

VCS Methodology for Agricultural Land Management Improved Grassland Management

**Mark Dangerfield
Charlie Wilson
James Schultz
Alex Nimz**

November 2010

Agricultural Land Management – Improved Grassland Management

Version 2.4 November 2010

Scope

This methodology is for estimating and monitoring the greenhouse gas emission reductions resulting from improved grassland management projects.

Table of Contents

Scope	2
Table of Contents	3
PART 1 - SOURCES, DEFINITIONS AND APPLICABILITY	6
1. Sources	6
2. Definitions	7
3. Symbols and Notations	7
3.1 Physical quantities	8
3.2 Scenario qualifiers	8
4. Applicability	9
PART 2 – STEP-BY-STEP METHODOLOGY DESCRIPTION	10
STEP 0 – Eligibility	12
STEP 1 - Project Boundaries and Scope	13
Step 1.1 Geographical Boundaries	13
Step 1.2 Temporal Boundaries	13
Step 1.3 Carbon Pools	14
Step 1.4 Greenhouse Gases	14
STEP 2 – Baseline Selection and Additionality	16
Step 2.1 Potential baseline scenarios	16
Step 2.2 Selecting the baseline scenario	16
Step 2.3 Additionality	16
STEP 3 – <i>Ex-ante</i> Grassland Management Plans and Stratification	17
Step 3.1 Grassland Management Plan	17
Step 3.2 Improved Grassland Management Plan	17
Step 3.3 Select carbon pools and greenhouse gas emission sources	18
Step 3.4 Stratification	20
STEP 4 – <i>Ex-ante</i> Net Greenhouse Gas Emissions in the Baseline Scenario	22
Step 4.1 Determine soil organic carbon stock change in the baseline scenario	22
Step 4.2 Determine carbon stock change in above-ground woody biomass in the baseline scenario	25
Step 4.3 Determine methane production from enteric emissions in the baseline scenario	29
Step 4.4 Determine greenhouse gas emissions from fossil fuel combustion in the baseline scenario	31
Step 4.5 Determine emissions from fertilizer use in the baseline scenario	32
Step 4.6 Net GHG emissions in the baseline scenario	33
STEP 5 – <i>Ex-ante</i> Net Greenhouse Gas Emissions in the Project Scenario	35
Step 5.1 Determine soil organic carbon stock change in the project scenario	35
Step 5.2 Determine carbon stock change in above-ground woody biomass in the project scenario	37

Step 5.3 Estimate methane production from enteric emissions in the project scenario	40
Step 5.4 Determine greenhouse gas emissions from fossil fuel combustion in the project scenario.....	42
Step 5.5 Estimate emissions from fertilizer use in the project scenario.....	42
Step 5.6 Estimate net Greenhouse gas emissions in the ex-ante project scenario.....	44
STEP 6 – Ex-post <i>Grassland Management Plans and stratification</i>	45
Step 6.1 Ex-post Grassland Management Plan	45
Step 6.2 Ex-post Improved Grassland Management Plan	46
Step 6.3 Update carbon pools and greenhouse gas emission sources	46
STEP 7 – <i>Ex post</i> Net Greenhouse Gas Emissions in the baseline scenario	49
Step 7.1 Determine SOC stock change in the baseline scenario	49
Step 7.2 Determine carbon stock change in above-ground woody biomass in the baseline scenario.....	49
Step 7.3 Determine methane production from enteric emissions in the ex-post baseline scenario.....	53
Step 7.4 Determine emissions from fossil fuel combustion in the ex-post baseline scenario.....	55
Step 7.5 Determine emissions from fertilizer use in the ex-post baseline scenario	56
Step 7.6 Net greenhouse gas emissions in the ex-post baseline scenario.....	57
STEP 8 – <i>Ex-post</i> Net Greenhouse Gas Emissions in the Project Scenario.....	59
Step 8.1 Estimate SOC stock change in the ex-post project scenario from SOC modelling	59
Step 8.2 Validate SOC stock change estimate in the ex-post project scenario	59
Step 8.3 Determine carbon stock change in above-ground woody biomass in the ex-post project scenario	62
Step 8.4 Determine emissions from enteric methane production in the ex-post project scenario.....	64
Step 8.5 Determine emissions from fossil fuel combustion in the ex-post project scenario.....	67
Step 8.6 Determine emissions from fertilizer use in the ex-post project scenario	68
Step 8.7 Net GHG emissions in the ex-post project scenario	70
STEP 9 – Project Leakage	71
Step 9.1 Activity shifting leakage	71
Step 9.2 Market leakage	72
STEP 10 – Net Project Greenhouse Gas Emission Reductions.....	74
STEP 11 – Project Voluntary Carbon Units	75
Step 11.1 Adjustment for uncertainty.....	75
Step 11.2 Calculation of voluntary carbon units.....	76
STEP 12 – Project Monitoring	77
Step 12.1 Scope of monitoring and the monitoring plan	77
Step 12.2 Monitoring of project implementation.....	77
Step 12.3 Data inputs to SOC model calibration.....	78

Step 12.4 Disturbance	79
Step 12.5 National livestock production	79
Step 12.6 General requirements for monitoring	80
Step 12.7 Conservative approach and uncertainty.....	80

PART 1 - SOURCES, DEFINITIONS AND APPLICABILITY

1. Sources

- VCS Program Guidelines 2007.1¹
- VCS Tool for AFOLU Methodological Issues²
- Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination³
- Tool for Calculation of the Number of Sample Plots for Measurements within A/R CDM Project Activities⁴
- Tool for Demonstration and Assessment of Additionality⁵
- Tool for testing significance of GHG emissions in A/R CDM project activities⁶

¹ http://www.v-c-s.org/docs/Voluntary%20Carbon%20Standard%20Program%20Guidelines%202007_1.pdf

² <http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Methodological%20Issues.pdf>

³ <http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Non-permanence%20Risk%20Analysis%20and%20Buffer%20Determination.pdf>

⁴ http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

⁵ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf>

⁶ http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

2. Definitions

This methodology uses all VCS approved definitions from the VCS Program Guidelines 2007.1⁷ and the VCS Tool for AFOLU Methodological Issues⁸.

The definitions in Table 1 are specific to this methodology.

Table 1. ALM-IGM Methodology: definitions

Term	Explanation
Grassland management	Activities on lands falling under the VCS definition for Grassland
GMP	<p>The Grassland Management Plan that is a description of the activities on grasslands that result in livestock production in the baseline scenario and includes:</p> <ul style="list-style-type: none">• livestock type, livestock stocking rate and grazing days per land parcel;• grassland management for forage production including any biomass burning and/or vegetation clearing, and/or pasture improvement;• fertilizer use as mass of synthetic fertilizer and/or mass of organic fertilizer to enhance forage production; and• fossil fuel consumed (as represented by fuel purchased by fuel type).
IGMP	<p>The Improved Grassland Management Plan that is a description of the activities on grasslands that result in livestock production in the project scenario and includes:</p> <ul style="list-style-type: none">• livestock type, livestock stocking rate and grazing days per land parcel;• grassland management for forage production including any biomass burning and/or vegetation clearing, and/or pasture improvement;• fertilizer use as mass of synthetic fertilizer and/or mass of organic fertilizer to enhance forage production; and• fossil fuel consumed (as represented by fuel purchased by fuel type).
Land parcel	Unit of land management under the GMP and IGMP, usually a paddock or field
Livestock	Any animals used in a production system and managed as asset
SOC	Soil organic carbon

⁷ http://www.v-c-s.org/docs/Voluntary%20Carbon%20Standard%20Program%20Guidelines%202007_1.pdf

⁸ <http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Methodological%20Issues.pdf>

3. Symbols and Notations

3.1 Physical quantities

In this section we present the symbols that are used throughout the methodology to represent physical quantities used in the accounting equations.

3.1.1 Flows of greenhouse gas(es)

The symbol GHG is the common identifier used throughout this methodology to represent flows of greenhouse gas(es) to/from the atmosphere.

For these flows, the absolute value represents the intensity of the flow, in $\text{tCO}_2\text{e year}^{-1}$, or the total amounts exchanged with the atmosphere, in tCO_2e .

3.1.2 Carbon stocks

The symbol C is the common identifier used throughout this methodology to represent carbon stocks. The values presented are either carbon stocks (in tC), or carbon stocks per unit area (in $\text{tC}\cdot\text{ha}^{-1}$) as indicated in the step-by-step methodology described under Part 2.

3.1.3 Carbon stock changes

The symbol ΔC is the common identifier used throughout this methodology to represent changes in carbon stocks. The values presented could be either total changes in carbon stocks (in tC), annual changes in carbon stocks (in $\text{tC}\cdot\text{year}^{-1}$), or annual changes in carbon stocks per unit area (in $\text{tC}\cdot\text{ha}^{-1}\cdot\text{year}^{-1}$), as indicated in the step-by-step methodology described under Part 2.

3.2 Scenario qualifiers

In this section we present the symbols that are used throughout the methodology as scenario qualifiers, for the physical quantities used in the accounting equations.

- Physical quantities referring to the **baseline scenario** feature the suffix */BSL*;
- Physical quantities referring to the **project scenario** feature the suffix, */PRS*; and
- Physical quantities derived from baseline and project scenario accounting feature the suffix */IGM*

4. Applicability

Project activities must fall within the AFOLU project category “ALM Improved Grassland Management” as defined in the most recent version of the VCS AFOLU Guidance document⁹.

Where perennial woody species are introduced as part of grassland management, carbon sequestration in perennial woody biomass may be included as part of emission reduction credits. However, projects proponents must demonstrate that they do not harm local ecosystems as outlined in the general AFOLU guidance (see section “B. Community and/or environmental impacts of projects”).

Specific conditions under which this methodology is applicable are:

- the boundaries of the project area must be clearly defined;
- the baseline scenario must be grassland management;
- a soil organic carbon model applicable to the project area and that satisfies the specific conditions of this methodology must be available;
- improved grassland management activities included in the IGMP must:
 - decrease the proportion of bare soil in the landscape; and/or
 - decrease the time bare soil is exposed; and/or
 - increase the proportion of perennial species above the baseline scenario;
- No improved grassland management activities can result in a land designation change;
- the project area must remain a grass-dominated system throughout the crediting period;
- improved grassland management activities must not result in an increase in woody perennials that would reach the threshold for the national definition of forest; and
- no clearing of vegetation shall occur after the project start date except where the grassland management activities that have been proven to enhance long-term grassland productivity are included in the IGMP.

⁹ <http://www.v-c-s.org/docs/Guidance%20for%20AFOLU%20Projects.pdf>

PART 2 – STEP-BY-STEP METHODOLOGY DESCRIPTION

Under the VCS standard project proponents shall present conservative estimations of the Agricultural Land Management (ALM) project activity.

The *Improved Grassland Management* (IGM) methodology presented here is designed as a detailed *step-by-step* procedure enabling conservative estimation of net GHG emissions resulting from ALM projects which would not be implemented in the absence of carbon finance.

The methodology is organised into nine steps:

- STEP 0 – Eligibility, sets the criteria for eligibility of projects under the proposed IGM methodology;
- STEP 1 – Project Boundaries and Scope, provides guidelines for defining the geographical and temporal boundaries of the project and lists the GHG emissions sources and carbon pools to be included in the project accounts;
- STEP 2 – Baseline Selection, Additionality and Baseline Modelling, provides guidelines to select the most conservative baseline scenario and to determine the additionality of the proposed project activities against the baseline selected;
- STEP 3 – Ex ante Grassland Management Plans and Stratification, develops *ex-ante* Grassland Management Plan (GMP) for the baseline scenario and the *ex-ante* Improved Grassland Management Plan (IGMP) for the project scenario;
- STEP 4 – Ex ante Greenhouse Gas Emissions in the Baseline Scenario, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks and GHG emission in the baseline scenario;
- STEP 5 – Ex ante Net Greenhouse Gas Emissions in the Project Scenario, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks and GHG emission in the *ex-ante* project scenario;
- STEP 6 – Ex post Grassland Management Plans and Stratification, develops *ex-post* Grassland Management Plan (GMP) for the baseline scenario and the *ex-post* Improved Grassland Management Plan (IGMP) for the project scenario;
- STEP 7 – Ex post Net Greenhouse Gas Emissions in the Baseline Scenario, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks and GHG emission in the *ex-post* baseline scenario;
- STEP 8 – Ex post Net Greenhouse Gas Emissions in the Project scenario, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks and GHG emission in the *ex-post* project scenario;
- STEP 9 – Project Leakage, describes the methodology approach to account for leakage mechanisms arising from the implementation of project activities;

- STEP 10 – Net Project Greenhouse Gas Emission Reductions, provides the methodological approach to determine the amount of net greenhouse gas emissions at the end of each year on the basis of the estimates of greenhouse gas emissions;
- STEP 11 – Project Voluntary Carbon Units, provides the methodological approach to determine, on the basis of the amount of net greenhouse gas emissions estimated at Step 6 and deductions to account for risk and uncertainty, the amount of carbon units that should be credited to the project each year over the crediting period; and
- STEP 12 – Project Monitoring, provides guidelines for the implementation of a monitoring plan and identifies monitored parameters to assess carbon stock change and disturbance in the project scenario.

STEP 0 – Eligibility

In order to be eligible for crediting under the VCS, ALM project proponents must demonstrate that the project area was not cleared of native ecosystems, such as forests, grasslands, scrublands or wetlands, to create VCUs.

Documented evidence shall be provided in the VCS-PD that no ALM project area was cleared of native ecosystems within the ten years prior to the proposed VCS project start.

The burden of proof rests with the project proponent.

Legal right to manage land in a manner aligned to Improved Grazing Management must pre-exist the implementation of the project; subsequently:

- the project proponent must provide documentary evidence of the legal right to implement the IGM project activity consistent with land tenure and/or ownership rights; and
- the project proponent must demonstrate that project activity is consistent with those permissible under any existing environmental legislation that covers the project area.

This methodology requires the use of a published soil carbon dynamics model, therefore:

- the selected soil organic carbon model must be able to generate output based on both the baseline and project scenario land management activities;
- soil type classification must be available at a level of precision for classification and area determination required as input to soil carbon models applicable to the project area;
- the time of first clearing of native vegetation for land management must be known for the project area;
- historical land management practices for a minimum of 10 years prior to the proposed project start date must be known for the project area or historical soil carbon data for the project area sufficient to calibrate the chosen soil organic carbon model must be available; and
- a digital, spatially explicit map of the project area identifying all strata must be available or generated.

STEP 1 - Project Boundaries and Scope

Step 1.1 Geographical Boundaries

Project proponents shall clearly define the spatial boundaries of a project so as to facilitate accurate measuring, monitoring, accounting, and verifying of the project's emissions reductions and removals.

The ALM project activity may contain more than one discrete area of land.

When describing physical project boundaries, the following information shall be provided per discrete area:

- name of the project area (including compartment number, allotment number, local name);
- map(s) of the area (preferably in digital format);
- geographic coordinates of each polygon vertex (preferably obtained from a GPS or from a geo-referenced digital map);
- total land area; and
- details of grassland rights holder and user rights.

The geographic boundaries of an ALM project are fixed and thus do not change over the project lifetime.

Following the VCS definition of market leakage the geographic boundaries for leakage from market effects are those of the country in which the project area occurs.

Step 1.2 Temporal Boundaries

The following temporal boundaries shall be defined:

Step 1.2.1 Start date and end date of the “crediting period”

The crediting period is the period of time for which the net GHG emissions reductions or removals will be verified, which under the VCS is equivalent to the project lifetime. The project must have an operating plan covering this period.

The duration of the project activity/crediting period shall be reported in the VCS Project Document (VCS-PD).

Step 1.2.2 Duration of the monitoring periods

Issuance of Voluntary Carbon Units (VCUs) is subject to monitoring and verification. The minimum duration of a monitoring period is one year and the maximum duration is 10 years.

Project proponents are free to decide the periodicity of verifications, however, under the VCS guidelines, if verification does not occur within 5 years, 50% of the buffer account credits are cancelled.

Baseline projections shall be annual and be available for each proposed future verification date.

Step 1.3 Carbon Pools

The carbon pools included or excluded from the project boundary are shown in Table 2.

Table 2: Carbon pools

Carbon pools	Included/Optional/ Excluded	Justification / Explanation of choice
Above-ground woody biomass	Included	Carbon in perennial woody biomass.
Above-ground non-woody Biomass	Excluded	Excluded from ALM projects
Below-ground	Included	Included as part of above-ground woody biomass ¹⁰
Dead-wood	Excluded	Excluded from ALM projects
Harvested wood products	Excluded	Excluded from ALM projects
Litter	Excluded	Insignificant and exclusion is conservative
Soil organic carbon	Included	Soil carbon is the primary pool of concern for ALM.

Step 1.4 Greenhouse Gases

The emissions sources included in or excluded from the project boundary are shown in Table 3.

Any one of these sources shall be neglected, i.e., accounted as zero, if the application of the most recent version of the “Tool for testing significance of GHG emissions in A/R CDM project activities” leads to the conclusion that the emission source is insignificant¹¹. In addition, the sum of decreases in carbon pools and increases in emissions that may be neglected shall be less than 5% of the total project GHG benefits (VCS, 2007.1).

¹⁰ Above-ground woody biomass calculations incorporate below ground biomass calculations, the below-ground biomass pool is not measured separately.

¹¹ http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

Table 3: Emission sources other than resulting from changes in stocks in carbon pools

Gas	Sources	Included/ Excluded	Justification/explanation of choice
Carbon dioxide (CO ₂)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Included	Conservative as emissions will be greater in the baseline scenario than in the project scenario.
	Removal of herbaceous vegetation	Excluded	Based on CDM EB decision reflected in paragraph 11 of the report of the 23 rd session of the board: cdm.unfccc.int/Panels/ar/023/ar_023_rep.pdf
Methane (CH ₄)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Included	Included as CO ₂ equivalent emission
	Burning of Biomass	Included	Included as CO ₂ equivalent emission
	Enteric emissions	Included	Included as CO ₂ equivalent emission
Nitrous oxide (N ₂ O)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Included	Potential emissions are negligible
	Nitrogen based fertilizer	Included	Included as CO ₂ equivalent emission
	Burning of Biomass	Excluded	Potential emissions are negligible

STEP 2 – Baseline Selection and Additionality

Step 2.1 Potential baseline scenarios

The project proponent shall select or establish criteria and procedures for identifying and assessing potential baseline scenarios in accordance with rule 6.3 VCS (2007.1) in the VCS Tool for Methodological Issues (paragraph 13)¹².

Project proponents must identify realistic and credible land-use scenarios that could occur on the land within the proposed project boundary in the absence of the ALM project activity. The scenarios must be credible and feasible for the project proponent or similar project developers taking into account relevant national and/or sectoral policies and circumstances.

The identification of realistic and credible land use scenarios shall use a combination of land-use records, field surveys, information from stakeholder consultation, historical land use practices, and information from other sources as appropriate.

Baseline scenarios must be general and can be a single or a combination of land management strategies, including but not exclusively, grazing management, fertilizer use, and irrigation practices. It is not necessary to consider all possible combinations of specific strategies as baseline scenarios but each of the realistic and credible strategies must be assessed through application of the VCS “Tool for Demonstration and Assessment of Additionality”¹³

Step 2.2 Selecting the baseline scenario

The project proponent shall use the current VCS “Tool for Demonstration and Assessment of Additionality”¹⁴ in AFOLU Project Activities to assess which of the baseline alternatives and management strategies shall be excluded from further consideration.

The project proponent shall arrive at a baseline scenario of grassland management.

The baseline scenario shall be described in the VCS-PD in the form of a baseline Grassland Management Plan (GMP) which defines the baseline management strategies and input data for estimates of greenhouse gas emissions in the baseline scenario. Proponents shall develop the GMP in Step 3.

Step 2.3 Additionality

The project proponent shall test the additionality of the project using the current VCS Tool for Demonstration and Assessment of Additionality in AFOLU Project Activities.

¹² <http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Methodological%20Issues.pdf>

¹³ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf>

¹⁴ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf>

STEP 3 – *Ex-ante* Grassland Management Plans and Stratification

This step develops *ex-ante*, the Grassland Management Plan (GMP) for the baseline scenario and the Improved Grassland Management Plan (IGMP) for the project scenario.

Step 3.1 Grassland Management Plan

The GMP shall define the baseline management strategies and input data for *ex ante* estimates of greenhouse gas emissions in the baseline scenario.

The GMP shall include details on an annualised basis of

- livestock management including stocking rate, livestock type, and grazing days per land parcel;
- grassland management including any biomass burning and/or vegetation clearing, and/or pasture improvement;
- fertilizer use as mass of synthetic fertilizer and/or mass of organic fertilizer; and
- fossil fuel consumed (as represented by fuel purchased by fuel type).

Project proponents must provide credible evidence for the management strategies and input values in the GMP for the baseline scenario in the VCS-PD. These shall be obtained from either:

- documented land management history for the project area, where such records include livestock type, livestock production and grazing management practices, or
- a common practice analysis of grassland management for similar properties in the district.

Step 3.2 Improved Grassland Management Plan

The IGMP shall define the project management strategies and input data for *ex-ante* estimates of greenhouse gas emissions in the project scenario.

Proponents shall select project strategies that are expected to increase carbon stock in measured pools and/or reduce emissions and/or avoid emissions when compared to the baseline scenario.

Grassland management strategies in the project area that

- decrease the proportion of bare soil, and/or
- decrease the time soil is exposed, and/or
- shift the vegetation composition toward deep rooted perennial species, and/or
- reduce energy and fertilizer inputs

are likely to increase carbon stocks and/or reduce greenhouse gas emissions compared to the baseline scenario.

The improved grassland management strategies selected must be achievable within the biophysical constraints of the project area, must be included as a parameter in the selected SOC model, and be within the land management capability of the project proponents.

The improved grassland management strategies must conform to the eligibility and applicability conditions of this methodology described at Step 0.

The IGMP outlines the strategies that make up the project scenario and must be described in the VCS-PD.

Step 3.3 Select carbon pools and greenhouse gas emission sources

This step selects carbon pools and greenhouse gas emission sources that are required or are material in the baseline scenario and project scenario defined by the grassland management strategies in the GMP and the IGMP.

Step 3.3.1 Carbon stock additions from above-ground woody biomass

In the **baseline scenario**, project proponents shall use the approved A/R CDM *Guidance on Conditions under which the Change in Carbon Stocks in Existing Live Woody Vegetation Need not be Accounted*¹⁵, to determine whether the change in carbon stocks in existing live woody vegetation (i.e. in trees and shrubs) are to be accounted in the baseline scenario greenhouse gas accounts.

Equations are given in Step 4.2.1

In the **project scenario**, project proponents may conservatively exclude above-ground woody biomass carbon stock additions from the *ex-ante* project scenario greenhouse accounts.

Where project proponents choose to account above-ground woody biomass carbon stock additions, equations are given in Step 5.2.1

Step 3.3.2 Above-ground woody biomass carbon stock losses

In the **baseline scenario**, where biomass clearing and/or burning is included in the management strategies described in the GMP, project proponents may choose to conservatively exclude carbon stock losses in above-ground woody biomass from the *ex-ante* baseline scenario greenhouse gas accounts.

Where project proponents choose to account above-ground woody biomass carbon stock losses, equations are given in Step 4.2.2

¹⁵ REF!

In the **baseline scenario**, if fire is included in the management strategies described in the GMP, the area burned shall be defined as a stratum, and all biomass in the stratum shall be considered to be burned.

In the **project scenario**, where biomass clearing and/or burning is an included management strategy in the IGMP, above-ground woody biomass carbon stock losses must be included in *ex-ante* project scenario greenhouse gas accounts.

Equations for above-ground woody biomass carbon stock losses in the project scenario are given in Step 5.2.2

Step 3.3.3 Enteric emissions from methane production

In the **baseline scenario**, project proponents may choose to conservatively exclude enteric emissions from the *ex-ante* baseline scenario greenhouse gas accounts.

Where project proponents choose to account enteric emissions, equations are given in Step 4.3

In the **project scenario**, it is necessary to compare baseline scenario GMP and the project scenario IGMP, and if there is:

- (a) no change in livestock numbers and livestock composition or type; or
- (b) a decrease in livestock numbers and no substitution to more emissions intensive livestock type(s) in the IGMP; or
- (c) a substitution to less emissions intensive livestock type(s) and no increase in livestock numbers in the IGMP;

project proponents may choose to exclude enteric emissions from the *ex-ante* project scenario greenhouse gas accounts.

Enteric emissions must be accounted in the *ex-ante* project scenario greenhouse gas accounts in all other situations using equations given in Step 5.3

Step 3.3.4 Emissions from fossil fuel combustion

In the **baseline scenario**, project proponents may choose to conservatively exclude emissions from fossil fuel combustion from the *ex-ante* baseline scenario greenhouse gas accounts.

Where project proponents choose to account emissions from fossil fuel combustion, equations are given in Step 4.4

In the **project scenario**, it is necessary to compare baseline scenario GMP and the project scenario IGMP, and if there is:

- (a) no change in fuel consumed and fuel type; or
- (b) a decrease in fuel consumed and no substitution to more emissions intensive fuel type(s) in the IGMP; or

- (c) a substitution to less emissions intensive fuel type(s) and no increase in fuel consumed in the IGMP;

project proponents may choose to exclude emissions from fossil fuel combustion in the *ex-ante* project scenario greenhouse gas accounts.

Emissions from fossil fuel combustion must be accounted in the *ex-ante* project scenario greenhouse gas accounts in all other situations using equations given in Step 5.4

Step 3.3.5 Emissions from fertilizer use

In the **baseline scenario**, where fertilizer use is included in the management strategies described in the GMP, project proponents may choose to conservatively exclude emissions from fertilizer use the *ex-ante* baseline scenario greenhouse gas accounts.

Where project proponents choose to account fertilizer use, equations are given in Step 4.5

In the **project scenario**, where fertilizer use is included in a management strategy in the IGMP, emissions from fertilizer use must be included in *ex-ante* project scenario greenhouse gas accounts using equations given in Step 5.5

Step 3.4 Stratification

Stratification of the project area must be carried out in order to determine the areas under each land management strategy to improve the accuracy and precision of carbon stock estimates.

Project proponents shall stratify the project area in the baseline scenario and the project scenario.

Strata shall be developed on the basis of key parameters used to estimate changes in carbon stocks.

At a minimum, strata must include soil type, vegetation type (and/or pasture species) and management strategies.

Based on the availability of data regarding the nature of soils and composition of the vegetation in the project area, stratification shall be developed on the basis of either:

- a) existing soils mapping for the project area; and
- b) existing vegetation mapping or stratification and/or a paddock map with paddock management histories for the project area; or
- c) estimates developed from sampling the project area using soil and vegetation survey tools appropriate for the region.

It is acceptable to group similar land management strategies into one strata provided justification for any grouping is given in the VCS-PD.

Where the selected SOC model allows for additional input parameters, proponents may choose to further stratify the project by these parameters to improve accuracy (See Step 3.1.1).

Project proponents will submit as part of the VCS-PD a detailed description of the stratification adopted and the data sources used to develop stratification of the project area.

STEP 4 – *Ex-ante* Net Greenhouse Gas Emissions in the Baseline Scenario

This step estimates *ex-ante*, $GHG_{NET,t|BSL}$, the greenhouse gas emissions in year t in the baseline scenario.

The following table lists the baseline emissions modelled by this methodology:

Included in modelling
Soil carbon, above ground woody biomass, biomass burning, enteric emissions, fossil fuel use, fertilizer use
Conservatively excluded from modelling
Above ground non-woody biomass

Step 4.1 Determine soil organic carbon stock change in the baseline scenario

The output of this step is *ex ante* projection of SOC stock change in the baseline scenario.

A modelling approach shall be used to determine the SOC stock change in the baseline scenario.

Step 4.1.1 Select the SOC model

Changes in SOC stocks in the baseline shall be estimated using a published soil carbon dynamics model applicable to the project site.

Proponents shall use a SOC model

- that has been accepted in peer-reviewed scientific publications such as the RothC¹⁶ or the CENTURY¹⁷ model,
- that has been field tested on soils within the geographic region that includes the project area(s),
- where the output resolution of the model can predict differences in SOC at the scale of project activity and stratification,
- that includes land management practice as an input parameter,
- is designed to account for time since clearing from natural vegetation,

¹⁶ Ref

¹⁷ Ref

- can generate forward and backward projections of SOC stocks in the modelled scenario
- where mean and variance in SOC density in t ha^{-1} at time t are outputs of the model¹⁸.

It is not acceptable to use a broad scale model that is not able to predict change at the scale of management activity, such as those designed for regional or national scale carbon accounts.

Proponents must follow the parameter inputs and settings defined by the baseline scenario, input these parameters into the model, and use the model to estimate the SOC projection over the project lifetime given the management practices in the baseline scenario.

Step 4.1.2 Align soil type classification to the SOC model

SOC models assume a certain level of soil classification as an input parameter.

Project proponents must select a level of soil classification for the project area that matches the required sensitivity of the chosen SOC model. Selection can be made amongst soil classification categories that exist in soil mapping for the project area or use soil classification systems that would be applied to the project area for standard soil surveys.

Step 4.1.3 Determine the spatial co-ordinates for SOC modelling

To generate spatial output from the selected SOC model it is necessary to determine a grid of spatial co-ordinates (virtual sample points) that will provide spatial representation of strata across the project area.

Project proponents shall select and describe in the VCS-PD the scale, resolution and arrangement of spatial co-ordinates across the project area that shall be used to generate model output.

In all land parcels defined by the baseline stratification that cover greater than 5% of the project area, and are therefore above *de minimis*, the sampling grid of spatial co-ordinates must generate at least 3 sample points. The grid must also generate a minimum of three sample points in each land parcel across sufficient strata to cover 95% of the project area.

Step 4.1.4 Run the SOC model for the baseline scenario

¹⁸ It is acceptable to convert model output to soil carbon density (t ha^{-1}) where the output of the model is in alternate units through the estimation of soil bulk density in the project area. Bulk density measurements must follow standard practice; and the methods and sampling design must be described in the VCS-PD.

For each spatial co-ordinate on the sampling grid, project proponents shall collate the data for each input parameter in the SOC model from soil maps, meteorological stations, land management records and land management projections for the chosen baseline scenario.

Data sources must be described in the VCS-PD.

Proponents shall run the selected SOC model for the baseline scenario at each of the selected spatial co-ordinates.

Model runs of the baseline scenario must project forward to cover the project crediting period and also be applied retrospectively for 10 years prior to the project start date.

Back projections are necessary to comply with the VCS requirement that *“soil C stock estimates shall be determined relative to the computed maximum C stocks that occurred in the designated land area within the previous 10 years.”*¹⁹

The output of the modelling will be a matrix of values for the SOC stock at each spatial co-ordinate for each year of the baseline scenario and for each of the ten years prior to the start date. Whilst *ex-ante* values for project start date, the end of the crediting period and the maximum carbon stock in the previous 10 years are required, annual carbon stocks must still be modelled for use in *ex-post* estimations at Step 5 and Step 6.

Step 4.1.5 Spatial interpolation of SOC stock

At this step, a spatial interpolation algorithm, $f(X, Y..)$, shall be applied to the spatial matrix of SOC stock estimates to generate a SOC stock profile for the baseline scenario across the project area at the project start date, the end of the crediting period, and for each of the ten years prior to the project start date.

Proponents shall use standard geostatistical interpolation methods to create the SOC stock profiles.

Project proponents must compute SOC stock profiles using proprietary geostatistical software applications where such applications have the ability to define the interpolation method, include the project boundaries as defined at Step 1.1, and to sum the SOC stock across the profile for the project area. Summation across the profile shall estimate the SOC stock across the total project area in t C.

The following parameters are then assigned to the output of spatial interpolation:

$C_{S_MAX BSL}$	maximum computed carbon stock in SOC in the 10 years prior to project start date in the baseline scenario, t C ²⁰ ;
$C_{S_START BSL}$	carbon stock in SOC at the project start date in the baseline scenario, t C; and
$C_{S_END BSL}$	carbon stock in SOC at the end of the project crediting period in the baseline scenario, t C.

¹⁹ Step 4, paragraph 13, Tool for AFOLU Methodological Issues

²⁰ For example, if SOC stocks on the project area were 10,000 t C in 2002, then declined to 9,000 t C by 2007 after intensive grazing, $C_{S_MAX|BSL}$ for a project established in 2008 would be 10,000 t C.

Step 4.1.6 Calculate the SOC stock change in the baseline scenario

This step estimates $\Delta C_{S|BSL}$, the *ex ante* SOC stock loss in the baseline scenario.

The carbon stock change in the baseline scenario shall be estimated as:

$$\Delta C_{S|BSL} = (C_{S_MAX|BSL} - C_{S_END|BSL}) - (C_{S_MAX|BSL} - C_{S_START|BSL}) \quad (1)$$

Where:

$\Delta C_{S BSL}$	carbon stock change in soil organic carbon in the baseline scenario, t C;
$C_{S_MAX BSL}$	maximum computed carbon stock in soil organic carbon in the 10 years prior to project start date in the baseline scenario, t C; and
$C_{S_END BSL}$	carbon stock in soil organic carbon at the end of the project crediting period in the baseline scenario, t C.

A simplifying and conservative assumption is made that SOC stock change in the baseline scenario is linear. Consequently, the total carbon stock change is divided by the project crediting period to annualise the carbon stock change in SOC in the baseline scenario:

$$\Delta C_{S,t|BSL} = \frac{\Delta C_{S|BSL}}{IGM_{CP}} \cdot \frac{44}{12} \quad (2)$$

Where:

$\Delta C_{S,t BSL}$	carbon stock change in soil organic carbon in year t in the baseline scenario, t CO ₂ -e;
$\Delta C_{S BSL}$	carbon stock change in soil organic carbon in the baseline scenario, t C; and
IGM_{CP}	crediting period for improved grassland management project, years.

Step 4.2 Determine carbon stock change in above-ground woody biomass in the baseline scenario

This step calculates $\Delta C_{AWB,t|BSL}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario.

Step 4.2.1 Above-ground woody biomass carbon stock additions in the baseline scenario

This step calculates $\Delta C_{AWB_AD,t|BSL}$ above-ground woody biomass carbon stock additions in year t in the baseline scenario.

If at Step 3.3.1 above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* baseline scenario, then:

$$\Delta C_{AWB_AD,t|BSL} = 0$$

Otherwise, proponents shall use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project*, to determine the following parameters²¹:

$\Delta C_{TREE_BSL,t}$ change in carbon stock in tree biomass within the project boundary in the baseline scenario in year t ; t CO₂-e

$\Delta C_{SHRUB_BSL,t}$ change in carbon stock in shrub biomass within the project boundary in the baseline scenario in year t ; t CO₂-e

Proponents shall estimate above-ground woody biomass carbon stock additions in year t in the baseline scenario as:

$$\Delta C_{AWB_AD,t|BSL} = \Delta C_{TREE_BSL,t} + \Delta C_{SHRUB_BSL,t} \quad (3)$$

Where:

$\Delta C_{AWB_AD,t|BSL}$ above-ground woody biomass carbon stock additions in year t in the baseline scenario; t CO₂-e

$\Delta C_{TREE_BSL,t}$ change in carbon stock in tree biomass within the project boundary in the baseline scenario in year t ; t CO₂-e; and

$\Delta C_{SHRUB_BSL,t}$ change in carbon stock in shrub biomass within the project boundary in the baseline scenario in year t ; t CO₂-e.

Step 4.2.2 Above-ground woody biomass carbon stock losses in the baseline scenario

This step calculates $\Delta C_{AWB_LS,t|BSL}$ the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario.

If at Step 6.3.2, above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* baseline scenario, then:

$$\Delta C_{AWB_LS,t|BSL} = 0$$

²¹ $\Delta C_{TREE_BSL,t}$ and $\Delta C_{SHRUB_BSL,t}$ are parameters in the A/R Methodological Tool and do not use the same nomenclature scenario qualifiers as this methodology.

If fire is used, the area burned shall be defined as a stratum, and all biomass in the stratum is considered to be burned. Burning from unplanned disturbance is dealt with separately under the project scenario (Step 11.4).

For all strata with managed biomass clearing and/or burning in year t in the baseline scenario, project proponents must use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities* to determine the following parameters:

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass in stratum i in the baseline scenario in year t ; t C; and

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass in stratum i in the baseline scenario in year t ; t C.

Proponents shall then estimate the above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i in year t in the baseline scenario as:

$$C_{AWB,i,t|BSL} = C_{TREE_BSL,i,t} + C_{SHRUB_BSL,i,t} \quad (4)$$

Where:

$C_{AWB,i,t|BSL}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the baseline scenario; t CO₂-e

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e; and

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e.

Therefore, $\Delta C_{AWB_LS,t|BSL}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario is calculated as:

$$\Delta C_{AWB_LS,t|BSL} = \sum_i C_{AWB,i,t|BSL} \quad (5)$$

Where:

$\Delta C_{AWB_LS,t|BSL}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario; t CO₂-e;

$C_{AWB,i,t|BSL}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the baseline scenario; t CO₂-e; and

i 1,2,3... clearing and/or burning strata.

Where fire is used, it is necessary to also estimate the instantaneous non-CO₂ greenhouse gas emissions due to biomass burning of tree and shrub biomass within those strata (Box 1).

Box 1. Non-CO₂ greenhouse gas emissions due to biomass burning

This box calculates the non-CO₂ greenhouse gas emissions due to biomass burning. These emissions are treated as an instantaneous greenhouse gas emission and not a carbon stock change.

Proponents shall estimate non-CO₂ emissions from tree biomass due to managed fire in stratum i in year t in the baseline scenario as:

$$GHG_{TREE,i,t|BSL} = C_{TREE_BSL,i,t} \cdot COMF_{TREE,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (6)$$

Where:

$GHG_{TREE,i,t|BSL}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e;

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e;

$COMF_{TREE,i}$ combustion factor for tree biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Proponents shall then estimate non-CO₂ emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario as:

$$GHG_{SHRUB,i,t|BSL} = C_{SHRUB_BSL,i,t} \cdot COMF_{SHRUB,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (7)$$

Where:

$GHG_{SHRUB,i,t|BSL}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e;

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e;

$COMF_{SHRUB,i}$ combustion factor for shrub biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Therefore, non-CO₂ greenhouse gas emissions due to managed fire in year t in the baseline scenario are calculated as:

$$GHG_{AWB,t|BSL} = \sum_i GHG_{TREE,i,t|BSL} + GHG_{SHRUB,i,t|BSL} \quad (8)$$

$GHG_{AWB,t BSL}$	non-CO ₂ greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the baseline scenario; t CO ₂ -e;
$GHG_{TREE,i,t BSL}$	non-CO ₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the baseline scenario; t CO ₂ -e;
$GHG_{SHRUB,i,t BSL}$	non-CO ₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario; t CO ₂ -e; and
i	1,2,3... clearing and/or burning strata.

Step 4.2.3 Above-ground woody biomass carbon stock in the baseline scenario

Therefore, $\Delta C_{AWB,t|BSL}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario is calculated as follows:

$$\Delta C_{AWB,t|BSL} = \Delta C_{AWB_LS,t|BSL} - \Delta C_{AWB_AD,t|BSL} \quad (9)$$

Where:

$\Delta C_{AWB,t BSL}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario; t CO ₂ -e;
$\Delta C_{AWB_AD,t BSL}$	above-ground woody biomass carbon stock additions in year t in the baseline scenario; t CO ₂ -e; and
$\Delta C_{AWB_LS,t BSL}$	change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario; t CO ₂ -e.

Step 4.3 Determine methane production from enteric emissions in the baseline scenario

This step calculates $GHG_{ENTERIC,t|BSL}$, the greenhouse gas emissions from enteric fermentation in year t in the baseline scenario.

If at Step 3.3.3 methane production from enteric emissions

in need not be accounted in the *ex-ante* baseline scenario, then

$$GHG_{ENTERIC,t|BSL} = 0$$

Otherwise, Proponents shall then estimate methane production from enteric emissions in year t in the *ex-ante* baseline scenario as:

$$EF_l = \left(\frac{GE_l \cdot MCF_l}{55.65} \right) \quad (10)$$

Where:

EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
GE_l	gross energy intake livestock type l , MJ head ⁻¹ day ⁻¹ ;
MCF_l	methane conversion factor for livestock type l , fraction of gross energy in feed converted to methane;
55.65	energy content of methane, MJ/kg CH ₄ ; and
l	species/category/type of livestock.

$$E_{ENTERIC,t|BSL} = \sum_l EF_l \cdot N_{l,t|BSL} \cdot GP_{l,t|BSL} \quad (11)$$

Where:

$E_{ENTERIC,t BSL}$	methane emissions from enteric fermentation in year t in the baseline scenario, kg CH ₄ yr ⁻¹ ;
EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
$N_{l,t BSL}$	number of livestock of type l in year t in the baseline scenario, head yr ⁻¹ ;
$GP_{l,t BSL}$	grazing days for livestock type l in year t in the baseline scenario, days; and
l	species/category/type of livestock.

The conversion of methane production to carbon dioxide equivalents shall be calculated as:

$$GHG_{ENTERIC,t|BSL} = E_{ENTERIC,t|BSL} \cdot 23 \cdot 10^{-3} \quad (12)$$

Where:

$GHG_{ENTERIC,t BSL}$	greenhouse gas emissions from enteric fermentation in year t in the baseline scenario; t CO ₂ -e yr ⁻¹ ;
$E_{ENTERIC,t BSL}$	methane emissions from enteric fermentation in year t in the baseline scenario, kg CH ₄ yr ⁻¹ ; and
23	global warming potential integrated over 100 years for CH ₄ , t CO ₂ -e t ⁻¹ CH ₄ .

Step 4.4 Determine greenhouse gas emissions from fossil fuel combustion in the baseline scenario

This step calculates $GHG_{FF,t|BSL}$, the greenhouse gas emissions from fossil fuel combustion in year t in the baseline scenario.

If at Step 3.3.4 emissions from fossil fuel combustion need not be accounted in the *ex-ante* baseline scenario, then:

$$GHG_{FF,t|BSL} = 0$$

Otherwise, greenhouse gas emissions from fossil fuel combustion in the baseline scenario shall be calculated as follows:

$$GHG_{FF,t|BSL} = \sum_{g=1}^3 \sum_{f=1}^{f^*} \left(EC_{f,t|BSL} \cdot EF_{g,f} \cdot GWP_g \right) \cdot 10^{-3} \quad (13)$$

Where:

$GHG_{FF,t BSL}$	greenhouse gas emissions from fossil fuel combustion in year t in the baseline scenario, tCO ₂ -e yr ⁻¹ ;
$EC_{f,t BSL}$	energy consumed for fuel type f in year t in the baseline scenario, TJ;
$EF_{g,f}$	emissions factor for greenhouse gas g for fuel type f ; kg TJ ⁻¹ ;
$GWP_{100,g}$	global warming potential integrated over 100 years for greenhouse gas g , t CO ₂ -e t ⁻¹ ;
g	unique identifier for each greenhouse gas; and
f	fuel type.

The energy consumed for each fuel type in the baseline scenario shall be calculated as follows:

$$EC_{f,t|BSL} = FC_{f,t|BSL} \cdot NCV_f \cdot D_f \quad (14)$$

Where:

$EC_{f,t BSL}$	energy consumed for fuel type f in year t in the baseline scenario, TJ;
$FC_{f,t BSL}$	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the baseline scenario, kL;
NCV_f	net calorific value for fuel type f , TJ Gg ⁻¹ ; and
D_f	density of fuel type f , Gg kL ⁻¹ .

Step 4.5 Determine emissions from fertilizer use in the baseline scenario

This step calculates $GHG_{FERT,t|BSL}$, the direct N₂O emissions that result from the application of nitrogen in the baseline scenario.

If at Step 3.3.5 emissions from fertilizer use need not be accounted in the *ex-ante* baseline scenario, then:

$$GHG_{FERT,t|BSL} = 0$$

If flooding irrigation or any flood has occurred on the project area within a period of 3 months from date of fertilization, then $GHG_{FERT,t|BSL}$ in year t is conservatively estimated as:

$$GHG_{FERT,t|BSL} = 0$$

For all other years, the direct nitrous oxide emissions from nitrogen fertilization in year t shall be calculated as:

$$GHG_{FERT,t|BSL} = (F_{SN,t} + F_{ON,t}) \cdot EF_1 \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad (15)$$

Where:

$GHG_{FERT,t BSL}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e;
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH ₃ and NO _x , t N;
$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH ₃ and NO _x , t N;
EF_1	emission factor for emissions from N inputs, t N ₂ O t ⁻¹ N input;
44/28	ratio of molecular weights of N ₂ O and N, t N ₂ O t ⁻¹ N; and
GWP_{N_2O}	global warming potential integrated over 100 years for N ₂ O, t CO ₂ -e t ⁻¹ N ₂ O.

$$F_{SN,t} = \sum_k M_{SF,k,t} \cdot NC_{SF,k} \cdot (1 - Frac_{GASF}) \quad (16)$$

Where:

$F_{SN,t}$	mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH ₃ and NO _x , t N;
------------	---

$M_{SF,k,t BSL}$	mass of synthetic fertilizer type k applied in year t in the baseline scenario, t ;
$NC_{SF,k}$	nitrogen content of synthetic fertilizer type k applied, $g\ N\ 100g^{-1}$ fertilizer;
$Frac_{GASF}$	Fraction that volatilises as NH_3 and NO_x for synthetic fertilizers, dimensionless; and
k	synthetic fertilizer type.

$$F_{ON,t} = \sum_j M_{OF,j,t} \cdot NC_{OF,j} \cdot (1 - Frac_{GASM}) \quad (17)$$

Where:

$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , $t\ N$;
$M_{OF,j,t BSL}$	mass of organic fertilizer type j applied in year t in the baseline scenario, t ;
$NC_{OF,j}$	nitrogen content of organic fertilizer type j applied, $g\ N\ 100g^{-1}$ fertilizer; and
$Frac_{GASM}$	Fraction that volatilises as NH_3 and NO_x for organic fertilizers, dimensionless; and
j	organic fertilizer type.

Step 4.6 Net GHG emissions in the baseline scenario

This step calculates $GHG_{NET,t|BSL}$, the net GHG emissions in year t in the baseline scenario.

Proponents shall calculate the net greenhouse gas emissions in year t in the *ex-ante* baseline scenario as:

$$GHG_{NET,t|BSL} = \Delta C_{S,t|BSL} + \Delta C_{AWB,t|BSL} + GHG_{AWB,t|BSL} + GHG_{ENTERIC,t|BSL} + GHG_{FF,t|BSL} + GHG_{FERT,t|BSL} \quad (18)$$

Where:

$GHG_{NET,t BSL}$	net greenhouse gas emissions in year t in the baseline scenario; $t\ CO_2-e$;
$\Delta C_{S,t BSL}$	carbon stock change in soil organic carbon in year t in the baseline scenario, $t\ CO_2-e$;
$\Delta C_{AWB,t BSL}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario; $t\ CO_2-e$

$GHG_{AWB,t BSL}$	non-CO ₂ greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the baseline scenario; t CO ₂ -e;
$GHG_{ENTERIC,t BSL}$	greenhouse gas emissions from enteric fermentation in year t in the baseline scenario; t CO ₂ -e;
$GHG_{FF,t BSL}$	greenhouse gas emissions from fossil fuel combustion in year t in the baseline scenario, t CO ₂ -e; and
$GHG_{FERT,t BSL}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e.

STEP 5 – *Ex-ante* Net Greenhouse Gas Emissions in the Project Scenario

This step estimates $GHG_{NET,t|PRS}$, *ex-ante* net greenhouse gas emissions in year t in the project scenario, in tCO₂-e.

Step 5.1 Determine soil organic carbon stock change in the project scenario

The output of this step is *ex ante* estimation of SOC stock change in the project scenario.

A modelling approach shall be used to determine the SOC stock change in the project scenario. The same SOC model chosen for the baseline scenario (Step 3.1.1) shall be used to model the project scenario.

Step 5.1.1 Apply project stratification under the chosen SOC model

Project proponents will submit as part of the VCS-PD a detailed description of the stratification adopted and the data sources used to develop project scenario stratification for the project area.

Step 5.1.2 Align soil type classification to the SOC model

Project proponents must use the same soil classification in the project scenario as that chosen for the baseline scenario.

Step 5.1.3 Determine the spatial co-ordinates for SOC modelling

To generate spatial output from the selected SOC model it is necessary to determine a grid of spatial co-ordinates (virtual sample points) that will provide spatial representation of strata across the project area.

Project proponents shall select and describe in the VCS-PD the scale, resolution and arrangement of spatial co-ordinates across the project area that shall be used to generate model output for the project scenario.

In all land parcels defined by the project stratification that cover greater than 5% of the project area, the sampling grid of spatial co-ordinates must generate at least 3 sample points. The grid must also generate a minimum of three sample points in each land parcel across sufficient strata to cover 95% of the project area.

Step 5.1.4 Run the SOC model for the project scenario

For each spatial co-ordinate on the sampling grid, proponents shall collate data for each input parameter in the SOC model from soil maps, meteorological stations, land management records and the Project Grassland Management Plan.

Data sources must be described in the VCS-PD.

Proponents shall run the selected SOC model for the project scenario at each of the selected spatial co-ordinates.

Model runs of the project scenario must project forward to cover the project crediting period.

The output of the modelling will be a matrix of values for the SOC stock at each spatial co-ordinate for each year of the project scenario.

Step 5.1.5 Spatial interpolation of SOC stock in the project scenario

At this step, a spatial interpolation algorithm, $f(X,Y..)$, shall be applied to the spatial matrix of SOC stock estimates to generate a SOC stock profile for the project scenario across the project area at the end of the crediting period.

At this step, spatial interpolation algorithms shall be applied to the spatial matrix of SOC stock estimates to generate a SOC stock profile for the end of the crediting period.

Proponents shall use the same geostatistical interpolation methods used to create the baseline scenario SOC stock profiles. Summation across the profile shall estimate the SOC stock across the total project area in t C.

The following parameter is then assigned to the output of spatial interpolation:

$C_{S_END|PRS}$ carbon stock in SOC at the end of the crediting period in the project scenario, t C

Step 5.1.6 Determine the SOC stock change in the project scenario

This step calculates $\Delta C_{S|PRS}$ the carbon stock change in SOC in the project scenario.

The carbon stock change in the project scenario shall be determined as:

$$\Delta C_{S|PRS} = (C_{S_END|PRS} - C_{S_MAX|BSL}) \quad (19)$$

Where:

$\Delta C_{S|PRS}$ carbon stock change in the soil organic carbon pool in the project scenario; t C;

$C_{S_END|PRS}$ carbon stock in soil organic carbon at the end of the project crediting period in the project scenario, t C; and

$C_{S_MAX|BSL}$ maximum computed carbon stock in soil organic carbon in the 10 years prior to project start date in the baseline scenario, t C.

The total carbon stock change is then divided by the project crediting period to remove fluctuations and annualise the carbon stock change in soil organic carbon:

$$\Delta C_{S,t|PRS} = \frac{\Delta C_{S|BSL}}{IGM_{CP}} \cdot \frac{44}{12} \quad (20)$$

Where:

$\Delta C_{S,t PRS}$	carbon stock change in soil organic carbon in year t in the baseline scenario; t CO ₂ -e;
$\Delta C_{S PRS}$	carbon stock change in soil organic carbon in the project scenario; t C ha ⁻¹ ; and
IGM_{CP}	crediting period for improved grassland management project, years.

Step 5.2 Determine carbon stock change in above-ground woody biomass in the project scenario

This step calculates $\Delta C_{AWB,t|PRS}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario.

Step 5.2.1 Above-ground woody biomass carbon stock additions in the project scenario

This step calculates $\Delta C_{AWB_AD,t|PRS}$ above-ground woody biomass carbon stock additions in year t in the project scenario.

If at Step 3.3.1 above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* project scenario, then:

$$\Delta C_{AWB_AD,t|PRS} = 0$$

Otherwise, proponents shall use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project*, to determine the following parameters²²:

$\Delta C_{TREE_PROJ,t}$	change in carbon stock in tree biomass within the project boundary in the project scenario in year t ; t CO ₂ -e
$\Delta C_{SHRUB_PROJ,t}$	change in carbon stock in shrub biomass within the project boundary in the project scenario in year t ; t CO ₂ -e

²² $\Delta C_{TREE_PROJ,t}$ and $\Delta C_{SHRUB_PROJ,t}$ are parameters in the A/R Methodological Tool and do not use the same nomenclature scenario qualifiers as this methodology.

Proponents shall estimate above-ground woody biomass carbon stock additions in year t in the project scenario as:

$$\Delta C_{AWB_AD,t|PRS} = \Delta C_{TREE_PROJ,t} + \Delta C_{SHRUB_PROJ,t} \quad (21)$$

Where:

$\Delta C_{AWB_AD,t|PRS}$ above-ground woody biomass carbon stock additions in year t in the project scenario; t CO₂-e

$\Delta C_{TREE_PRS,t}$ change in carbon stock in tree biomass within the project boundary in the project scenario in year t ; t CO₂-e; and

$\Delta C_{SHRUB_PRS,t}$ change in carbon stock in shrub biomass within the project boundary in the project scenario in year t ; t CO₂-e.

Step 5.2.2 Above-ground woody biomass carbon stock losses in the ex-ante project scenario

This step calculates $\Delta C_{AWB_LS,t|PRS}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario. If fire is used, the area burned shall be defined as a stratum, and all biomass in the stratum is considered to be burned.

Burning from unplanned disturbance is dealt with separately under the *ex-post* project scenario (Step 8.3.2).

Project proponents must use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities* to determine the following parameters:

$C_{TREE_PROJ,i,t}$ carbon stock in tree biomass in stratum i in the project scenario in year t ; t C; and

$C_{SHRUB_PROJ,i,t}$ carbon stock in shrub biomass in stratum i in the project scenario in year t ; t C.

Proponents shall then estimate the above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i in year t in the project scenario as:

$$C_{AWB,i,t|PRS} = C_{TREE_PROJ,i,t} + C_{SHRUB_PROJ,i,t} \quad (22)$$

Where:

$C_{AWB,i,t|PRS}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the project scenario; t CO₂-e

$C_{TREE_PRSi,t}$ carbon stock in tree biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e; and

$C_{SHRUB_PRSi,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e.

Therefore, $\Delta C_{AWB_LS,t|PRS}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario is calculated as:

$$\Delta C_{AWB_LS,t|PRS} = \sum_i C_{AWB,i,t|PRS} \quad (23)$$

Where:

- $\Delta C_{AWB_LS,t|PRS}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario; t CO₂-e;
- $C_{AWB,i,t|PRS}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the project scenario; t CO₂-e; and
- i 1,2,3... clearing and/or burning strata.

Where fire is used, it is necessary to also estimate the instantaneous non-CO₂ greenhouse gas emissions due to biomass burning of tree and shrub biomass within those strata (Box 2).

Box 2. Non-CO₂ greenhouse gas emissions due to biomass burning

This box calculates the non-CO₂ greenhouse gas emissions due to biomass burning. These emissions are treated as an instantaneous greenhouse gas emission and not a carbon stock change.

Proponents shall estimate non-CO₂ emissions from tree biomass due to managed fire in stratum i in year t in the project scenario as:

$$GHG_{TREE,i,t|PRS} = C_{TREE_PROJ,i,t} \cdot COMF_{TREE,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (24)$$

Where:

- $GHG_{TREE,i,t|PRS}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e;
- $C_{TREE_PROJ,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e;
- $COMF_{TREE,i}$ combustion factor for tree biomass in stratum i , dimensionless;
- ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;
- 16/44 ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and
- GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Proponents shall then estimate non-CO₂ emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario as:

$$GHG_{SHRUB,i,t|PRS} = C_{SHRUB_PROJ,i,t} \cdot COMF_{SHRUB,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (25)$$

Where:

- $GHG_{SHRUB,i,t|PRS}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e;
- $C_{SHRUB_PROJ,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e;

$COMF_{SHRUB,i}$	combustion factor for shrub biomass in stratum i , dimensionless;
ER_{CH_4}	emissions factor for CH_4 , $t\ CH_4\ t^{-1}\ C$ burnt;
$16/44$	ratio of molecular weights of CH_4 and CO_2 ; $mol\ mol^{-1}$; and
GWP_{CH_4}	global warming potential for CH_4 ; $t\ CO_2-e\ t^{-1}\ CH_4$.

Therefore, non- CO_2 greenhouse gas emissions due to managed fire in year t in the project scenario are calculated as:

$$GHG_{AWB,t|PRS} = \sum_i GHG_{TREE,i,t|PRS} \cdot GHG_{SHRUB,i,t|PRS} \quad (26)$$

$GHG_{AWB,t PRS}$	non- CO_2 greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the project scenario; $t\ CO_2-e$;
$GHG_{TREE,i,t PRS}$	non- CO_2 greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the project scenario; $t\ CO_2-e$;
$GHG_{SHRUB,i,t PRS}$	non- CO_2 greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario; $t\ CO_2-e$; and
i	1,2,3... clearing and/or burning strata.

Step 5.2.3 Above-ground woody biomass carbon stock in the project scenario

Therefore, $\Delta C_{AWB,t|PRS}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario is calculated as follows:

$$\Delta C_{AWB,t|PRS} = \Delta C_{AWB_AD,t|PRS} - \Delta C_{AWB_LS,t|PRS} \quad (27)$$

Where:

$\Delta C_{AWB,t PRS}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario; $t\ CO_2-e$;
$\Delta C_{AWB_AD,t PRS}$	above-ground woody biomass carbon stock additions in year t in the project scenario; $t\ CO_2-e$; and
$\Delta C_{AWB_LS,t PRS}$	change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario; $t\ CO_2-e$.

Step 5.3 Estimate methane production from enteric emissions in the project scenario

If selected at Step 3.3.3, greenhouse gas emission from enteric methane production in year t shall be calculated as:

$$EF_l = \left(\frac{GE_l \cdot MCF_l}{55.65} \right) \quad (28)$$

Where:

EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
GE_l	gross energy intake livestock type l , MJ head ⁻¹ day ⁻¹ ;
MCF_l	methane conversion factor for livestock type l , fraction of gross energy in feed converted to methane;
55.65	energy content of methane, MJ/kg CH ₄ ; and
l	species/category/type of livestock.

$$E_{ENTERIC,t|PRS} = \sum_l EF_l \cdot N_{l,t|PRS} \cdot GD_{l,t|PRS} \quad (29)$$

Where:

$E_{ENTERIC,t PRS}$	methane emissions from enteric fermentation in year t in the project scenario, kg CH ₄ yr ⁻¹ ;
EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
$N_{l,t PRS}$	number of livestock of type l in year t in the project scenario, head yr ⁻¹ ;
$GD_{l,t PRS}$	grazing days for livestock type l in year t in the project scenario, days; and
l	species/category/type of livestock.

The conversion of methane production to carbon dioxide equivalents shall be calculated as:

$$GHG_{ENTERIC,t|PRS} = E_{ENTERIC,t|PRS} \cdot 23 \cdot 10^{-3} \quad (30)$$

Where:

$GHG_{ENTERIC,t PRS}$	greenhouse gas emissions from enteric fermentation in year t in the project scenario; t CO ₂ -e yr ⁻¹ ;
$E_{ENTERIC,t PRS}$	methane emissions from enteric fermentation in year t in the project scenario, kg CH ₄ yr ⁻¹ ; and
23	global warming potential integrated over 100 years for CH ₄ , t CO ₂ -e t ⁻¹ CH ₄ .

Step 5.4 Determine greenhouse gas emissions from fossil fuel combustion in the project scenario

If selected at Step 3.3.4, greenhouse gas emission from fossil fuel combustion in year t shall be calculated as:

$$GHG_{FF,t|PRS} = \sum_{g=1}^3 \sum_{f=1}^{f^*} EC_{f,t|PRS} \cdot EF_{g,f} \cdot GWP_g \cdot 10^{-3} \quad (31)$$

Where:

$GHG_{FF,t PRS}$	greenhouse gas emissions from fossil fuel combustion in year t in the project scenario, tCO ₂ -e yr ⁻¹ ;
$EC_{f,t PRS}$	energy consumed for fuel type f in year t in the project scenario, TJ;
$EF_{g,f}$	emissions factor for greenhouse gas g for fuel type f ; kg TJ ⁻¹ ;
$GWP_{100,g}$	global warming potential integrated over 100 years for greenhouse gas g , t CO ₂ -e t ⁻¹ ;
g	unique identifier for each greenhouse gas; and
f	fuel type.

The energy consumed for each fuel type in the baseline scenario shall be calculated as follows:

$$EC_{f,t|PRS} = FC_{f,t|PRS} \cdot NCV_f \cdot D_f \quad (32)$$

Where:

$EC_{f,t PRS}$	energy consumed for fuel type f in year t in the project scenario, TJ;
$FC_{f,t PRS}$	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the project scenario, kL;
NCV_f	net calorific value for fuel type f , TJ Gg ⁻¹ ; and
D_f	density of fuel type f , Gg kL ⁻¹ .

Step 5.5 Estimate emissions from fertilizer use in the project scenario

In the project scenario direct nitrous oxide emissions from nitrogen fertilization is measured even when flood irrigation or flooding has occurred on the project area within a period of 3 months from date of fertilization, as this is conservative. The direct nitrous oxide emissions from nitrogen fertilization in year t shall be estimated as follows:

$$GHG_{FERT,t|PRS} = (F_{SN,t} + F_{ON,t}) \cdot EF_1 \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad (33)$$

Where:

$GHG_{FERT,t PRS}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year <i>t</i> in the project scenario, t CO ₂ -e;
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied in year <i>t</i> adjusted for volatilization as NH ₃ and NO _x , t N;
$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year <i>t</i> adjusted for volatilization as NH ₃ and NO _x , t N;
EF_1	emission factor for emissions from N inputs, t N ₂ O-N t ⁻¹ N input;
44/28	ratio of molecular weights of N ₂ O and N, t N ₂ O t ⁻¹ N; and
GWP_{N_2O}	global warming potential integrated over 100 years for N ₂ O, t CO ₂ -e t ⁻¹ N ₂ O.

$$F_{SN,t} = \sum_k M_{SF,k,t} \cdot NC_{SF,k} \cdot (1 - Frac_{GASF}) \quad (34)$$

Where:

$F_{SN,t PRS}$	mass of synthetic fertilizer nitrogen applied in year <i>t</i> in the project scenario adjusted for volatilization as NH ₃ and NO _x , t N;
$M_{SF,k,t PRS}$	mass of synthetic fertilizer type <i>k</i> applied in year <i>t</i> in the project scenario, t;
$NC_{SF,k}$	nitrogen content of synthetic fertilizer type <i>k</i> applied, g N 100g ⁻¹ fertilizer;
$Frac_{GASF}$	Fraction that volatilises as NH ₃ and NO _x for synthetic fertilizers, dimensionless; and
<i>k</i>	synthetic fertilizer type.

$$F_{ON,t} = \sum_j M_{OF,j,t} \cdot NC_{OF,j} \cdot (1 - Frac_{GASM}) \quad (35)$$

Where:

$F_{ON,t PRS}$	mass of organic fertilizer nitrogen applied in year <i>t</i> in the project scenario adjusted for volatilization as NH ₃ and NO _x , t N;
$M_{OF,j,t PRS}$	mass of organic fertilizer type <i>j</i> applied in year <i>t</i> in the project scenario, t;

$NC_{OF,j}$	nitrogen content of organic fertilizer type j applied, g N 100g ⁻¹ fertilizer; and
$Frac_{GASM}$	Fraction that volatilises as NH ₃ and NO _x for organic fertilizers, dimensionless; and
j	organic fertilizer type.

Step 5.6 Estimate net Greenhouse gas emissions in the ex-ante project scenario

This step calculates $GHG_{NET,t|PRS}$, the net GHG emissions in year t in the project scenario.

Proponents shall calculate the net greenhouse gas emissions in year t in the *ex-ante* project scenario as:

$$GHG_{NET,t|PRS} = GHG_{AWB,t|PRS} + GHG_{ENTERIC,t|PRS} + GHG_{FF,t|PRS} + GHG_{FERT,t|PRS} - (\Delta C_{S,t|PRS} + \Delta C_{AWB,t|PRS}) \quad (36)$$

Where:

$GHG_{NET,t PRS}$	net greenhouse gas emissions in year t in the project scenario; t CO ₂ -e;
$GHG_{ENTERIC,t PRS}$	greenhouse gas emissions from enteric fermentation in year t in the project scenario; t CO ₂ -e;
$GHG_{FF,t PRS}$	greenhouse gas emissions from fossil fuel combustion in year t in the project scenario, tCO ₂ -e; and
$GHG_{FERT,t PRS}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e;
$\Delta C_{S,t PRS}$	carbon stock change in soil organic carbon in year t in the project scenario, t CO ₂ -e; and
$\Delta C_{AWB,t PRS}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario; t CO ₂ -e.

STEP 6 – Ex-post Grassland Management Plans and stratification

This step recalibrates the GMP and the IGMP to account for environmental and management conditions that occurred during each verification period, and updates parameter selection for *ex-post* baseline scenario greenhouse gas emissions and *ex post* project scenario greenhouse gas emissions.

Where historical data were used to provide parameter input (such as rainfall, temperature, market forces) and management strategy decisions that generated *ex-ante* estimation of the baseline scenario, these data and management strategy decisions must be updated to use *ex post* data for the verification period.

The project proponent must, at a minimum, update rainfall and temperature parameters and baseline grassland management parameters in the GMP and IGMP where *ex post* data for management practices can be obtained or where historical or common practice justification can be made based on economic, rainfall and temperature patterns over the verification period.

Step 6.1 Ex-post Grassland Management Plan

The GMP, the grassland management plan which defines the baseline management strategies and input data for *ex ante* estimates of greenhouse gas emissions in the baseline scenario, shall be updated with parameter values from:

- livestock management including stocking rate, livestock type, and grazing days per land parcel;
- grassland management including any biomass burning and/or vegetation clearing, and/or pasture improvement;
- fertilizer use as mass of synthetic fertilizer and/or mass of organic fertilizer; and
- fossil fuel consumed (as represented by fuel purchased by fuel type).

Project proponents must provide credible evidence for updated values to the *ex-post* GMP for the baseline scenario in the VCS verification report.

Stratification shall be updated where environmental or market conditions during the verification period would justify a change in the GMP. Evidence for updated stratification must come from recorded common practice for the baseline grassland management scenario. It is not acceptable to update the baseline stratification based on evidence from indicators that arise from project activity.

Project proponents must submit evidence for changes to baseline scenario strata in the verification report.

Step 6.2 Ex-post Improved Grassland Management Plan

The IGMP, the improved grassland management plan which defines the project management strategies and input data for ex ante estimates of greenhouse gas emissions in the project scenario, must be updated with *ex post* measured and monitored parameters.

Where management strategies deviated from those in the *ex ante* IGMP, project proponents must update the *ex post* IGMP and all changes must be reported in the VCS verification report.

Stratification shall be updated where environmental or market conditions during the verification period would justify a change in the IGMP. Evidence for updated stratification must come from recorded common practice for the baseline grassland management scenario. It is not acceptable to update the baseline stratification based on evidence from indicators that arise from project activity.

Project proponents must submit evidence for changes to project scenario strata in the verification report.

Step 6.3 Update carbon pools and greenhouse gas emission sources

As *ex post* grassland management strategies may have deviated from those in the *ex ante* GMP and IGMP, this step reselects carbon pools and greenhouse gas emission sources that are required or are material in the *ex post* GMP and the *ex post* IGMP.

Step 6.3.1 Carbon stock additions from above-ground woody biomass

In the **baseline scenario**, project proponents shall use the approved A/R CDM *Guidance on Conditions under which the Change in Carbon Stocks in Existing Live Woody Vegetation Need not be Accounted*, to determine whether the change in carbon stocks in existing live woody vegetation (i.e. in trees and shrubs) are to be accounted in the *ex post* baseline scenario greenhouse gas accounts.

Equations are given in Step 7.2.1

In the **project scenario**, project proponents may conservatively exclude above-ground woody biomass carbon stock additions from the *ex-post* project scenario greenhouse accounts.

Where project proponents choose to account above-ground woody biomass carbon stock additions, equations are given in Step 8.3.1

Step 6.3.2 Above-ground woody biomass carbon stock losses

In the **baseline scenario**, where biomass clearing and/or burning is included in the management strategies described in the GMP, project proponents may choose to conservatively exclude carbon stock losses in above-ground woody biomass from the *ex-post* baseline scenario greenhouse gas accounts.

Where project proponents choose to account above-ground woody biomass carbon stock losses, equations are given in Step 7.2.2

In the **baseline scenario**, if fire is included in the management strategies described in the GMP, the area burned shall be defined as a stratum, and all biomass in the stratum shall be considered to be burned.

In the **project scenario**, where biomass clearing and/or burning is an included management strategy in the *ex post* IGMP, above-ground woody biomass carbon stock losses must be included in *ex-post* project scenario greenhouse gas accounts.

Equations for above-ground woody biomass carbon stock losses in the project scenario are given in Step 8.3.2

Step 6.3.3 Enteric emissions from methane production

In the **baseline scenario**, project proponents may choose to conservatively exclude enteric emissions from the *ex-post* baseline scenario greenhouse gas accounts.

Where project proponents choose to account enteric emissions, equations are given in Step 7.3

In the **project scenario**, it is necessary to compare *ex post* baseline scenario GMP and the *ex post* project scenario IGMP, and if there is:

- (d) no change in livestock numbers and livestock composition or type; or
- (e) a decrease in livestock numbers and no substitution to more emissions intensive livestock type(s) in the IGMP; or
- (f) a substitution to less emissions intensive livestock type(s) and no increase in livestock numbers in the IGMP;

project proponents may choose to exclude enteric emissions from the *ex-post* project scenario greenhouse gas accounts.

Enteric emissions must be accounted in the *ex-post* project scenario greenhouse gas accounts in all other situations using equations given in Step 8.4

Step 6.3.4 Emissions from fossil fuel combustion

In the **baseline scenario**, project proponents may choose to conservatively exclude emissions from fossil fuel combustion from the *ex-post* baseline scenario greenhouse gas accounts.

Where project proponents choose to account emissions from fossil fuel combustion, equations are given in Step 7.4

In the **project scenario**, it is necessary to compare *ex-post* baseline scenario GMP and the *ex-post* project scenario IGMP, and if there is:

- (d) no change in fuel consumed and fuel type; or

- (e) a decrease in fuel consumed and no substitution to more emissions intensive fuel type(s) in the IGMP; or
- (f) a substitution to less emissions intensive fuel type(s) and no increase in fuel consumed in the IGMP;

project proponents may choose to exclude emissions from fossil fuel combustion in the *ex-post* project scenario greenhouse gas accounts.

Emissions from fossil fuel combustion must be accounted in the *ex-post* project scenario greenhouse gas accounts in all other situations using equations given in Step 8.5

Step 6.3.5 Emissions from fertilizer use

In the **baseline scenario**, where fertilizer use is included in the management strategies described in the GMP, project proponents may choose to conservatively exclude emissions from fertilizer use the *ex-post* baseline scenario greenhouse gas accounts.

Where project proponents choose to account fertilizer use, equations are given in Step 7.5

In the **project scenario**, where fertilizer use is an included management strategy in the IGMP, emissions from fertilizer use must be included in *ex-post* project scenario greenhouse gas accounts using equations given in Step 8.6

STEP 7 – *Ex post* Net Greenhouse Gas Emissions in the baseline scenario

Step 7.1 *Determine SOC stock change in the baseline scenario*

The output of this step is *ex post* estimation of SOC stock change in the baseline scenario for the current verification period.

Step 7.1.1 Collate *ex post* parameter data for spatial co-ordinates

Project proponents must update the input parameters for each spatial co-ordinate with actual data for the verification period.

Step 7.1.2 Run SOC model for the baseline scenario

Proponents shall rerun the *ex-ante* SOC model for the baseline scenario at each of the selected spatial co-ordinates using the updated input parameters.

The output of the modelling will be a matrix of values for the SOC stock at each spatial coordinate for each year of the verification period.

Step 7.1.3 Spatial interpolation of SOC stock

At this step, the same spatial interpolation algorithms used for *ex-ante* estimation of SOC stocks in the baseline scenario shall be applied to the matrix of *ex-post* SOC stock estimates to generate an *ex-post* SOC stock profile for the baseline scenario in the preceding verification period.

Step 7.2 *Determine carbon stock change in above-ground woody biomass in the baseline scenario*

This step calculates $\Delta C_{AWB,t/BSL}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario.

Step 7.2.1 *Above-ground woody biomass carbon stock additions in the baseline scenario*

This step calculates $\Delta C_{AWB_AD,t/BSL}$ above-ground woody biomass carbon stock additions in year t in the baseline scenario.

If at Step 6.3.1 above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* baseline scenario, then:

$$\Delta C_{AWB_AD,t/BSL} = 0$$

Otherwise, proponents shall use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project*, to determine the following parameters²³:

- $\Delta C_{TREE_BSL,t}$ change in carbon stock in tree biomass within the project boundary in the baseline scenario in year t ; t CO₂-e
- $\Delta C_{SHRUB_BSL,t}$ change in carbon stock in shrub biomass within the project boundary in the baseline scenario in year t ; t CO₂-e

Proponents shall estimate above-ground woody biomass carbon stock additions in year t in the baseline scenario as:

$$\Delta C_{AWB_AD,t|BSL} = \Delta C_{TREE_BSL,t} + \Delta C_{SHRUB_BSL,t} \quad (37)$$

Where:

- $\Delta C_{AWB_AD,t|BSL}$ above-ground woody biomass carbon stock additions in year t in the baseline scenario; t CO₂-e
- $\Delta C_{TREE_BSL,t}$ change in carbon stock in tree biomass within the project boundary in the baseline scenario in year t ; t CO₂-e; and
- $\Delta C_{SHRUB_BSL,t}$ change in carbon stock in shrub biomass within the project boundary in the baseline scenario in year t ; t CO₂-e.

Step 7.2.2 Above-ground woody biomass carbon stock losses in the baseline scenario

This step calculates $\Delta C_{AWB_LS,t|BSL}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario.

If at Step 6.3.2, above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* baseline scenario, then:

$$\Delta C_{AWB_LS,t|BSL} = 0$$

If fire is used, the area burned shall be defined as a stratum, and all biomass in the stratum is considered to be burned. Burning from unplanned disturbance is dealt with separately under the *ex-post* project scenario (Step 11.4).

Project proponents must use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities* to determine the following parameters:

²³ $\Delta C_{TREE_BSL,t}$ and $\Delta C_{SHRUB_BSL,t}$ are parameters in the A/R Methodological Tool and do not use the same nomenclature scenario qualifiers as this methodology.

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass in stratum i in the baseline scenario in year t ; t C; and

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass in stratum i in the baseline scenario in year t ; t C.

Proponents shall then estimate the above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i in year t in the baseline scenario as:

$$C_{AWB,i,t|BSL} = C_{TREE_BSL,i,t} + C_{SHRUB_BSL,i,t} \quad (38)$$

Where:

$C_{AWB,i,t|BSL}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the baseline scenario; t CO₂-e

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e; and

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e.

Therefore, $\Delta C_{AWB_LS,t|BSL}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario is calculated as:

$$\Delta C_{AWB_LS,t|BSL} = \sum_i C_{AWB,i,t|BSL} \quad (39)$$

Where:

$\Delta C_{AWB_LS,t|BSL}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario; t CO₂-e;

$C_{AWB,i,t|BSL}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the baseline scenario; t CO₂-e; and

i 1,2,3... clearing and/or burning strata.

Where fire is used, it is necessary to also estimate the instantaneous non-CO₂ greenhouse gas emissions due to burning of tree and shrub biomass within those strata (Box 3).

Box 3. Non-CO₂ greenhouse gas emissions due to biomass burning

This box calculates the non-CO₂ greenhouse gas emissions due to biomass burning. These emissions are treated as an instantaneous greenhouse gas emission and not a carbon stock change.

Proponents shall estimate non-CO₂ emissions from tree biomass due to managed fire in

stratum i in year t in the baseline scenario as:

$$GHG_{TREE,i,t|BSL} = C_{TREE_BSL,i,t} \cdot COMF_{TREE,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (40)$$

Where:

$GHG_{TREE,i,t|BSL}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e;

$C_{TREE_BSL,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e;

$COMF_{TREE,i}$ combustion factor for tree biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Proponents shall then estimate non-CO₂ emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario as:

$$GHG_{SHRUB,i,t|BSL} = C_{SHRUB_BSL,i,t} \cdot COMF_{SHRUB,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (41)$$

Where:

$GHG_{SHRUB,i,t|BSL}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e;

$C_{SHRUB_BSL,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the baseline scenario in year t ; t CO₂-e;

$COMF_{SHRUB,i}$ combustion factor for shrub biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Therefore, non-CO₂ greenhouse gas emissions due to managed fire in year t in the baseline scenario are calculated as:

$$GHG_{AWB,t|BSL} = \sum_i GHG_{TREE,i,t|BSL} + GHG_{SHRUB,i,t|BSL} \quad (42)$$

$GHG_{AWB,t|BSL}$ non-CO₂ greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the baseline scenario; t CO₂-e;

$GHG_{TREE,i,t|BSL}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e;

$GHG_{SHRUB,i,t|BSL}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the baseline scenario; t CO₂-e; and

i 1,2,3... clearing and/or burning strata.

Step 7.2.3 Above-ground woody biomass carbon stock in the baseline scenario

Therefore, $\Delta C_{AWB,t|BSL}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario is calculated as follows:

$$\Delta C_{AWB,t|BSL} = \Delta C_{AWB_{LS},t|BSL} - \Delta C_{AWB_{AD},t|BSL} \quad (43)$$

Where:

$\Delta C_{AWB,t|BSL}$ the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario; t CO₂-e;

$\Delta C_{AWB_{AD},t|BSL}$ above-ground woody biomass carbon stock additions in year t in the baseline scenario; t CO₂-e; and

$\Delta C_{AWB_{LS},t|BSL}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the baseline scenario; t CO₂-e.

Step 7.3 Determine methane production from enteric emissions in the ex-post baseline scenario

If at Step 6.3.3 methane production from enteric emissions need not be accounted in the *ex-post* baseline scenario, then

$$GHG_{ENTERIC,t|BSL} = 0$$

Otherwise, the updated *ex-post* GMP inputs data to the following parameters:

$N_{l,t|BSL}$ number of livestock of type l in year t in the baseline scenario, head yr⁻¹; and

$GP_{l,t|BSL}$ grazing days for livestock type l in year t in the baseline scenario, days.

Proponents shall then estimate methane production from enteric emissions in year t in the *ex-post* baseline scenario as:

$$EF_l = \left(\frac{GE_l \cdot MCF_l}{55.65} \right) \quad (44)$$

Where:

EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
GE_l	gross energy intake livestock type l , MJ head ⁻¹ day ⁻¹ ;
MCF_l	methane conversion factor for livestock type l , fraction of gross energy in feed converted to methane;
55.65	energy content of methane, MJ/kg CH ₄ ; and
l	species/category/type of livestock.

$$E_{ENTERIC,t|BSL} = \sum_l \left[EF_l \cdot N_{l,t|BSL} \cdot GP_{l,t|BSL} \right] \quad (45)$$

Where:

$E_{ENTERIC,t BSL}$	methane emissions from enteric fermentation in year t in the baseline scenario, kg CH ₄ yr ⁻¹ ;
EF_l	emissions factor for livestock type l , kg CH ₄ head ⁻¹ day ⁻¹ ;
$N_{l,t BSL}$	number of livestock of type l in year t in the baseline scenario, head yr ⁻¹ ;
$GP_{l,t BSL}$	grazing days for livestock type l in year t in the baseline scenario, days; and
l	species/category/type of livestock.

The conversion of methane production to carbon dioxide equivalents shall be calculated as:

$$GHG_{ENTERIC,t|BSL} = E_{ENTERIC,t|BSL} \cdot 23 \cdot 10^{-3} \quad (46)$$

Where:

$GHG_{ENTERIC,t BSL}$	greenhouse gas emissions from enteric fermentation in year t in the baseline scenario; t CO ₂ -e yr ⁻¹ ;
$E_{ENTERIC,t BSL}$	methane emissions from enteric fermentation in year t in the baseline scenario, kg CH ₄ yr ⁻¹ ; and
23	global warming potential integrated over 100 years for CH ₄ , t CO ₂ -e t ⁻¹ CH ₄ .

Step 7.4 Determine emissions from fossil fuel combustion in the ex-post baseline scenario

If at Step 6.3.4 emissions from fossil fuel combustion need not be accounted in the *ex-post* baseline scenario, then:

$$GHG_{FF,t|BSL} = 0$$

Otherwise, the updated *ex-post* GMP inputs data to the following parameters:

$FC_{f,t BSL}$	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the baseline scenario, kL.
f	fuel type.

Greenhouse gas emissions from fossil fuel combustion in the *ex-post* baseline scenario in year t shall be calculated as follows:

$$GHG_{FF,t|BSL} = \sum_{g=1}^3 \sum_{f=1}^{f^*} EC_{f,t|BSL} \cdot EF_{g,f} \cdot GWP_g \cdot 10^{-3} \quad (47)$$

Where:

$GHG_{FF,t BSL}$	greenhouse gas emissions from fossil fuel combustion in year t in the baseline scenario, tCO ₂ -e yr ⁻¹ ;
$EC_{f,t BSL}$	energy consumed for fuel type f in year t in the baseline scenario, TJ;
$EF_{g,f}$	emissions factor for greenhouse gas g for fuel type f ; kg TJ ⁻¹ ;
$GWP_{100,g}$	global warming potential integrated over 100 years for greenhouse gas g , t CO ₂ -e t ⁻¹ ;
g	unique identifier for each greenhouse gas; and
f	fuel type.

The energy consumed for each fuel type in the baseline scenario shall be calculated as follows:

$$EC_{f,t|BSL} = FC_{f,t|BSL} \cdot NCV_f \cdot D_f \quad (48)$$

Where:

$EC_{f,t BSL}$	energy consumed for fuel type f in year t in the baseline scenario, TJ;
$FC_{f,t BSL}$	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the baseline scenario, kL;
NCV_f	net calorific value for fuel type f , TJ Gg ⁻¹ ; and

D_f density of fuel type f , Gg kL⁻¹.

Step 7.5 Determine emissions from fertilizer use in the ex-post baseline scenario

If at Step 6.3.3 emissions from fertilizer use need not be accounted in the *ex-post* baseline scenario, then:

$$GHG_{FERT,t|BSL} = 0$$

Otherwise, the updated *ex-post* GMP inputs data to the following parameters:

$M_{SF,k,t}$ mass of synthetic fertilizer type k applied in year t , t;

$M_{OF,j,t}$ mass of organic fertilizer type j applied in year t , t.

If flooding irrigation or any natural flood has occurred on the project area within a period of 3 months from date of fertilizer application, then $GHG_{FERT,t|BSL}$ for that year t is conservatively estimated as:

$$GHG_{FERT,t|BSL} = 0$$

For all other years, the direct nitrous oxide emissions from nitrogen fertilization in year t shall be calculated as:

$$GHG_{FERT,t|BSL} = (F_{SN,t} + F_{ON,t}) \cdot EF_1 \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad (49)$$

Where:

$GHG_{FERT,t BSL}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e;
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH ₃ and NO _x , t N;
$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH ₃ and NO _x , t N;
EF_1	emission factor for emissions from N inputs, t N ₂ O-N t ⁻¹ N input;
$44/28$	ratio of molecular weights of N ₂ O and N, t N ₂ O t ⁻¹ N; and
GWP_{N_2O}	global warming potential integrated over 100 years for N ₂ O, t CO ₂ -e t ⁻¹ N ₂ O.

$$F_{SN,t} = \sum_k M_{SF,k,t} \cdot NC_{SF,k} \cdot (1 - Frac_{GASF}) \quad (50)$$

Where:

$F_{SN,t}$	mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
$M_{SF,k,t}$	mass of synthetic fertilizer type k applied in year t , t;
$NC_{SF,k}$	nitrogen content of synthetic fertilizer type k applied, g N $100g^{-1}$ fertilizer;
$Frac_{GASF}$	Fraction that volatilises as NH_3 and NO_x for synthetic fertilizers, dimensionless; and
k	synthetic fertilizer type.

$$F_{ON,t} = \sum_j M_{OF,j,t} \cdot NC_{OF,j} \cdot (1 - Frac_{GASM}) \quad (51)$$

Where:

$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
$M_{OF,j,t}$	mass of organic fertilizer type j applied in year t , t;
$NC_{OF,j}$	nitrogen content of organic fertilizer type j applied, g N $100g^{-1}$ fertilizer; and
$Frac_{GASM}$	Fraction that volatilises as NH_3 and NO_x for organic fertilizers, dimensionless; and
j	organic fertilizer type.

Step 7.6 Net greenhouse gas emissions in the ex-post baseline scenario

This step calculates $GHG_{NET,t|BSL}$, the net GHG emissions in year t in the baseline scenario.

Proponents shall calculate the net greenhouse gas emissions in year t in the *ex-post* baseline scenario as:

$$GHG_{NET,t|BSL} = \Delta C_{S,t|BSL} + \Delta C_{AWB,t|BSL} + GHG_{AWB,t|BSL} + GHG_{ENTERIC,t|BSL} + GHG_{FF,t|BSL} + GHG_{FERT,t|BSL} \quad (52)$$

Where:

$GHG_{NET,t BSL}$	net greenhouse gas emissions in year t in the baseline scenario; t CO_2 -e;
$\Delta C_{S,t BSL}$	carbon stock change in soil organic carbon in year t in the baseline scenario, t CO_2 -e;

$\Delta C_{AWB,t/BSL}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the baseline scenario; t CO ₂ -e
$GHG_{AWB,t/BSL}$	non-CO ₂ greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the baseline scenario; t CO ₂ -e;
$GHG_{ENTERIC,t/BSL}$	greenhouse gas emissions from enteric fermentation in year t in the baseline scenario; t CO ₂ -e;
$GHG_{FF,t/BSL}$	greenhouse gas emissions from fossil fuel combustion in year t in the baseline scenario, tCO ₂ -e; and
$GHG_{FERT,t/BSL}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e.

STEP 8 – *Ex-post* Net Greenhouse Gas Emissions in the Project Scenario

This step calculates *ex-post* net greenhouse gas emissions, $GHG_{NET|PRS}$, in the project scenario.

Step 8.1 Estimate SOC stock change in the ex-post project scenario from SOC modelling

The output of this step is *ex-post* estimation of SOC stock change in the project scenario for each verification period.

Project proponents shall use a model calibration method to calculate and monitor SOC stock change in the project scenario.

Step 8.1.1 Collate *ex post* parameter data for spatial co-ordinates

Project proponents must update the input parameters for each spatial co-ordinate used to determine the *ex-ante* project scenario with actual data for the verification period under the project scenario.

Environmental data must be obtained from the same sources as those used to parameterize the project scenario modelling and from records contained in the *ex-post* IGMP.

Step 8.1.2 Run SOC model for the *ex-post* project scenario

Proponents shall rerun the SOC model for the *ex-post* project scenario at each of the spatial co-ordinates generated for the *ex-ante* project scenario using the updated input parameters.

The output of the modelling will be a matrix of values for the SOC stock at each spatial coordinate for each year of the verification period.

Step 8.1.3 Spatial interpolation of SOC stock

At this step, the same spatial interpolation algorithms used for *ex-ante* estimation of SOC stocks in the project scenario shall be applied to the matrix of *ex-post* SOC stock estimates to generate an *ex-post* SOC stock profile for the project scenario in the verification period.

Step 8.2 Validate SOC stock change estimate in the ex-post project scenario

This step completes the calibration of the SOC model output by comparison with selective SOC values determined by field sampling in the project area.

This step requires the completion of field sampling of SOC.

The methods applied to field sampling and SOC analysis described below must be applied. However, new technologies can be applied as they become available once scientific peer review and tests on soils equivalent to those in the project scenario have been completed.

It is acceptable for proponents to outsource soil sampling and soil analysis to certified analytical laboratories.

Step 8.2.1 Determine stratified sampling design for field measurement of SOC

Proponents must generate a soil sampling design prior to completing fieldwork.

Field sampling shall take place at a sub-set of the spatial co-ordinates used to generate output for the chosen SOC model. The sub-set of spatial co-ordinates shall be stratified to cover the project area and include the strata used as parameters in the chosen SOC model for the project scenario.

The sub-set of spatial co-ordinates must include:

- the major soil types;
- sampling from a minimum of three co-ordinates in sufficient strata identified in the project scenario that cover 80% of the project area;
- include all areas of the project where variance in model output is 65% greater than the average variance; and
- a minimum of 30 samples across the project area.

The sampling design must be described in the VCS verification report.

Step 8.2.2 Field sampling

Soil sampling for SOC must follow standard procedures compliant with ISO standards.²⁴

The standard depth of soil sampling shall be 30cm.

Depth of soil samples may differ from 30cm where this is necessary for consistency with the parameters and output of the selected SOC model. It is only acceptable to compare model output for soil to a depth that is consistent with the chosen SOC model. Justification for any variance from the 30cm depth of sampling must be provided in the verification report.

At each sampling co-ordinate three soil cores must be taken within a minimum of 1m radius, and no greater than 5m radius, apart, to the determined sampling depth. These samples must be pooled and sub-sampled for analysis following ISO compliant procedures.²⁵

²⁴ ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques

Step 8.2.3 Sample analysis for SOC determination

It is acceptable to use either dry combustion or wet oxidation methods to determine soil organic carbon content of soil samples where the method chosen is compliant with ISO standards for soil carbon analysis.²⁶

It is also acceptable to apply new technologies as they become available once scientific peer review and tests on soils equivalent to those in the project scenario have been completed.

All SOC estimates must be given as a carbon density. Where the chosen SOC model produces SOC estimates as a percentage (%C) it is necessary to convert %C to carbon density by measurement of soil bulk density for each soil sample. Methods for the determination of bulk density must be ISO compliant²⁷ and be described in the verification report.

Step 8.2.4 Comparison of SOC from model output and field sampling

This step compares the SOC estimates from model output with SOC estimates from field sampling.

For the sub-set of spatial co-ordinates proponents shall complete a table comparing the model and sampled SOC values and complete significance tests.

Statistical testing shall be applied sequentially to determine:

- any statistical difference between the model output and field sample estimates of SOC across the sample sub-set
- that there is no strata effect on the difference between the model output and field sample estimates of SOC
- that there is no spatial effect on the difference between the model output and field sample estimates of SOC

The project proponent must complete a paired comparison test on data from the sub-set of spatial co-ordinates used in the field sampling to determine if the estimates of SOC from field sampling are significantly different to the SOC values predicted by the SOC model.

²⁵ ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques

²⁶ ISO 10694:1995 Soil quality -- Determination of organic and total carbon after dry combustion (elementary analysis), and ISO 14235:1998 Soil quality -- Determination of organic carbon by sulfochromic oxidation.

²⁷ ISO 11272: 1998 Soil quality - Determination of dry bulk density

Where paired comparison test are significant a sign test shall be completed to determine whether the model output or field samples give consistently higher values. Where this analysis shows that the field samples are consistently higher than estimates from the SOC model, the proponent shall use the model output to calculate the SOC stock change in the project scenario.

Where the paired comparison test is not statistically significant or where the test is significant but a sign test does not confirm that field samples are consistently above SOC model estimates for SOC, project proponents shall compute paired comparison tests on data from the sub-set of spatial co-ordinates used in the field sampling that have been grouped by strata.

Each major stratum that accounts for more than 10% of the project area shall form the groupings for analysis. Where the selection of strata fail to cover the project area it is necessary to also include a spatial stratification to the groupings for paired comparison tests.

Where paired comparison test for a stratum is significant a sign test shall be completed to determine whether the model output or field samples give consistently higher values. Where this analysis shows that the field samples are consistently higher than estimates from the SOC model, the proponent shall use the model output to calculate the SOC stock change in the project scenario for that stratum.

Where the overall paired test for a stratum is significant but the sign test shows that SOC model estimates are consistently higher than sample values, then the field sample values for the stratum must be used to compute a spatial interpolation of SOC for the calculation of SOC in the project scenario.

Computation of spatial interpolation of SOC for the calculation of SOC in the project scenario shall include SOC model estimates and field sample values for strata where the model predicts higher SOC than was observed. As field sample values will be fewer in number than the original spatial co-ordinates matrix and lower than the model predictions this interpolation is conservative.

Step 8.3 Determine carbon stock change in above-ground woody biomass in the ex-post project scenario

This step calculates $\Delta C_{AWB,t|PRS}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the *ex-post* project scenario.

Step 8.3.1 Above-ground woody biomass carbon stock additions in the ex-post project scenario

This step calculates $\Delta C_{AWB_AD,t|PRS}$ above-ground woody biomass carbon stock additions in year t in the project scenario.

If at Step 6.3.1 above-ground woody biomass carbon stock additions need not be accounted in the *ex-post* project scenario, then:

$$\Delta C_{AWB_AD,t|PRS} = 0$$

Otherwise, proponents shall use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project*, to determine the following parameters:

$\Delta C_{TREE_PROJ,t}$ change in carbon stock in tree biomass within the project boundary in the project scenario in year t ; t CO₂-e

$\Delta C_{SHRUB_PROJ,t}$ change in carbon stock in shrub biomass within the project boundary in the project scenario in year t ; t CO₂-e

Proponents shall estimate above-ground woody biomass carbon stock additions in year t in the *ex-post* project scenario as:

$$\Delta C_{AWB_AD,t|PRS} = \Delta C_{TREE_PROJ,t} + \Delta C_{SHRUB_PROJ,t} \quad (53)$$

Where:

$\Delta C_{AWB_AD,t|PRS}$ above-ground woody biomass carbon stock additions in year t in the project scenario; t CO₂-e

$\Delta C_{TREE_PRS,t}$ change in carbon stock in tree biomass within the project boundary in the project scenario in year t ; t CO₂-e; and

$\Delta C_{SHRUB_PRS,t}$ change in carbon stock in shrub biomass within the project boundary in the project scenario in year t ; t CO₂-e.

Step 8.3.2 Above-ground woody biomass carbon stock losses in the ex-post project scenario

This step calculates $\Delta C_{AWB_LS,t|PRS}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the *ex-post* project scenario. Where unplanned disturbance to above-ground woody biomass occurs, the equations in this step are used to calculate these carbon stock losses. Guidance on unplanned disturbance and how to include it within these equations is dealt with under project monitoring (Step 12.4).

If at Step 6.3.2, above-ground woody biomass carbon stock losses need not be accounted in the *ex-post* project scenario and no unplanned disturbance has occurred, then:

$$\Delta C_{AWB_LS,t|PRS} = 0$$

If fire is used, the area burned shall be defined as a stratum, and all biomass in the stratum is considered to be burned.

Project proponents must use the approved A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities* to determine the following parameters:

$C_{TREE_PROJ,i,t}$ carbon stock in tree biomass in stratum i in the *ex-post* project scenario in year t ; t C; and

$C_{SHRUB_PROJ,i,t}$ carbon stock in shrub biomass in stratum i in the *ex-post* project scenario in year t ; t C.

Proponents shall then estimate the above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i in year t in the *ex-post* project scenario as:

$$C_{AWB,i,t|PRS} = C_{TREE_PROJ,i,t} + C_{SHRUB_PROJ,i,t} \quad (54)$$

Where:

$C_{AWB,i,t|PRS}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the *ex-post* project scenario; t CO₂-e

$C_{TREE_PRSi,,t}$ carbon stock in tree biomass within the project boundary in stratum i in the *ex-post* project scenario in year t ; t CO₂-e; and

$C_{SHRUB_PRSi,,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the *ex-post* project scenario in year t ; t CO₂-e.

Therefore, $\Delta C_{AWB_LS,t|PRS}$, the change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario is calculated as:

$$\Delta C_{AWB_LS,t|PRS} = \sum_i C_{AWB,i,t|PRS} \quad (55)$$

Where:

$\Delta C_{AWB_LS,t|PRS}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario; t CO₂-e;

$C_{AWB,i,t|PRS}$ above-ground woody biomass carbon stock impacted by clearing and/or burning in stratum i year t in the project scenario; t CO₂-e; and

i 1,2,3... clearing and/or burning strata.

Where fire is used, it is necessary to also estimate the instantaneous non-CO₂ greenhouse gas emissions due to biomass burning of tree and shrub biomass within those strata (Box 4).

Box 4. Non-CO₂ greenhouse gas emissions due to biomass burning

This box calculates the non-CO₂ greenhouse gas emissions due to biomass burning. These emissions are treated as an instantaneous greenhouse gas emission and not a carbon stock change.

Proponents shall estimate non-CO₂ emissions from tree biomass due to managed fire in stratum i in year t in the project scenario as:

$$GHG_{TREE,i,t|PRS} = C_{TREE_PROJ,i,t} \cdot COMF_{TREE,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (56)$$

Where:

$GHG_{TREE,i,t|PRS}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e;

$C_{TREE_PROJ,i,t}$ carbon stock in tree biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e;

$COMF_{TREE,i}$ combustion factor for tree biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Proponents shall then estimate non-CO₂ emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario as:

$$GHG_{SHRUB,i,t|PRS} = C_{SHRUB_PROJ,i,t} \cdot COMF_{SHRUB,i} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (57)$$

Where:

$GHG_{SHRUB,i,t|PRS}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e;

$C_{SHRUB_PROJ,i,t}$ carbon stock in shrub biomass within the project boundary in stratum i in the project scenario in year t ; t CO₂-e;

$COMF_{SHRUB,i}$ combustion factor for shrub biomass in stratum i , dimensionless;

ER_{CH_4} emissions factor for CH₄, t CH₄ t⁻¹ C burnt;

$16/44$ ratio of molecular weights of CH₄ and CO₂; mol mol⁻¹; and

GWP_{CH_4} global warming potential for CH₄; t CO₂-e t⁻¹ CH₄.

Therefore, non-CO₂ greenhouse gas emissions due to managed fire in year t in the project scenario are calculated as:

$$GHG_{AWB,t|PRS} = \sum_i GHG_{TREE,i,t|PRS} + GHG_{SHRUB,i,t|PRS} \quad (58)$$

$GHG_{AWB,t|PRS}$ non-CO₂ greenhouse gas emissions from above-ground woody biomass due to managed fire in year t in the project scenario; t CO₂-e;

$GHG_{TREE,i,t|PRS}$ non-CO₂ greenhouse gas emissions from tree biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e;

$GHG_{SHRUB,i,t|PRS}$ non-CO₂ greenhouse gas emissions from shrub biomass due to managed fire in stratum i in year t in the project scenario; t CO₂-e; and

i	$1, 2, 3 \dots$ clearing and/or burning strata.
-----	---

Step 8.3.3 Above-ground woody biomass carbon stock in the project scenario

Therefore, $\Delta C_{AWB,t|PRS}$, the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario is calculated as follows:

$$\Delta C_{AWB,t|PRS} = \Delta C_{AWB_AD,t|PRS} - \Delta C_{AWB_LS,t|PRS} \quad (59)$$

Where:

- $\Delta C_{AWB,t|PRS}$ the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario; t CO₂-e;
- $\Delta C_{AWB_AD,t|PRS}$ above-ground woody biomass carbon stock additions in year t in the project scenario; t CO₂-e; and
- $\Delta C_{AWB_LS,t|PRS}$ change in above-ground woody biomass carbon stock due to managed biomass clearing and/or burning in year t in the project scenario; t CO₂-e.

Step 8.4 Determine emissions from enteric methane production in the ex-post project scenario

If at Step 6.3.3 methane production from enteric emissions need not be accounted in the *ex-post* project scenario, then

$$GHG_{ENTERIC,t|PRS} = 0$$

Otherwise, the updated *ex-post* IGMP inputs data to the following parameters:

- $N_{l,t|PRS}$ number of livestock of type l in year t in the project scenario, head yr⁻¹; and
- $GP_{l,t|PRS}$ grazing days for livestock type l in year t in the project scenario, days.

Proponents shall then estimate methane production from enteric emissions in year t in the *ex-post* project scenario as:

$$EF_l = \left(\frac{GE_l \cdot MCF_l}{55.65} \right) \quad (60)$$

Where:

- EF_l emissions factor for livestock type l , kg CH₄ head⁻¹ day⁻¹;
- GE_l gross energy intake livestock type l , MJ head⁻¹ day⁻¹;
- MCF_l methane conversion factor for livestock type l , fraction of gross energy in feed converted to methane;

55.65 energy content of methane, MJ/kg CH₄; and
l species/category/type of livestock.

$$E_{ENTERIC,t|PRS} = \sum_l EF_l \cdot N_{l,t|PRS} \cdot GD_{l,t|PRS} \quad (61)$$

Where:

$E_{ENTERIC,t|PRS}$ methane emissions from enteric fermentation in year *t* in the project scenario, kg CH₄ yr⁻¹;
 EF_l emissions factor for livestock type *l*, kg CH₄ head⁻¹ day⁻¹;
 $N_{l,t|PRS}$ number of livestock of type *l* in year *t* in the project scenario, head yr⁻¹;
 $GD_{l,t|PRS}$ grazing days for livestock type *l* in year *t* in the project scenario, days; and
l species/category/type of livestock.

The conversion of methane production to carbon dioxide equivalents shall be calculated as:

$$GHG_{ENTERIC,t|PRS} = E_{ENTERIC,t|PRS} \cdot 23 \cdot 10^{-3} \quad (62)$$

Where:

$GHG_{ENTERIC,t|PRS}$ greenhouse gas emissions from enteric fermentation in year *t* in the project scenario; t CO₂-e yr⁻¹;
 $E_{ENTERIC,t|PRS}$ methane emissions from enteric fermentation in year *t* in the project scenario, kg CH₄ yr⁻¹; and
 23 global warming potential integrated over 100 years for CH₄, t CO₂-e t⁻¹ CH₄.

Step 8.5 Determine emissions from fossil fuel combustion in the ex-post project scenario

If at Step 6.3.4 emissions from fossil fuel combustion need not be accounted in the *ex-post* baseline scenario, then:

$$GHG_{FF,t|PRS} = 0$$

Otherwise, the updated *ex-post* IGMP inputs data to the following parameters:

$FC_{f,t|PRS}$ fuel consumed (as represented by fuel purchased) for fuel type *f* in year *t* in the project scenario, kL.

f fuel type

Greenhouse gas emissions from fossil fuel combustion in the project scenario shall be estimated as follows:

$$GHG_{FF,t|PRC} = \sum_{g=1}^3 \sum_{f=1}^{f^*} (EC_{f,t|PRC} \cdot EF_{g,f} \cdot GWP_g) \cdot 10^{-3} \quad (63)$$

Where:

$GHG_{FF,t PRC}$	greenhouse gas emissions from fossil fuel combustion in year t in the project scenario, tCO ₂ -e yr ⁻¹ ;
$EC_{f,t PRC}$	energy consumed for fuel type f in year t in the project scenario, TJ;
$EF_{g,f}$	emissions factor for greenhouse gas g for fuel type f ; kg TJ ⁻¹ ;
$GWP_{100,g}$	global warming potential integrated over 100 years for greenhouse gas g , t CO ₂ -e t ⁻¹ ;
g	unique identifier for each greenhouse gas; and
f	fuel type.

The energy consumed for each fuel type in the project scenario shall be calculated as follows:

$$EC_{f,t|PRC} = FC_{f,t|PRC} \cdot NCV_f \cdot D_f \quad (64)$$

Where:

$EC_{f,t PRC}$	energy consumed for fuel type f in year t in the project scenario, TJ;
$FC_{f,t PRC}$	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the project scenario, kL;
NCV_f	net calorific value for fuel type f , TJ Gg ⁻¹ ; and
D_f	density of fuel type f , Gg kL ⁻¹ .

Step 8.6 Determine emissions from fertilizer use in the ex-post project scenario

In the *ex-post* project scenario direct nitrous oxide emissions from nitrogen fertilization is measured even when flood irrigation or flooding has occurred on the project area within a period of 3 months from date of fertilizer application, as this is conservative.

For *ex-post* estimation of $GHG_{FERT,t|PRC}$, the updated *ex-post* IGMP inputs data to the following parameters:

$M_{SF,k,t}$ mass of synthetic fertilizer type k applied in year t , t;

$M_{OF,j,t}$ mass of organic fertilizer type j applied in year t , t.

The direct nitrous oxide emissions from nitrogen fertilization in year t can be estimated using equations as follows:

$$GHG_{FERT,t|PRS} = (F_{SN,t} + F_{ON,t}) \cdot EF_1 \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad (65)$$

Where:

$GHG_{FERT,t PRS}$	direct N_2O emission as a result of nitrogen application within the project boundary in year t in the <i>ex-post</i> project scenario, t CO_2 -e;
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
EF_1	emission factor for emissions from N inputs, t N_2O -N t ⁻¹ N input;
44/28	ratio of molecular weights of N_2O and N, t N_2O t ⁻¹ N; and
GWP_{N_2O}	global warming potential integrated over 100 years for N_2O , t CO_2 -e t ⁻¹ N_2O .

$$F_{SN,t} = \sum_k M_{SF,k,t} \cdot NC_{SF,k} \cdot (1 - \text{Frac}_{GASF}) \quad (66)$$

Where:

$F_{SN,t}$	mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
$M_{SF,k,t}$	mass of synthetic fertilizer type k applied in year t , t;
$NC_{SF,k}$	nitrogen content of synthetic fertilizer type k applied, g N 100g ⁻¹ fertilizer;
Frac_{GASF}	Fraction that volatilises as NH_3 and NO_x for synthetic fertilizers, dimensionless; and
k	synthetic fertilizer type.

$$F_{ON,t} = \sum_j M_{OF,j,t} \cdot NC_{OF,j} \cdot (1 - \text{Frac}_{GASM}) \quad (67)$$

Where:

$F_{ON,t}$	mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH_3 and NO_x , t N;
$M_{OF,j,t}$	mass of organic fertilizer type j applied in year t , t;
$NC_{OF,j}$	nitrogen content of organic fertilizer type j applied, g N $100g^{-1}$ fertilizer; and
$Frac_{GASM}$	Fraction that volatilises as NH_3 and NO_x for organic fertilizers, dimensionless; and
j	organic fertilizer type.

Step 8.7 Net GHG emissions in the ex-post project scenario

This step calculates $GHG_{NET,t|PRS}$, the net GHG emissions in year t in the project scenario.

Proponents shall calculate the net greenhouse gas emissions in year t in the *ex-post* project scenario as:

$$GHG_{NET,t|PRS} = GHG_{AWB,t|PRS} + GHG_{ENTERIC,t|PRS} + GHG_{FF,t|PRS} + GHG_{FERT,t|PRS} - (\Delta C_{S,t|PRS} + \Delta C_{AWB,t|PRS}) \quad (68)$$

Where:

$GHG_{NET,t PRS}$	net greenhouse gas emissions in year t in the project scenario; t CO ₂ -e;
$GHG_{AWB,t PRS}$	greenhouse gas emissions from above-ground woody biomass in year t in the project scenario; t CO ₂ -e;
$GHG_{ENTERIC,t PRS}$	greenhouse gas emissions from enteric fermentation in year t in the project scenario; t CO ₂ -e;
$GHG_{FF,t PRS}$	greenhouse gas emissions from fossil fuel combustion in year t in the project scenario, tCO ₂ -e; and
$GHG_{FERT,t PRS}$	direct N ₂ O emission as a result of nitrogen application within the project boundary in year t , t CO ₂ -e;
$\Delta C_{S,t PRS}$	carbon stock change in soil organic carbon in year t in the project scenario, t CO ₂ -e; and
$\Delta C_{AWB,t PRS}$	the carbon stock change in above-ground woody biomass within the project boundary in year t in the project scenario; t CO ₂ -e.

STEP 9 – Project Leakage

Leakage is defined as any increase in greenhouse gas emissions that occur outside a project's boundary, but within the same country, that is measurable and attributable to the project activity.

Step 9.1 Activity shifting leakage

There may be no leakage due to activity shifting.

At each verification documentation must be provided covering any other grasslands controlled by the project proponent where leakage could occur, including, at a minimum, their location(s), area and type of existing land use(s), and grazing management plans.

Where the project proponent controls multiple parcels of land under grassland management within the country, the project proponent must demonstrate that the grassland management plans and/or land-use designations of the land parcels they control have not materially changed as a result of the planned improved grazing management project.

This must be demonstrated through:

- historical records showing grassland management and livestock production do not deviate from historical trends; and/or
- grassland management on all land parcels controlled by the project proponent show no deviation from grassland management plans prepared greater than 24 months prior to the start of the improved grassland management project.

Where activity shifting occurs or a project proponent is unable to provide the necessary documentation at first and subsequent verification, the project shall not meet the requirements for verification.

Therefore, the project shall be subject to the VCS conditions on projects which fail to submit periodic verification after the commencement of the project. Project proponents may optionally choose to submit a methodology deviation with their future verifications to address activity shifting leakage.

Where the project proponent has control only over resource use in the project area and has no access to other forest resource, then the only type of leakage emissions calculated is GHG emissions due to market effects that result from project activity.

Step 9.2 Market leakage

Leakage due to market effects results from the displacement of baseline scenario livestock production to commercial producers operating outside the project boundary which is measureable and attributable to the improved grazing management project activity.²⁸

Step 9.2.1 Direct substitution

Where there is direct substitution in livestock production there shall be no market leakage.

Direct substitution occurs where a demand for production is met by an alternative production source with equivalent or lower greenhouse gas emissions than livestock production in the *ex-post* project scenario.

Direct substitution shall apply where a decrease in livestock production in the project scenario is met by alternative livestock production outside the project area and/or where direct product substitution occurs within the project boundary.

Project proponents shall provide evidence in the VCS verification report for direct substitution.

Step 9.2.2 Livestock production

Leakage due to market effects is equal to the net emissions in the baseline scenario multiplied by an appropriate leakage factor:

$$GHG_{LK,t|IGM} = LF_{me} * GHG_{NET,t|BSL} \quad (69)$$

Where:

$GHG_{LK|LIPF}$ is market leakage in year t as a result of IGM activities, tCO₂e;
 LF_{ME} is the dimensionless leakage factor for market-effects calculations;
 $GHG_{NET|BSL}$ net greenhouse gas emissions in year t in the baseline scenario, tCO₂e.

Where livestock production is lower in the *ex-post* baseline scenario than the *ex-post* project scenario or where livestock production in the *ex-post* baseline scenario is not significantly different to livestock production in the *ex-post* project scenario there shall be no market leakage.

Therefore,

$$LF_{ME} = 0$$

Livestock production shall be compared in standard livestock units from data provided to recalibrate the GMP and the IGMP to account for environmental and management conditions that occurred during each verification period (Step 6).

²⁸ CDM 5/CMP.1, Annex, paragraph 1(e)

Step 9.2.3 Livestock production trigger

Where livestock production in the *ex-post* project scenario is greater than or equal to 20% lower than the average livestock production in the *ex-post* baseline scenario over the verification period, project proponents shall determine whether a displacement of production and subsequent emissions are measureable and attributable to the project activity.

Displacement of the sum of removed production shall be determined to have occurred when the amount of livestock production foregone in the project area is greater than 5% of the variance of average national production in units of production for the same product during the period of 10 years preceding project implementation on the relevant national livestock market.

Where livestock production in the *ex-post* project scenario is greater than or equal to 20% lower than the average livestock production in the *ex-post* baseline scenario over the verification period but the detection trigger is not met, there shall be no market leakage.

Therefore,

$$LF_{ME} = 0$$

Where livestock production in the *ex-post* project scenario is greater than or equal to 20% lower than the average livestock production in the *ex-post* baseline scenario over the verification period and the detection trigger is met, market leakage shall be:

$$LF_{ME} = 0.5$$

STEP 10 – Net Project Greenhouse Gas Emission Reductions

This step calculates $GHG_{CREDITS,t|IGM}$, the net project greenhouse gas emission credits associated with the implementation of improved grazing management (IGM) activities in the project scenario.

At validation the following equation shall be applied using the *ex-ante* greenhouse gas emission calculations at Step 4 for *ex-ante* baseline scenario and at Step 5 for *ex-ante* project scenario greenhouse gas emissions assuming that in the *ex-ante* case leakage is zero:

$$GHG_{CREDITS,t|IGM} = GHG_{NET,t|PRS} - GHG_{NET,t|BSL} \quad (70)$$

Where:

- $GHG_{CREDITS,t|IGM}$ project greenhouse gas emission credits in year t associated with the implementation of Improved Grazing Management (IGM) project, tCO₂e;
- $GHG_{NET,t|BSL}$ net greenhouse gas emissions in year t in the baseline scenario since the start of the project activity, tCO₂e; and
- $GHG_{NET,t|PRS}$ net greenhouse gas emissions in year t in the project scenario since the start of the project activity, tCO₂e.

At verification the following equation shall also be applied using the *ex-post* greenhouse gas emission calculations at Step 7 for *ex-post* baseline scenario and at Step 8 for *ex-post* project scenario greenhouse gas emissions and the calculation of project leakage at Step 9.

$$GHG_{CREDITS,t|IGM} = GHG_{NET,t|PRS} - GHG_{NET,t|BSL} - GHG_{LK,t|IGM} \quad (71)$$

Where:

- $GHG_{CREDITS,t|IGM}$ project greenhouse gas emission credits in year t associated with the implementation of Improved Grazing Management (IGM) project, tCO₂e;
- $GHG_{NET,t|BSL}$ net greenhouse gas emissions in year t in the baseline scenario since the start of the project activity, tCO₂e;
- $GHG_{NET,t|PRS}$ net greenhouse gas emissions in year t in the project scenario since the start of the project activity, tCO₂e; and
- $GHG_{LK,t|IGM}$ total greenhouse gas emissions due to leakage arising outside the project boundary as a result of the implementation of improved grazing management (IGM) project, tCO₂e.

STEP 11 – Project Voluntary Carbon Units

The number of Voluntary Carbon Units (VCUs) for each year t in the crediting period is the greenhouse gas emission credits adjusted for uncertainty and risk.

Step 11.1 Adjustment for uncertainty

Estimated greenhouse gas emissions and emission reductions from IGM activities have uncertainties associated with parameters and coefficients including estimates of area, carbon stocks, stratification and greenhouse gas emissions. It is assumed that the uncertainties associated with input data are available, either as default uncertainty values given in most recent IPCC guidelines, or as statistical estimates based on sampling.

Uncertainty at all times is defined as the 95% confidence interval as a percentage of the mean.

Procedures including stratification and the allocation of sufficient measurement plots will help ensure that low uncertainty results and ultimately full crediting can result.

It is good practice to consider uncertainty at an early stage to identify the data sources with the highest uncertainty to allow the opportunity to conduct further work to diminish uncertainty.

Uncertainties arising from the measurement and monitoring of carbon pools and greenhouse gases shall always be quantified. Errors in each pool shall be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

For both the baseline and the with-project scenario the total uncertainty is equal to the square root of the sum of the squares of each component uncertainty and is calculated at the time of reporting through propagating the error in the baseline stocks and the error in the project stocks.

Therefore, total uncertainty for IGM project is calculated as:

$$U_{TOTAL,t|IGM} = \sqrt{U_{t|PRJ}^2 + U_{t|BSL}^2} \quad (72)$$

Where:

$U_{TOTAL IGM}$	total uncertainty in year t for IGM Project, dimensionless;
$U_{ PRS}$	total uncertainty in year t for the improved grassland management activities in the project scenario, dimensionless; and
$U_{ BSL}$	total uncertainty in year t for the baseline scenario, dimensionless.

Project proponents must justify the selection of uncertainty propagation in the VCS-PD.

If $U_{total|IGM} \leq 0.1$ then no deduction will result for uncertainty.

If $U_{total|IGM} > 0.1$ then the amount of greenhouse gas emission credits associated with IFM activities will be deducted as follows:

$$Credits_{TOTAL,t|IGM} = GHG_{CREDITS,t|IGM} \cdot (1 - U_{TOTAL,t|IGM}) \quad (73)$$

Where:

$Credits_{total|IGM}$ total greenhouse gas emission credits adjusted for uncertainty in year t in the crediting period;

$GHG_{credits|IGM}$ project greenhouse gas emission credits in year t associated with the implementation of improved forest management (IFM) activities in the project scenario, $tCO_2e \cdot year^{-1}$; and

$U_{total|IGM}$ total uncertainty in year t for IGM Project, dimensionless.

Step 11.2 Calculation of voluntary carbon units

The amount of greenhouse gas emission credits estimated at Step 7.1 above shall be adjusted to account for risk.

They shall be subject to deductions based on application of the VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination²⁹.

Therefore, the amount of VCU's that can be issued in year t is calculated as:

$$VCU_{net,t|IGM} = Credits_{total,t|IGM} \cdot (1 - Bu_{IGM}) \quad (74)$$

Where:

$VCU_{net,t|IGM}$ number of voluntary carbon units in year t for the IGM project; dimensionless;

$Credits_{TOTAL,t|IGM}$ total greenhouse gas emission credits adjusted for uncertainty in year t in the crediting period;

$Bu_{IFM-VCS}$ total buffer proportion withheld in VCS buffer account.

²⁹<http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Non-Permanence%20Risk%20Analysis%20and%20Buffer%20Determination.pdf>

STEP 12 – Project Monitoring

Step 12.1 Scope of monitoring and the monitoring plan

Monitoring is required to:

- a) confirm project activity;
- b) record environmental parameters such as rainfall and temperature necessary for SOC modelling and determination of *ex-post* GMP and IGMP
- c) record parameter values under the IGMP;
- d) determine soil carbon stock change and GHG emissions from project activity;
- e) record fertilizer use in the project scenario; and
- f) determine GHG emissions from disturbance due to unplanned fire, erosion, pests and disease;

In some project scenarios monitoring may also be implemented to update stratification.

It is a requirement that the monitoring plan presented in the VCS-PD shall address the monitoring of project implementation, the monitoring of actual carbon stock changes from project activity, and estimation of *ex-post* net carbon stock changes from disturbance.

The description of the monitoring plan in the VCS-PD will include the following for each of these monitoring tasks:

- a) technical description of the monitoring task;
- b) a list of data and parameters to be collected;
- c) overview of data collection procedures;
- d) quality control and quality assurance procedure;
- e) data archiving; and
- f) organisation and responsibilities of the parties involved in all the above.

Step 12.2 Monitoring of project implementation

Step 12.2.1 Monitoring of project boundaries and stratification

Information shall be provided, and recorded in the VCS-PD, to establish that:

- the geographic position of the project boundary is recorded for all areas of land;
- the geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This will be achieved by field survey (e.g. using GPS) or by using georeferenced spatial data (e.g. maps, GIS datasets, aerial photography, or georeferenced remote sensing images);
- standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for any field data measurements are applied; and
- the *ex-ante* and *ex-post* GMP and *ex-ante* and *ex-post* IGMP, shall be available for

validation or verification as appropriate.

Step 12.2.2 Grassland management activity records

Information shall be provided, and recorded in the VCS-PD, to establish that:

- commonly accepted principles of grassland management are implemented;
- livestock management parameters relevant to the grassland management implemented including stocking rate, livestock adjustment, production and changes in livestock type or composition are recorded. It is acceptable to use grassland management records and farm management records to provide these data;
- fossil fuel use in implementing the grassland management are recorded. It is acceptable to provide fuel purchase records as evidence of fossil fuel use;
- all applications of fertilizer are recorded to include the type of fertilizer, together with the rate, timing and location of fertilizer application(s).

Step 12.2.3 Monitoring of vegetation

Information shall be provided, and recorded in the VCS-PD, to establish that vegetation cover has been maintained or increased as a result of project implementation.

Project proponents shall establish a minimum of three photopoints in each strata (the combination of soil type and management practice used to calibrate the SOC model) that each cover greater than 10% of the project area.

At each photopoint images shall be captured biannually in the same month and corresponding to the average annual biomass peak and trough for the district.

Protocols for image capture shall follow common practice for photopoint interpretation.

Step 12.3 Data inputs to SOC model calibration

Monitoring of parameters is required to recalibrate the GMP and the IGMP to account for environmental and management conditions that occurred during each verification period, and to update parameter selection for *ex-post* baseline scenario greenhouse gas emissions and *ex post* project scenario greenhouse gas emissions.

Rainfall and temperature data must be obtained from the nearest weather station certified to provide data to the national weather recording system. Where project locations are more than 100km from a certified weather station it is acceptable to obtain data from an independent recording station.

Calibration parameters related to grassland management are specific to the chosen SOC model and must be recorded in a format acceptable to the selected SOC model.

Appropriate QA/QC procedures shall be applied to data collection.

Where historical data were used to provide parameter input (such as rainfall, temperature, market forces) and management strategy decisions that generated *ex-ante* estimation of the baseline scenario, these data and management strategy decisions must be updated to use *ex post* data for the verification period.

The project proponent must, at a minimum, update rainfall and temperature parameters and baseline grassland management parameters in the GMP and IGMP where *ex post* data for management practices can be obtained or where historical or common practice justification can be made based on economic, rainfall and temperature patterns over the verification period.

Step 12.4 Disturbance

It is a requirement that any greenhouse gas emissions from natural disturbance above *de minimis* that may occur in the project area are monitored.

For fire damage it is assumed that a fire burning in the project scenario would also have burned in the baseline. Project emissions are therefore equal to the fire damage to biomass absent in the baseline scenario but present in the project scenario.

Where fires occur *ex post* in the project area, the area burned shall be delineated. Any above-ground biomass stock present in the delineated area shall be included as a stratum in the calculation of above-ground woody biomass carbon stock losses in the *ex-post* project scenario (Step 8.3.2)

In the case of erosion and/or pests and disease it is assumed that disturbance in the project scenario would also have occurred in the baseline scenario. Where erosion and/or pests and disease occur *ex post* in the project area, the area of erosion and/or pests and disease shall be delineated.

The SOC stock change that was present in the delineated area shall be removed from the *ex-post* project scenario net greenhouse gas emissions.

Step 12.5 National livestock production

Data shall be obtained on the national livestock production to inform the leakage calculation at Step 9.

It is acceptable to obtain livestock production data from published national agricultural records.

Step 12.6 General requirements for monitoring

All data collected as part of monitoring will be archived electronically and be kept at least for 2 years after the end of the crediting period. All measurements will be conducted according to relevant standards.

Data archiving shall take both electronic and paper forms, and copies of all data shall be provided to each project participant.

All electronic data and reports shall also be copied on durable media such as CDs and copies of the CDs are to be stored in multiple locations.

The archives shall include:

- copies of all original field measurement data, laboratory data, photopoint images, data analysis spreadsheets;
- estimates of the carbon stock changes in all pools and non-CO₂ GHG and corresponding calculation spreadsheets;
- GIS products; and
- copies of the measuring and monitoring reports.

Step 12.7 Conservative approach and uncertainty

Project proponents shall apply all relevant equations for the *ex-ante* calculation of net anthropogenic GHG removals by sinks with care and provide transparent estimations for the parameters that are monitored during the crediting period. These estimates shall be based on measured or existing published data where possible and project proponents should retain 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.

An uncertainty analysis is required for all estimates from monitoring related to change in area, change in carbon stocks and emissions for both the baseline and project scenario.

Data and parameters not monitored (default or possibly measured one time)

In addition to the parameters listed in the tables presented in the following pages, the provisions on data and parameters not monitored in the tools referred to in this methodology apply. In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, project participants must retain 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.

Data / parameter:	GE_l
Data unit:	MJ head ⁻¹ day ⁻¹
Used in equations:	
Description:	Gross energy intake by livestock type /
Source of data:	
Measurement procedures (if any):	
Any comment:	

Data / parameter:	MCF_l
Data unit:	fraction of gross energy in feed converted to methane
Used in equations:	
Description:	methane conversion factor for livestock type /
Source of data:	
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$COMF_{TREE,i}$
Data unit:	Dimensionless
Used in equations:	
Description:	Combustion factor of tree for stratum <i>i</i> (vegetation type)
Source of data:	Default values in Table 2.6 of IPCC, 2006

Measurement procedures (if any):	N/A
Any comment:	<p>The combustion factor is a measure of the proportion of the fuel that is actually combusted, which varies as a function of the size and architecture of the fuel load (i.e., a smaller proportion of large, coarse fuel such as tree stems will be burnt compared to fine fuels, such as grass leaves), the moisture content of the fuel and the type of fire (i.e., intensity and rate of spread).</p> <p>Default values shall be updated whenever new guidelines are produced by the IPCC</p>

Data parameter: /	$COMF_{SHRUB,i}$
Data unit:	Dimensionless
Used in equations:	
Description:	Combustion factor of shrub for stratum i (vegetation type)
Source of data:	Default values in Table 2.6 of IPCC, 2006
Measurement procedures (if any):	N/A
Any comment:	<p>The combustion factor is a measure of the proportion of the fuel that is actually combusted, which varies as a function of the size and architecture of the fuel load (i.e., a smaller proportion of large, coarse fuel such as tree stems will be burnt compared to fine fuels, such as grass leaves), the moisture content of the fuel and the type of fire (i.e., intensity and rate of spread).</p> <p>Default values shall be updated whenever new guidelines are produced by the IPCC</p>

Data / parameter:	NCV_f
Data unit:	TJ Gg ⁻¹ (Terajoules per Gigagram)
Used in equations:	
Description:	net calorific value for fuel type f
Source of data:	
Measurement procedures (if any):	

any):	
Any comment:	

Data / parameter:	D_f
Data unit:	Gg kL ⁻¹ (Gigagrams per kilolitre)
Used in equations:	
Description:	density of fuel type f
Source of data:	
Measurement procedures (if any):	
Any comment:	

Data / parameter:	EF_1
Data unit:	t N ₂ O t ⁻¹ N input
Used in equations:	
Description:	emission factor for emissions from N inputs
Source of data:	Country-specific data, IPCC
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$NC_{SF,k}$
Data unit:	g N 100g ⁻¹ fertilizer
Used in equations:	
Description:	nitrogen content of synthetic fertilizer type k applied
Source of data:	Producers of synthetic fertilizer purchased and used
Measurement procedures (if any):	Keep record of nitrogen content from producers
Any comment:	IF producers do not provide data on nitrogen content, the nitrogen content must be determined by qualified lab

Data / parameter:	Frac _{GASF}
Data unit:	dimensionless
Used in equations:	
Description:	Fraction that volatilises as NH ₃ and NO _x for synthetic fertilizers
Source of data:	Country-specific data, IPCC
Measurement procedures (if any):	
Any comment:	

Data / parameter:	NC _{OF,j}
Data unit:	g N 100g ⁻¹ fertilizer
Used in equations:	
Description:	nitrogen content of organic fertilizer type j applied
Source of data:	Producers of synthetic fertilizer purchased and used
Measurement procedures (if any):	Keep record of nitrogen content from producers
Any comment:	IF producers do not provide data on nitrogen content, the nitrogen content must be determined by qualified lab

Data / parameter:	Frac _{GASM}
Data unit:	dimensionless
Used in equations:	
Description:	Fraction that volatilises as NH ₃ and NO _x for organic fertilizers
Source of data:	Country-specific data, IPCC
Measurement procedures (if any):	
Any comment:	

Data and parameters used in monitoring

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply. In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, project participants must retain 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.

Data / parameter:	$N_{l,t/BSL}$	
Data unit:	head yr ⁻¹	
Used in equations:		
Description:	number of livestock of type <i>l</i> in year <i>t</i> in the baseline scenario	
Source of data:	shall be reported in the baseline Grassland Management Plan <i>Ex-ante</i> proponents are to use in descending order of preference: (I) historical data (II) common practice for the region to determine amount applied in each year of the project crediting period. <i>Ex-post</i> proponents are to use in descending order of preference: (I) historical data (II) common practice for the region to determine amount applied in each year of the project crediting period, based on the environmental and economic data.	
Measurement procedures (if any):		
Measurement Frequency	Annual	
QA/QC Procedures		
Any comment:		

Data / parameter:	$GP_{l,t/BSL}$	
Data unit:	days	
Used in equations:		
Description:	grazing days for livestock type <i>l</i> in year <i>t</i> in the baseline scenario	
Source of data:	shall be reported in the baseline Grassland Management Plan <i>Ex-ante</i> proponents are to use in descending order of preference:	

	(III) historical data (IV) common practice for the region to determine amount applied in each year of the project crediting period. <i>Ex-post</i> proponents are to use in descending order of preference: (III) historical data (IV) common practice for the region to determine amount applied in each year of the project crediting period, based on the environmental and economic data.	
Measurement procedures (if any):		
Measurement Frequency		
QA/QC Procedures		
Any comment:		

Data / parameter:	$FC_{f,t/BSL}$	
Data unit:	kL	
Used in equations:		
Description:	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the baseline scenario	
Source of data:	shall be reported in the baseline Grassland Management Plan <i>Ex-ante</i> proponents are to use in descending order of preference: (V) historical data (VI) common practice for the region to determine amount applied in each year of the project crediting period. <i>Ex-post</i> proponents are to use in descending order of preference: (V) historical data (VI) common practice for the region to determine amount applied in each year of the project crediting period, based on the environmental and economic data.	
Measurement procedures (if any):		
Measurement		

Frequency		
QA/QC Procedures		
Any comment:		

Data / parameter:	$M_{SF,k,t BSL}$
Data unit:	t
Used in equations:	
Description:	mass of synthetic fertilizer type k applied in year t in the baseline scenario
Source of data:	<p>Record of synthetic fertilizer purchased and used shall be reported in the baseline Grassland Management Plan</p> <p><i>Ex-ante</i> proponents are to use in descending order of preference:</p> <ul style="list-style-type: none"> (VII) historical data (VIII) common practice for the region <p>to determine amount applied in each year of the project crediting period.</p> <p><i>Ex-post</i> proponents are to use in descending order of preference:</p> <ul style="list-style-type: none"> (VII) historical data (VIII) common practice for the region <p>to determine amount applied in each year of the project crediting period, based on the environmental and economic data.</p>
Measurement procedures (if any):	
Measurement Frequency	Annually
QA/QC Procedures	
Any comment:	

Data / parameter:	$M_{OF,j,t BSL}$
Data unit:	t
Used in equations:	
Description:	mass of organic fertilizer type j applied in year t in the baseline scenario
Source of data:	<p>Record organic fertilizer purchased and used shall be reported in the baseline Grassland Management Plan</p> <p><i>Ex-ante</i> proponents are to use in descending order of preference:</p>

	<p>(IX) historical data (X) common practice for the region</p> <p>to determine amount applied in each year of the project crediting period. <i>Ex-post</i> proponents are to use in descending order of preference:</p> <p>(IX) historical data (X) common practice for the region</p> <p>to determine amount applied in each year of the project crediting period, based on the environmental and economic data.</p>
Measurement procedures (if any):	
Measurement Frequency	
QA/QC Procedures	
Any comment:	

Data / parameter:	$N_{l,t PRS}$
Data unit:	head yr ⁻¹
Used in equations:	
Description:	number of livestock of type <i>l</i> in year <i>t</i> in the project scenario
Source of data:	<p>Predicted and reported in the Improved Grassland Management Plan <i>Ex-ante</i>, project proponents are to use in descending order of preference:</p> <p>(I) historical data (II) common practice for the region/management strategy</p> <p>to determine amount applied in each year of the project crediting period. <i>Ex-post</i> livestock type shall be reported in the project scenario Improved Grassland Management Plan</p>
Measurement procedures (if any):	Record of livestock type shall be reported in the project scenario Improved Grassland Management Plan
Measurement Frequency	Annually
QA/QC Procedures	
Any comment:	

Data /	$GD_{l,t PRS}$
---------------	----------------

parameter:	
Data unit:	days
Used in equations:	
Description:	grazing days for livestock type l in year t in the project scenario,
Source of data:	<p>Predicted and reported in the Improved Grassland Management Plan <i>Ex-ante</i>, project proponents are to use in descending order of preference:</p> <p>(III) historical data (IV) common practice for the region/management strategy</p> <p>to determine amount applied in each year of the project crediting period. <i>Ex-post</i> grazing days shall be reported in the project scenario Improved Grassland Management Plan</p>
Measurement procedures (if any):	Record of grazing days shall be reported in the project scenario Improved Grassland Management Plan
Measurement Frequency	Annually
QA/QC Procedures	
Any comment:	

Data / parameter:	$FC_{f,t PRS}$
Data unit:	kL
Used in equations:	
Description:	fuel consumed (as represented by fuel purchased) for fuel type f in year t in the project scenario
Source of data:	<p>Use is predicted and reported in the Improved Grassland Management Plan <i>Ex-ante</i>, project proponents are to use in descending order of preference:</p> <p>(V) historical data (VI) common practice for the region/management strategy</p> <p>to determine amount applied in each year of the project crediting period. <i>Ex-post</i> fuel purchased and used shall be reported in the project scenario Improved Grassland Management Plan.</p>
Measurement procedures (if any):	Record of synthetic fertilizer purchased and used shall be reported in the project scenario Improved Grassland Management Plan
Measurement	Annually

Frequency	
QA/QC Procedures	
Any comment:	

Data / parameter:	$M_{SF,k,t PRJ}$
Data unit:	t
Used in equations:	
Description:	mass of synthetic fertilizer type k applied in year t in the project scenario
Source of data:	<p>Synthetic fertilizer use is predicted and reported in the Improved Grassland Management Plan</p> <p><i>Ex-ante</i>, project proponents are to use in descending order of preference:</p> <ul style="list-style-type: none"> (VII) historical data (VIII) common practice for the region/management strategy <p>to determine amount applied in each year of the project crediting period.</p> <p><i>Ex-post</i> synthetic fertilizer purchased and used shall be reported in the project scenario Improved Grassland Management Plan.</p>
Measurement procedures (if any):	Record of synthetic fertilizer purchased and used shall be reported in the project scenario Improved Grassland Management Plan
Measurement Frequency	Annually
QA/QC Procedures	
Any comment:	

Data / parameter:	$M_{OF,j,t PRJ}$
Data unit:	t
Used in equations:	
Description:	mass of organic fertilizer type j applied in year t in the project scenario
Source of data:	<p>Organic fertilizer use is predicted and reported in the Improved Grassland Management Plan</p> <p><i>Ex-ante</i>, project proponents are to use in descending order of preference:</p> <ul style="list-style-type: none"> (IX) historical data (X) common practice for the region/management strategy <p>to determine amount applied in each year of the project crediting</p>

	period. <i>Ex-post</i> synthetic fertilizer purchased and used shall be reported in the project scenario Improved Grassland Management Plan.
Measurement procedures (if any):	Record of synthetic fertilizer purchased and used shall be reported in the project scenario Improved Grassland Management Plan
Measurement Frequency	Annually
QA/QC Procedures	
Any comment:	