u>Sampling framework</u>

To determine the sample size of each stratum, the project proponent must use the latest version of the CDM *Tool for the Calculation of the number of sample plots for measurements within A/R CDM project activities*. The targeted precision level for estimation across the project must be a precision of 15 percent at the 95 percent confidence level. Note that although the CDM tool does not allow temporary plots, such plots are permitted under this methodology.

The selection of random points in each stratum has been greatly facilitated by the widespread use of Global Positioning System (GPS) receivers in field research. The points to be sampled can

be randomly selected before going to the field, downloaded into the GPS unit, and then the researcher can use the GPS to guide them to that location in the field.

9.3.4 Recording of Data and Parameters Monitored

The following parameters must be record and monitored during the project. When applying the equations provided in this methodology for the *ex-ante* calculation of net anthropogenic GHG removals by sinks, the project proponent must provide transparent estimations for the parameters that are monitored during the project crediting period. These estimates must be based on measured or existing published data where possible and the project proponent must apply a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

For the estimate of annual emissions from the use of synthetic fertilizers, the following parameters must be recorded at each application during the project crediting period:

- Mass and type of synthetic N fertilizer applied;
- Nitrogen content of synthetic N fertilizer applied.

For the estimate of annual emissions from the burning of grassland, the following parameters must be recorded annually during the project crediting period:

- Annual area of N-fixing species
- Annual dry matter, including aboveground and below ground, returned to grassland soils for N-fixing species
- Fraction of N in dry matter for N-fixing species

For the estimate of annual emissions from the burning of grassland, the following parameters must be recorded at each burning activity during the project crediting period:

- Area burned in year t during the project crediting period
- Aboveground biomass burned exclude litter and dead wood

For the estimate of annual CH_4 emissions from enteric fermentation, population of livestock type *l* and grazing days of livestock type *l* must be recorded annually during the project crediting period.

For the estimate of annual CH_4 and N_2O emissions from manure deposition during grazing, grazing days of livestock of type *l*, and average grazing hours per day of livestock type *l* during the grazing season must be recorded in every grazing season, in each year during the project project crediting period.

For the estimate of annual CO_2 emissions due to the use of fossil fuels for SGM, the following parameters must be recorded at each time a management practice using machines is adopted

and reported annually during the project crediting period:

- Quantity of fuel consumption;
- Fuel type;
- Machine type.

For the estimate of annual emissions and removals from woody perennials, the area of trees and shrubs of each stratum must be recorded annually during the project crediting period:

To estimate project removals due to changes in SOC with a validated model, project areas in grassland with different management practice must be recorded.

If option 2 for estimating project removals due to changes in SOC is selected, the following parameters must be monitored at least once every five years during the project crediting period. The soil sampling, handling and storage, processing and measurement, and quality control procedures implemented in soil organic carbon analysis that follow a scientific peer-reviewed or nationally approved standard.

- SOC content;
- Soil bulk density;
- Percentage of rocks with a diameter larger than 2mm, roots and other dead residues;
- Carbonate content.

For the estimate of leakage emissions, the monitoring parameters required in the VCS modules VMD033 *Estimation of Emissions from Market Leakage* and VMD040 *Estimation of Leakage Emissions from Displacement of Grazing Activity due to Implementation of Sustainable Grassland Management Activities* must be recorded annually during the project crediting period.

10 REFERENCES

Carter M.R. and Gregoroch EG, (eds). 2006. Soil Sampling and Methods of Analysis. Second Edition. . Taylor & Francis Group, *LLC.* Pp743-759.

IPCC. 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Institute for Global Environmental Strategies (IGES)

IPCC. 2003. Good Practice Guidance for Land Use, Land Use Change and Forestry. Institute for Global Environmental Strategies (IGES)

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies (IGES)

Nelson, D.W. and Sommers, L.E.. 1996. Total carbon, organic carbon, and organic matter. In: A.L. Page et al., (eds). Methods of Soil Analysis, Part 2 (2nd ed.) Agronomy. 9:961-1010. Am. Soc. of Agron., Inc. Madison, WI.

OECD. 1998. OECD Principles of Good Laboratory Practice. OECD Environmental Health and Safety Publications Series on Principles of Good Laboratory Practice and Compliance Monitoring. OECD: Paris

Parton, W.J., Schimel, D.S., Cole, C.V. & Ojima, D.S. 1987. Analysis of factors controlling soil organic matter levels in Great Plains grasslands. Soil Science Society of America Journal, 51(5): 1173–1179.

Stolbovoy, V., Montanarella, L., Filippi, N., Jones, A., Gallego, J., and Grassi, G. 2007. Soil sampling protocol to certify the changes of organic carbon stock in mineral soil of the European Union. Version 2. European Commission, Joint Research Centre. ISBN 978-92-79-05379-5 http://eusoils.jrc.ec.europa.eu/esdb_archive/eusoils_docs/other/EUR21576.

Zar, J.H. 1996. *Biostatistical Analysis*. Prentice-Hall.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	22 Apr 2014	Initial version
V1.1	24 June 2021	Equation 43 updated to remove the need to divide the increases in soil organic carbon across the period it takes for the soil to reach equilibrium.