METHODOLOGY TITLE

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Reference Number	

Relationship to Approved or Pending Methodologies

There is no similar Methodology approved under the VCS Program.

There are two related methodologies are under development. One is "ALM Adoption of Sustainable Grassland Management through Adjustment of Fire and Grazing". Another is "Agricultural Land Management – Improved Grassland Management". The former is applicable only to projects where land is potentially subject to burning and wildfires, and, where the use of cultivation and fertilizer for improved grassland management are unallowable activities. The latter includes some applicability conditions, such as "a soil organic carbon model applicable to the project area", and "increase the proportion of perennial species above the baseline scenario" which may restrict is applicability to *potential grassland management activities. The proposed methodology is for improved grassland management activities not restricted by the above applicability conditions.*

Table of Contents

1 SOURCES

This methodology is based on the project “Three Rivers Grassland Carbon Sequestration Project” in Qinghai Province, China. The project will introduce improved grassland management practices such as improving the rotation of grazing animals between summer and winter pastures, limiting the timing and number of grazing animals on degraded pastures, and restoration of severely degraded lands by replanting with perennial grasses and ensuring appropriate management over the long-term.

The following tools will be applied:

- Tool for the identification of degraded or degrading lands for consideration in implementing A/R CDM project activities[1];
- Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities[2];
- Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities[3];
- Calculation of the number of sample plots for measurements within A/R CDM project activities[4];
- Tool for testing significance of GHG emissions in A/R CDM project activities[5].
- Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity ar-am-tool-15-v1

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

The methodology aims to estimate the reduction of greenhouse gas emissions from grassland and increase grassland soil organic carbon stock by applying sustainable grassland management practices (SGM). Carbon stock enhancement within the project boundary in above ground and soil carbon pools is considered. This methodology is applicable to projects that introduce SGM into a grassland landscape subject to conditions such that the soil organic carbon would remain constant or decrease in the absence of the project. Where biogeochemical models can be demonstrated to be applicable in the project region, they may be used in estimation of soil carbon pool changes. Where such models are not applicable, the methodology provides guidance for estimation of soil organic carbon pool changes using direct measurement methods.

[1] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-13-v1.pdf
[2] http://www.v-c-s.org/methodologies/VT0001
[3] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v2.1.0.pdf
[4] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.1.0.pdf
[5] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf

2.1 Baseline methodology

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

1. Identify and delineate the project boundary;
2. Identify the baseline scenario and demonstrate additionality;
3. Estimate the annual emissions from the use of synthetic fertilizers;
4. Estimate the annual emissions from the use of n-fixing species;
5. Estimate the annual emissions from the burning of grass;
6. Estimate the annual CH_4 emissions from enteric fermentation;
7. Estimate the annual emissions from manure deposition during grazing;
8. Estimate the annual CO_2 emissions due to the use of fossil fuels for GM;
9. Estimate the annual removals from existing woody perennials; and
10. Estimate the equilibrium soil organic carbon in the baseline assuming no changes in grassland management practices or inputs.

2.2 Project methodology

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

1. Estimate the annual emissions from the use of synthetic fertilizers;
2. Estimate the annual emissions from the use of n-fixing species;
3. Estimate the annual emissions from the burning of grass;
4. Estimate the annual CH_4 emissions from enteric fermentation;
5. Estimate the annual emissions from manure deposition during grazing;
6. Estimate the annual CO_2 emissions due to the use of fossil fuels for SGM;
7. Estimate the annual emissions and removals from woody perennials; and
8. Project removals due to changes in soil organic carbon.

2.3 Leakage

GHG emissions by sources and removals by sinks caused by changes in grazing of livestock within and outside the project boundary in the project and baseline scenarios.

2.4 Monitoring Plan

3 DEFINITIONS

The following definitions are specific to this methodology:

1. Sustainable grassland management: Activities on lands falling under the VCS definition for Grassland, including improving the rotation of grazing animals between pastures, limiting the

number of grazing animals on degraded pastures, and restoration of severely degraded lands by replanting with perennial grasses and ensuring appropriate management over the long-term.

2. Significance: The sum of increase in greenhouse gas emissions from the increase in the number of livestock, displacement of manure, increase in fossil fuels from agricultural management and increase of fossil fuels for cooking as a result of the project is insignificant if it is less than 5% of the emission reductions by the project.

Acronyms used in this methodology:

1. SGM: Sustainable grassland management.
2. SOC: Soil organic carbon.
3. AEZ: Agroecological Zone.
4. Pps:project proponents.

4 APPLICABILITY CONDITIONS

This methodology is applicable to projects that introduce sustainable grassland management practices into a grassland landscape subject to the following conditions:

a) Land is grassland at the start of the project;

b) Grassland to be sustainably managed is degraded (due to physical constraints as well as anthropogenic actions) and the lands are still degrading[i6];

c) There is no displacement of manure from outside the project boundary to within the project boundary;

d) There is no significant increase of use of fossil fuels, fuel wood from non-renewable sources for cooking and heating as a result of the project activity;

e) There is no significant change in manure management systems within the project boundary;

f) The project activity does not include land use change. To clarify, seeding fodder grasses or legumes on degraded grassland is not considered a land-use change activity;

g) If there are studies (for example scientific journals, university theses, or work carried out by the project proponents) that demonstrate that the use of the selected model[ii7]is valid for the project region or a similar agroecological zone (AEZ)[8], the model can be applied for estimating of carbon stock changes for the SGM VCS project. Otherwise, direct measurement of actual carbon stocks will be carried out;

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[6] The latest version of the "Tool for the identification of degraded or degrading lands for consideration in implementing A/R CDM project activities"[6] shall be applied for demonstrating that lands are degraded or degrading.
[7] The use of the selected model is appropriate for 2006 IPCC AFOLU Guidelines. The model to be applied in the SGM VCS project should be capable of representing the relevant management practices of the project and that the model inputs (i.e., driving variables) are validated from the project region-specific locations that are representatives of the variability of climate, soil and management systems.
[8] The details of global agroecological zones classification outlined by Food and Agricultural Organization of United Nations (FAO), Rome, Italy and International Institute for Applied Systems Analysis, Laxenburg, Austria are available at: http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm.

h) Regions where precipitation is less or equal to potential evaporation in same period. The indirect N_2O emission from leach and runoff is not considered according to Chapter 11, Volume 4 of 2006 IPCC Guidelines.

5 PROJECT BOUNDARY

5.1 Project boundary

The "project boundary" geographically delineates that the grasslands with sustainable grassland management practice are under control of the project participants. The SGM VCS project activity may contain more than one discrete area of land. At the time the PDD is validated, the following shall be defined:

- Each discrete area of land shall have a unique geographical identification;
- Aggregation of grassland properties with multiple landowners is permitted under the methodology with aggregated areas treated as a single project area;
- The project participants shall describe legal title to ownership or exclusive use of the grassland, rights of access to the sequestered carbon and avoided GHG emissions;
- The project participants shall justify, that during the crediting period, each discrete area of land is expected to be subject to a SGM project activity under the control of the project participants.

5.2 Selected carbon pools and emission sources

Table 1: Selected Carbon pools

Carbon pools	Selected Carbon pools	Explanation / justification
Above ground	Optional	In calculating the baseline net greenhouse gas removals by sinks and/or actual net greenhouse gas removals by sinks, project participants can choose not to account for above-ground biomass. This is subject to the provision of transparent and verifiable information that the choice will not increase the expected net anthropogenic greenhouse gas removals by sinks.
Below ground	Optional	In calculating the baseline net greenhouse gas removals by sinks and/or actual net greenhouse gas removals by sinks, project participants can choose not to account for below-ground biomass. This is subject to the provision of transparent and verifiable information that the choice will not increase the expected net anthropogenic greenhouse gas removals by sinks.
Dead wood	No	None of the applicable SGM practices decrease dead wood. Thus

		it can be conservatively ignored.
Litter	No	None of the applicable SGM practices decrease the amount of litter. Thus it can be conservatively ignored.
Soil organic carbon	Yes	A major carbon pool covered by SGM practices.

Table 2: Selected GHG sources and gases

Source		Gas	Included?	Justification/Explanation
Baseline	Use of fertilizers	CO_2	NO	Not applicable.
		CH_4	NO	Not applicable.
		N_2O	Yes	Main gas for this source.
		Other	NO	Not applicable.
	Use of N-fixing species	CO_2	NO	Not applicable.
		CH_4	NO	Not applicable.
		N_2O	Yes	Main gas for this source.
		Other	NO	Not applicable.
	Burning of biomass	CO_2	NO	CO_2 emissions from biomass burning in grassland are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.
		CH_4	Yes	Non-CO_2 emissions from the burning of biomass.
		N_2O	Yes	Non-CO_2 emissions from the burning of biomass.
		Other	NO	Not applicable.
	Manure deposition on grassland	CO_2	NO	CO_2 emissions from biomass decomposition is not reported.
		CH_4	NO	Not main gas for this source. Excluded for simplification.
		N_2O	Yes	Main gas for this source.
		Other	NO	Not applicable.
	Farming machine	CO_2	Yes	Main gas for this source.
		CH_4	NO	Not main gas for this source. Excluded for simplification.
		N_2O	NO	Not main gas for this source. Excluded for simplification.
		Other	NO	Not applicable.
	Enteric fermentation	CO_2	NO	CO_2 emission from enteric fermentation is not reported.
		CH_4	Yes	Main gas for this source. .
		N_2O	NO	No N_2O emission from enteric fermentation.
		Other	NO	Not applicable.
		CO_2	NO	Not applicable.
		CH_4	NO	Not applicable.
		N_2O	Yes	Main gas for this source.

		Other	NO	Not applicable.
	Use of N-fixing species	CO_2	NO	Not applicable.
		CH_4	NO	Not applicable.
		N_2O	Yes	Main gas for this source.
		Other	NO	Not applicable.
	Burning of biomass	CO_2	NO	CO_2 emissions from biomass burning in grassland are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to a few years after burning.
		CH_4	Yes	Non-CO_2 emissions from the burning of biomass.
		N_2O	Yes	Non-CO_2 emissions from the burning of biomass.
		Other	NO	Not applicable.
	Manure deposition on grassland	CO_2	NO	CO_2 emissions from biomass decomposition is not reported.
		CH_4	NO	Not main gas for this source. Excluded for simplification.
		N_2O	Yes	Main gas for this source.
		Other	NO	Not applicable.
	Farming machine	CO_2	Yes	Main gas for this source.
		CH_4	NO	Not main gas for this source. Excluded for simplification.
		N_2O	NO	Not main gas for this source. Excluded for simplification.
		Other	NO	Not applicable.
	Enteric fermentation	CO_2	NO	CO_2 emission from enteric fermentation is not reported.
		CH_4	Yes	Main gas for this source.
		N_2O	NO	No N_2O emission from enteric fermentation.
		Other	NO	Not applicable.

6 PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

Project proponents shall use the most recent version of the “Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities” to identify the most plausible baseline scenario.

7 PROCEDURE FOR DEMONSTRATING ADDITIONALITY

Project participants shall use the most recent version of the “Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities” to justify additionality.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

8.1.1 Baseline N_2O emissions due to fertilizer use

Baseline N_2O emissions due to fertilizer use include two components: 1) Baseline direct N_2O emission from synthetic nitrogen fertilizer use; 2) Baseline indirect N_2O emission from the synthetic nitrogen fertilizer use. Total baseline N_2O emissions due to fertilizer use equals baseline direct N_2O emission plus indirect N_2O emission, as described in equation (1).

$$BE_{N_2O_{SN}} = GWP_{N_2O} \times (BE_{D,N_2O_{SN}} + BE_{ID,N_2O_{SN}}) \quad (1)$$

$BE_{N_2O_{SN}}$	Total baseline N_2O emissions due to fertilizer use, t CO_2e
$BE_{D,N_2O_{SN}}$	Baseline direct N_2O emission from synthetic nitrogen fertilizer use, t N_2O
$BE_{ID,N_2O_{SN}}$	Baseline indirect N_2O emission from synthetic nitrogen fertilizer use, t N_2O
GWP_{N_2O}	Global warming potential for N_2O

1) Baseline direct N_2O emission from synthetic nitrogen fertilizer use

The baseline direct N_2O emission from synthetic fertilizer use, $BE_{D,N_2O_{SN}}$, is calculated using IPCC methodology recommended by 2006 IPCC Guidelines for National Greenhouse Gas Inventories[iii] (thereafter '2006 IPCC Guidelines'), as described in equation (2):

$$BE_{D,N_2O_{SN}} = F_{SN,B} \times EF_1 \times 44/28 \quad (2)$$

$F_{SN,B}$	Annual amount of synthetic fertiliser N applied to grassland soils under baseline, adjusted for volatilization as NH_3 and NO_x, t N. $F_{SN,B}$ can be calculated according to equation (3) below
EF_1	N_2O emission factor for synthetic N fertiliser use, kg N_2O-N (kg N applied)$^{-1}$ Project participants may use N_2O emission factors from the peer reviewed scientific literature that are specific for the project area. When country-specific factors are unavailable, default N_2O emission factor recommended by the 2006 IPCC Guidelines can be used (Table 11.1, volume 4 of 2006 IPCC Guidelines)
44/28	Conversion of N_2O-N to N_2O

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

$M_{SNi,B}$ Mass of synthetic N fertilizer type *i* applied under baseline, t N

$NC_{SNi,B}$ Nitrogen content of synthetic N fertilizer type *i* applied, g-N (g fertilizer)$^{-1}$

$Frac_{GAS,F,i}$ Fraction of synthetic N fertilizer type *i* that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$. Project participants may use values that are specific for the project area. When country-specific values are unavailable, default data recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines)

i Index of synthetic N fertilizer types

2) Baseline indirect N_2O emission from synthetic N fertilizer use

Indirect N_2O emission from the synthetic N fertilizer use excluding N_2O emissions from leaching and runoff in regions where leaching and runoff occurs according to the applicability conditions, as described in equation (4).

$$BE_{ID,N_2O_{SN}}E = GWP_{N2O} \times BE_{IDV,N_2O_{SN}} \tag{4}$$

$BE_{ID,N_2O_{SN}}$ Annual baseline indirect N_2O emission from the synthetic N fertilizer use in baseline, t CO_2e

$BE_{IDV,N_2O_{SN}}$ Annual baseline indirect N_2O emission from atmospheric deposition of N volatilized as NH_3 and NO_x from fertilizer applied, t N_2O

- Indirect N_2O emission from atmospheric deposition of N volatilized

The N_2O emission from atmospheric deposition of N volatilised NH_3 and NO_x from fertilized grassland is estimated using Equation (5).

$$BE_{IDV,N_2O_{SN}} = \sum_{i=1}^{I}(F_{SNi,B} \times Frac_{GAS,F,i}) \times EF_4 \times 44/28 \tag{5}$$

EF_4 Emission factor for N_2O emission from atmospheric deposition of N on soils and water surfaces, [kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$]. Project participants may use EF_4 from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, default EF_4 recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines)

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

The baseline emissions from the use of N-fixing species, $BE_{N_2O,NF}$, a can be estimated using equations as follows:

$$BE_{N_2O_{NF}} = F_{CR,B} \times EF_1 \times 44/28 \times GWP_{N_2O} \tag{6}$$

$BE_{N_2O_{NF}}$ — N_2O emission as a result of n-fixing species within the project boundary under baseline, tCO_2e

$F_{CR,B}$ — Annual amount of N in N-fixing grass (above and below ground) , and from forage/pasture renewal, returned to soils, under baseline, t N.

EF_1 — Emission Factor for N_2O emissions from N inputs of n-fixing species to grassland soil, kg N_2O-N (kg N input)$^{-1}$. Project participants may use N_2O emission factors from the peer reviewed scientific literature that are specific for the project area. When country-specific factors are unavailable, default N_2O emission factor recommended by 2006 IPCC Guidelines can be used (Table 11.1, volume 4 of 2006 IPCC Guidelines)

$$F_{CR,B} = \sum_{g=1}^{G} Area_{g,B} \times Crop_{g,B} \times N_{content,g,B} \tag{7}$$

$Area_{g,B}$ — Annual area of N-fixing species g under baseline, ha

Expert survey within the project boundary before the start of the project activity to obtain $Area_{g,B}$ data.

$Crop_{g,B}$ — Annual dry matter, including above ground and below ground, returned grassland soils for N-fixing species g under baseline, t dm ha^{-1}

Project participants may use $Crop_{g,B}$ from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, expert survey within the project boundary before the start of the project activity should be carried out to obtain $Crop_{g,B}$ data.

$N_{content,g,B}$ — Fraction of N in dry matter for N-fixing species g under baseline, tN tm^{-1}

Project participants may use $N_{content,g,B}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $N_{content,g,B}$ data are unavailable, expert survey within the project boundary before the start of the project activity should be carried to obtain $N_{content,g,B}$ data.

g Index of N-fixing species

These equations can be used for both ex ante and ex post estimation of the nitrous oxide emissions from the use of nitrogen fixing species within the boundary of a SGM VCS project activity. For *ex post* estimation purposes, activity data (quantities of N returned to grassland soil) are monitored or estimated.

8.1.3 Baseline emissions due to burning of biomass

The baseline emissions due to burning of biomass, BE_{BB}, only include CH_4 and N_2O emissions, with the assumption that the CO_2 emissions would be counterbalanced by CO_2 removals from the subsequent re-growth of the vegetation within one year. The baseline total GHG emissions equals CH_4 emission from biomass burning plus N_2O emission from biomass burning, as described in equation (8).

$$BE_{BB} = BE_{CH_{4BB}} + BE_{N_2O_{BB}} \tag{8}$$

BE_{BB} Total baseline GHG emissions from biomass burning under baseline, t CO_2e

$BE_{CH_{4BB}}$ Baseline CH_4 emission from biomass burning under baseline, t CO_2e

$BE_{N_2O_{BB}}$ Baseline N_2O emission from biomass burning under baseline, t CO_2e

1) CH_4 emission from biomass burning

CH_4 emission from biomass burning can be calculated using equation (9).

$$BE_{CH_{4BB}} = A_B \times M_{B,B} \times C_f \times EF_{CH_4} \times 10^{-3} \times GWP_{CH_4} \tag{9}$$

A_B Area burned under baseline, ha

$M_{B,B}$ Above ground biomass burned under baseline, t ha^{-1}.

C_f Combustion factor, dimensionless. Project participants may use C_f data from the peer reviewed scientific literature that are specific for the project area. When country-specific C_f data are unavailable, default C_f values in Table 2.6 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

EF_{CH_4} CH_4 emission factor for biomass burning, g kg^{-1} dry matter burnt. Project participants may use EF_{CH_4} data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_{CH_4} data are unavailable, default EF_{CH_4} values in table 2.5 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

GWP_{CH_4} Global warming potential for CH_4

2) N_2O emission from biomass burning

N_2O emission from biomass burning can be calculated using equation (10).

$$BE_{N_2O_{BB}} = A_B \times M_{B,B} \times C_f \times EF_{N_2O} \times 10^{-3} \times GWP_{N_2O} \quad (10)$$

EF_{N_2O} N_2O emission factor, g kg-1 dry matter burnt. Project participants may use EF_{N_2O} data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_{N_2O} data are unavailable, default EF_{N_2O} values in table 2.5 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

8.1.4 Baseline CH_4 emissions due to enteric fermentation

Baseline CH_4 emission from enteric fermentation is calculated based on the IPCC methodology recommended by 2006 IPCC Guidelines, equation (11).

$$BE_{CH_{4EF}} = GWP_{CH4} \times \sum_{l=1}^{L} P_{l,B} \times EF_l \div 1000 \quad (11)$$

$BE_{CH_{4EF}}$ Baseline CH_4 emission from enteric fermentation in year t, t CO_2e

$P_{l,B}$ Population of livestock type *l* t under baseline, head

l Index of livestock type

EF_l Enteric CH_4 emission factor per head of livestock type *l per year*, kg CH_4 head^{-1}year^{-1}. Project participants may use EF_l data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_l data are unavailable, default EF_l values can be taken from tables 10.10, 10.11 of the 2006 IPCC Guidelines. See Annex IV of this methodology.

8.1.5 Baseline N_2O emissions from manure and urine deposited on grassland soil during the grazing period

The baseline emissions from manure and urine deposited on grassland soil during the grazing period include two parts: 1) Baseline direct N_2O emission from manure and urine deposited on grassland soil during the grazing period; 2) Baseline indirect N_2O emission from manure and urine deposited on grassland soil during the grazing period.

Total baseline N_2O emission from manure and urine deposited on grassland soil equals baseline direct N_2O emission plus baseline indirect N_2O emission from manure and urine deposited on grassland soil during the grazing period is calculated as described in equation (12).

$$BE_{N_2O_{MD}} = GWP_{N_2O} \times (BE_{D,N_2O_{MD}} + BE_{ID,N_2O_{MD}}) \quad (12)$$

$BE_{N_2O_{MD}}$ Total baseline N_2O emission from manure and urine deposited on grassland soil in baseline, t CO_2e

$BE_{D,N_2O_{MD}}$ Baseline direct N_2O emissions from manure and urine deposited on grassland soil during the grazing period under baseline, t N_2O

$BE_{ID,N_2O_{MD}}$ Baseline indirect N_2O emission from manure and urine deposited on grassland soil during the grazing period under baseline, t N_2O.

1) Baseline direct N_2O emission from manure and urine deposited on grassland soil

Baseline direct N_2O emission from manure and urine deposited on grassland soil is calculated using IPCC methodology recommended by 2006 IPCC Guidelines as described in equation (13 or 14).

$$BE_{D,N_2O_{MD}} = \sum_{l1=1}^{L1} F_{MD,l1,B} \times EF_{3,PRP,CPP} \times 44/28 \quad (13)$$

Or

$$BE_{D,N_2O_{MD}} = \sum_{l2=1}^{L2} F_{MD,l2,B} \times EF_{3,PRP,SO} \times 44/28 \quad (14)$$

$F_{MD,l1,B}$ Annual amount of nitrogen in cattle, poultry and pigs manure and urine deposited on grassland soil during the grazing period, adjusted for volatilization as NH_3 and NO_x, t-N under baseline. $F_{MD,l1,B}$ can be calculated according to equation (15)

$F_{MD,l2,B}$ Annual amount of nitrogen in sheep and other animals manure and urine deposited on grassland soil during the grazing period, adjusted for volatilization as NH_3 and NO_x, t-N ibaseline. $F_{MD,l2,B}$ can be calculated according to equation (15)

$EF_{3,PRP,CPP}$ N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on grassland soil during the grazing period, kg N_2O-N (kg N input)$^{-1}$. Project participants may use $EF_{3,PRP,CPP}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $EF_{3,PRP,CPP}$ data are unavailable, default $EF_{3,PRP,CPP}$ values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used.

$EF_{3,PRP,SO}$ N_2O emission factor for sheep and other animals manure and urine deposited on grassland soil during the grazing period, kg N_2O-N (kg N input)$^{-1}$. Project participants may use $EF_{3,PRP,SO}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $EF_{3,PRP,SO}$ data are unavailable, default $EF_{3,PRP,SO}$ values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used.

l1 Index of livestock cattle, poultry and pigs

l2 Index of livestock sheep and other animals

$$F_{MD,l,B} = P_{l,B} \times W_l \times Nex_l \div 1000_a \times H_B \div 24 \times G_{days,l,B} \div 1000_b \times (1 - Frac_{GAS,MD,l}) \quad (15)$$

$P_{l,B}$ Population of livestock type l under baseline, head

W_l Average weight of livestock *l*, kg head^{-1}. Project participants may use data from the peer reviewed scientific literature that are specific for the project area. When specific data are unavailable for the project region, default values can be taken from tables 10A.1~10A.9 in Chapter 10, volume 4 of the 2006 IPCC Guidelines

Nex_l Nitrogen excretion, kg/1000 kg animal mass/day. Project participants may use Nex_l data from the peer reviewed scientific literature that are specific for the project area. When country-specific Nex_l data are unavailable, default Nex_l values in table 10.19 of Chapter 11 of 2006 IPCC Guidelines

1000_a Conversion of nitrogen excretion (kg/1000 kg livestock mass) to nitrogen excretion (kg/kg livestock mass), 1000

H_B Average grazing hours per day during grazing season, h

24 24 hours a day

$G_{days,l,B}$ Grazing days under baseline, day

1000_b Conversion kg to t

$Frac_{GAS,MD,l}$ Fraction of volatilisation from dung and urine deposited by grazing animals as NH_3 and NO_x, kg N volatilised (kg of N deposited)$^{-1}$.

Project participants may use $Frac_{GAS,MD,l}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $Frac_{GAS,MD,l}$ data are unavailable, default $Frac_{GAS,MD,l}$ values in table 11.3 of Chapter 11 of 2006 IPCC Guidelines can be used.

l Index of grazing livestock types

2) Baseline indirect N_2O emissions from urine and dung N deposited on grassland soils

Indirect N_2O emission from urine and dung N deposited on grassland soils including N_2O emissions from atmospheric deposition of N volatilized from urine and dung N deposited on grassland soils. N_2O emission from leaching and runoff is not considered according to the application conditions.

- Indirect N_2O emission from atmospheric deposition of N volatilized of urine and dung N deposited on grassland soils

The Indirect N_2O emissions from atmospheric deposition of N volatilised of urine and dung N deposited on grassland soils is estimated using Equation (16).

$$BE_{IDV,N_2O_{MD}} = \sum_{l=1}^{L} F_{MD,l,B} \times Frac_{GAS,MD,l} \times EF_4 \times 44/28 \quad (16)$$

EF_4 N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity, [kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$]. Project participants may use EF_4 data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_4 data are unavailable, default EF_4 values in table 11.3 of Chapter 11 of 2006 IPCC Guidelines can be used.

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

Equation (17) is applied to calculate CO_2 emissions from consumption of fossil fuels for SGM under baseline scenario.

$$BE_{FC} = \sum_{k=1}^{K} \sum_{j=1}^{J} \sum_{p=1}^{P} FC_{p,j,k,B} \times EF_{CO2,k} \times NCV_k \div 1000 \quad (17)$$

where,

BE_{FC} Baseline CO_2 emissions from farming machine fossil fuel consumption, in stratum a, under baseline scenario, tCO_2

$FC_{p,j,k,B}$ Fuel consumption by type *k*, machine type *j* , parcel grassland *p*, under baseline, kg yr^{-1}

$EF_{CO_2,k}$ CO_2 emission factor by fuel type *k* (tCO_2 GJ^{-1})

NCV_k	Thermal value of fuel type *k* (GJ t^{-1})
k	Index of fuel type
j	Index of machine type
p	Index of grassland parcel

8.1.7 Baseline removals from existing woody perennials

Where proponents choose to include above and below ground woody biomass pools, $BRWP$ is calculated using the A/R Working Group Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"[iv]. Where proponents choose not to include above and below ground woody biomass pools, baseline removals, $BRWP$, are assumed to be zero.

Carbon gain-loss approach will be applied to estimation of the change in carbon stocks in existing woody vegetation.

The change in carbon stocks of existing live woody biomass, for each species in each vegetation class of a stratum, can be written as:

$$BRWP = \Delta C_{BG,j} - \Delta C_{BL,j} \tag{18}$$

where:

$BRWP$	Average net change in carbon stocks of existing woody biomass for species j, under baseline; t CO_2 yr^{-1}
$\Delta C_{BG,j}$	Average increase in carbon stocks of existing woody biomass for species j, under baseline; t CO_2 yr^{-1}
$\Delta C_{BL,j}$	Average loss in carbon stocks of existing woody biomass for species j, under baseline; t CO_2 yr^{-1}

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

The average increase in carbon stocks in existing live woody biomass, for each species in a stratum, can be written as:

$$\Delta C_{BG,j} = A_{B,s} \times G_{j,B} \times CF_j \times 44/12 \tag{19}$$

where:

$\Delta C_{BG,j}$ Average increase in carbon stocks of existing woody biomass for species j, under baseline; t CO_2 yr^{-1}

$A_{B,s}$ Area of stratum S under baseline; ha

$G_{j,B}$ Average increase in existing woody biomass of species j, under baseline; t d.m ha^{-1} yr^{-1}

CF_j Carbon fraction for species j (default values: 0.50, and 0.49, for tree and shrub species, respectively); t C (t d.m.)$^{-1}$

$44/12$ Ratio of molecular weights of CO_2 and C; g mol^{-1} (g mol^{-1})$^{-1}$

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

$$G_{j,B} = G_{AB,j,B}(1 + R_j) \tag{20}$$

where:

$G_{j,B}$ Average increase in existing woody biomass of species j, under baseline; t d.m ha^{-1} yr^{-1}

$G_{AB,j,B}$ Average increase in existing above-ground woody biomass of species j; t d.m ha^{-1} yr^{-1}

R_j Root: shoot ratio of species *j*; t d.m. (t d.m.)$^{-1}$

8.1.8 Baseline removals due to changes in soil organic carbon

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

$BRS = 0$

BRS Baseline removals due to changes in soil organic carbon under baseline, t CO_2e.

8.1.9 Total baseline emissions and removals

The total baseline emissions and removals are given by:

$$BE = BE_{N_2O_{SN}} + BE_{N_2O_{NF}} + BE_{BB} + BE_{CH_{4EF}} + BE_{GHG_{MD}} + BE_{FC} + BRWP - BRS \tag{21}$$

BE Total baseline emissions and removals, t CO_2e

$BE_{N_2O_{SN}}$	Baseline N_2O emissions due to fertilizer use, t CO_2e
$BE_{N_2O_{NF}}$	Baseline N_2O emission as a result of n-fixing species, tCO_2e
BE_{BB}	Baseline emissions due to the use of N-fixing species, t CO_2e
$BE_{CH_{4EF}}$	Baseline CH_4 emission due to enteric fermentation, t CO_2e
$BE_{N_2O_{MD}}$	Baseline N_2O emissions from manure and urine deposited on grassland during the grazing period, t CO_2e
BE_{FC}	Baseline CO_2 emissions due to the use of fossil fuels for GM, t CO_2e
$BRWP$	Baseline removals from existing woody perennials, tCO_2e
BRS	Baseline removals due to changes in soil organic carbon, tCO_2e

8.2 Project Emissions

8.2.1 Project N_2O emissions due to fertilizer use

Project N_2O emissions due to fertilizer use include two components: 1) Project direct N_2O emission from synthetic nitrogen fertilizer use; 2) Indirect N_2O emission from the synthetic nitrogen fertilizer use. Total project N_2O emissions due to fertilizer use equals project direct N_2O emission plus indirect N_2O emission, as described in equation (22).

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

$PE_{N_2O_{SN},t}$	Total project N_2O emissions due to fertilizer use in year t, t CO_2e
$PE_{D,N_2O_{SN},t}$	Project direct N_2O emission from synthetic nitrogen fertilizer use in year t, t N_2O
$PE_{ID,N_2O_{SN},t}$	Project indirect N_2O emission from synthetic nitrogen fertilizer use in year t, t N_2O
GWP_{N_2O}	Global warming potential of N_2O

1) Project direct N_2O emission from synthetic nitrogen fertilizer use

The project direct N_2O emission from synthetic fertilizer use is calculated using IPCC methodology recommended by 2006 IPCC Guidelines, as described in equation (23):

$$PE_{D,N_2O_{SN},t} = F_{SN,p,t} \times EF_1 \times 44/28 \tag{23}$$

$F_{SN,p,t}$	Annual amount of synthetic fertiliser N applied to grassland soils under project

activity, adjusted for volatilization as NH_3 and NO_x in year t, t N. $F_{SN,p,t}$ can be calculated according to equation (24) below

EF_1 N₂O emission factor for synthetic N fertiliser use, kg N_2O-N (kg N applied)$^{-1}$. Project participants may use N_2O emission factors from the peer reviewed scientific literature that are specific for the project area. When country-specific factors are unavailable, default N_2O emission factor recommended by 2006 IPCC Guidelines can be used (Table 11.1, volume 4 of 2006 IPCC Guidelines)

44/28 Conversion of N_2O-N to N_2O

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

$M_{SNi,p,t}$ Mass of synthetic N fertilizer type *i* applied under project activity in year t, t N

$NC_{SNi,p}$ Nitrogen content of synthetic N fertilizer type *i* applied, g-N (g fertilizer)$^{-1}$

$Frac_{GAS,F,i}$ Fraction of synthetic N fertiliser t type *i* that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$. Project participants may use specific values that are specific for the project area. When country-specific values are unavailable, default data recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines)

t Year

i Index of synthetic N fertilizer types

2) Indirect N_2O emission from the synthetic N fertilizer use under project activity

Indirect N_2O emission from the synthetic N fertilizer use including N_2O emission from atmospheric deposition of N volatilized as NH_3 and NO_x from fertilizer applied under project activity. N_2O emissions from leaching and runoff is not considered according to application conditions.

- Indirect N_2O emission from atmospheric deposition of N volatilized

The N_2O emission from atmospheric deposition of N volatilised NH_3 and NO_x from fertilized grassland under project activity is estimated using Equation (25).

$$PE_{IDV,N_2O_{SN},t} = \sum_{i=1}^{I} (F_{SNi,p,t} \times Frac_{GAS,F,i}) \times EF_4 \times 44/28 \tag{25}$$

EF_4 Emission factor for N_2O emission from atmospheric deposition of N on soils and water surfaces, [kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$]. Project participants may use EF_4 from the peer reviewed scientific literature that are specific for the project area. When country-specific factors are unavailable, default EF_4 recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines)

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

The project emissions from the use of N-fixing species, $PE_{N_2O,NF,t}$, a can be estimated using equations as follows:

$$PE_{N_2O_{NF},t} = F_{CR,p,t} \times EF_1 \times 44/28 \times GWP_{N_2O} \tag{26}$$

$PE_{N_2O_{NF},t}$ Project N_2O emission as a result of n-fixing species within the project boundary in year t, tCO_2e

$F_{CR,p,t}$ Annual amount of N in N-fixing grass (above and below ground) , and from forage/pasture renewal, returned to soils under project activity in year t, t N.

EF_1 Emission Factor for N_2O emissions from N inputs of n-fixing species to grassland soil, kg N_2O-N (kg N input)$^{-1}$. Project participants may use N_2O emission factors from the peer reviewed scientific literature that are specific for the project area. When country-specific factors are unavailable, default N_2O emission factor recommended by 2006 IPCC Guidelines can be used (Table 11.1, volume 4 of 2006 IPCC Guidelines)

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

$Area_{g,p,t}$ Total annual area of N-fixing species *g* in year t under project activity, ha

Expert survey within the project boundary under project activity should be carried out to obtain $Area_{g,p,t}$ data.

$Crop_{g,p,t}$ Annual dry matter, including above ground and below ground, returned grassland soils for N-fixing species *g* under project activity in year t, t dm ha^{-1}

Project participants may use $Crop_{g,p,t}$ from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, expert survey within the project boundary under the project activity should be carried out to obtain $Crop_{g,p,t}$ data.

$N_{content,p,g}$ Fraction of N in dry matter for N-fixing species g, tN tdm^{-1}

Project participants may use $N_{content,p,g}$ from the peer reviewed scientific literatures that are specific for the project area. When country-specific $N_{content,p,g}$ data are unavailable, expert survey within the project boundary under project activity should be carried to obtain $N_{content,p,g}$ data.

g Index of N-fixing species

8.2.3 Project emissions due to burning of biomass

The project emissions due to burning of biomass only include CH_4 and N_2O emissions with an assumption that the CO_2 emissions would be counterbalanced by CO_2 removals from the subsequent re-growth of the vegetation within one year. The project total GHG emissions equals CH_4 emission from biomass burning plus N_2O emission from biomass burning under project activity, as described in equation (28).

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

$PE_{BB,t}$ Total project GHG emissions from biomass burning in year t, t CO_2e

$PE_{CH_{4BB},t}$ Project CH_4 emission from biomass burning in year t, t CO_2e

$PE_{N_2O_{BB},t}$ Project N_2O emission from biomass burning in year t, t CO_2e

1) CH_4 emission from biomass burning under project activity

CH_4 emission from biomass burning can be calculated using equation (29).

$$PE_{CH_{4BB},t} = A_{p,t} \times M_{B,p,t} \times C_f \times EF_{CH_4} \times 10^{-3} \times GWP_{CH_4} \quad (29)$$

$PE_{CH_{4BB},t}$ Amount of CH_4 emission from biomass burning in year t under project activity in year t, t CO_2e

$A_{p,t}$ Area burned under project activity in year t, ha

$M_{B,p,t}$ Above ground biomass burned exclude litter and dead wood under project activity in year t, tonnes ha^{-1}.

C_f Combustion factor, dimensionless. Project participants may use C_f data from the peer reviewed scientific literature that are specific for the project area. When country-specific C_f data are unavailable, default C_f values in Table 2.6 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

EF_{CH_4} — CH_4 emission factor, g kg^{-1} dry matter burnt. Project participants may use EF_{CH_4} data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_{CH_4} data are unavailable, default EF_{CH_4} values in table 2.5 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

2) N_2O emission from biomass burning under project activity

N_2O emission from biomass burning can be calculated using equation (30).

$$PE_{N_2O_{BB},t} = A_{p,t} \times M_{B,p,t} \times C_f \times EF_{N_2O} \times 10^{-3} \times GWP_{N_2O} \quad (30)$$

EF_{N_2O} — N_2O emission factor, g kg^{-1} dry matter burnt. Project participants may use EF_{N_2O} data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_{N_2O} data are unavailable, default EF_{N_2O} values in table 2.5 of Chapter 2, volume 4 of 2006 IPCC Guidelines can be used.

8.2.4 Project CH_4 emissions due to enteric fermentation

Project CH_4 emission from enteric fermentation is calculated based on IPCC methodology recommended by 2006 IPCC Guidelines, equation (31).

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

$PE_{CH_{4EF},t}$ — Project CH_4 emission from enteric fermentation in year t, t CO_2e

$P_{l,p,t}$ — Population of livestock type *l* in year t under project activity, head

l — Index of livestock type

EF_l — Enteric CH_4 emission factor per head of livestock type l per year, kg CH_4 $head^{-1}year^{-1}$.

Project participants may use EF_l data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_l data are unavailable, default EF_l values can be taken from tables 10.10, 10.11 of the 2006 IPCC Guidelines.

8.2.5 Project N_2O emissions from manure and urine deposited on grassland soil during the grazing period

The project emissions from manure and urine deposited on grassland soil during the grazing period include two parts: 1) Project direct N_2O emission from manure and urine deposited on grassland soil during the grazing period; 2) Project indirect N_2O emission from manure and urine deposited on grassland soil during the grazing period. Total project N_2O emission from manure and urine deposited on grassland soil is calculated as described in equation (32).

$$PE_{N_2O_{MD},t} = GWP_{N_2O} \times (PE_{D,N_2O_{MD},t} + PE_{ID,N_2O_{MD},t}) \quad (32)$$

$PE_{N_2O_{MD},t}$ Total project N_2O emission from manure and urine deposited on grassland soil in year t, t CO_2e

$PE_{D,N_2O_{MD},t}$ Project direct N_2O emissions from manure and urine deposited on grassland soil during the grazing period in year t, t N_2O

$PE_{ID,N_2O_{MD},t}$ Project indirect N_2O emission from manure and urine deposited on grassland soil during the grazing period in year t, t N_2O.

1) Project direct N_2O emission from manure and urine deposited on grassland soil

Project direct N_2O emission from manure and urine deposited on grassland soil is calculated using IPCC methodology recommended by 2006 IPCC Guidelines as described in equation (33 or 34).

$$PE_{D,N_2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,p,t,l1} \times EF_{3,PRP,CPP} \times 44/28 \quad (33)$$

Or

$$PE_{D,N_2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,p,t,l2} \times EF_{3,PRP,SO} \times 44/28 \quad (34)$$

$F_{MD,p,t,l1}$ Annual amount of nitrogen in cattle , poultry and pigs manure and urine deposited on grassland soil during the grazing period, adjusted for volatilization as NH_3 and NO_x, t-N in year t. $F_{MD,p,t,l1}$ can be calculated according to equation (35)

$F_{MD,p,t,l2}$ Annual amount of nitrogen in sheep and other animals manure and urine deposited on grassland soil during the grazing period, adjusted for volatilization as NH_3 and NO_x, t-N in year t. $F_{MD,p,t,l2}$ can be calculated according to equation (35)

$EF_{3,PRP,CPP}$ N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on grassland soil during the grazing period, kg N_2O-N (kg N input)$^{-1}$. Project participants may use $EF_{3,PRP,CPP}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $EF_{3,PRP,CPP}$ data are unavailable, default $EF_{3,PRP,CPP}$ values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used.

$EF_{3,PRP,SO}$ — N_2O emission factor for sheep and other animals manure and urine deposited on grassland soil during the grazing period, kg N_2O-N (kg N input)$^{-1}$. Project participants may use $EF_{3,PRP,SO}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $EF_{3,PRP,SO}$ data are unavailable, default $EF_{3,PRP,SO}$ values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used.

$$F_{MD,p,t,l} = P_{l,p,t} \times W_l \times Nex_l \div 1000_a \times H_{p,t} \div 24 \times G_{days,p,t,l} \div 1000_b \times (1 - Frac_{GAS,MD,l}) \quad (35)$$

$P_{l,p,t}$ — Population of livestock type *l in year t* under project activity*, head*

W_l — Average weight of livestock *l* under project activity*,* kg head^{-1}. Project participants may use data from the peer reviewed scientific literature that are specific for the project area. When specific data are unavailable for the project region, default values can be taken from tables 10A.1~10A.9 in Chapter 10, volume 4 of the *2006 IPCC Guidelines*

Nex_l — Nitrogen excretion, kg/1000 kg animal mass/day. Project participants may use Nex_l data from the peer reviewed scientific literature that are specific for the project area. When country-specific Nex_l data are unavailable, default Nex_l values in table 10.19 of Chapter 11 of 2006 IPCC Guidelines

1000_a — Conversion of nitrogen excretion (kg/1000 kg livestock mass) to nitrogen excretion (kg/kg livestock mass), 1000

$H_{p,t}$ — Average grazing hours per day during grazing season under project activity in year t, h

24 — 24 hours a day

$G_{days,p,t,l}$ — Grazing days in year t under project activity, day

1000_b — Conversion kg to t, 1000

$Frac_{GAS,MD,l}$ — Fraction of volatilisation from dung and urine deposited by grazing animals as NH_3 and NO_x, kg N volatilised (kg of N deposited)$^{-1}$. Project participants may use

$Frac_{GAS,MD,l}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $Frac_{GAS,MD,l}$ data are unavailable, default $Frac_{GAS,MD,l}$ values in table 11.3 of Chapter 11 of 2006 IPCC Guidelines can be used.

t	Year
l	Index of grazing livestock types

2) Project indirect N_2O emissions from urine and dung N deposited on grassland soils

Project indirect N_2O emission from urine and dung N deposited on grassland soils including N_2O emissions from atmospheric deposition of N volatilized from urine and dung N deposited on grassland soils. N_2O emission from leaching and runoff is considered according to application conditions.

- Indirect N_2O emission from atmospheric deposition of N volatilized of urine and dung N deposited on grassland soils

Indirect N_2O emissions from atmospheric deposition of N volatilised of urine and dung N deposited on grassland soils is estimated using Equation (36).

$$PE_{IDV,N_2O_{MD},t} = \sum_{l=1}^{L} F_{MD,p,t,l} \times Frac_{GAS,MD,l} \times EF_4 \times 44/28 \quad (36)$$

$F_{MD,p,t,l}$	Annual amount of nitrogen in manure and urine deposited on grassland soil during the grazing period for livestock type *l* under project activity, adjusted for volatilization as NH_3 and NO_x, t-N in year t.
EF_4	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity, [kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$]. Project participants may use EF_4 data from the peer reviewed scientific literature that are specific for the project area. When country-specific EF_4 data are unavailable, default EF_4 values in table 11.3 of Chapter 11 of 2006 IPCC Guidelines can be used.

8.2.6 CO_2 emissions due to the use of fossil fuels for SGM

Equation (37) is applied to calculate CO_2 emissions from consumption of fossil fuels for SGM under project activity.

$$PE_{FC,t} = \sum_{k=1}^{K} \sum_{j=1}^{J} \sum_{p=1}^{P} FC_{p,j,k,p,t} \times EF_{CO2,k} \times NCV_k \div 1000 \quad (37)$$

where,

$PE_{FC,t}$	CO_2 emissions from farming machine fossil fuel consumption, in stratum a, in year t under project activity, tCO_2
$FC_{p,j,k,p,t}$	Fuel consumption by type *k,* machine type *j* , parcel grassland *p*, in year *t* under project activity*,* kg yr^{-1}
$EF_{CO_2,k}$	CO_2 emission factor by fuel type *k*, tCO_2 GJ^{-1}
NCV_k	Thermal value of fuel type *k* （GJ t^{-1}）
k	Index of fuel type
j	Index of machine type
p	Index of parcel grassland

8.2.7 Project removals from woody perennials

Where proponents choose to include above ground woody biomass pools, $PRWP_t$ is calculated using the A/R Working Group Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"[v]. Where proponents choose not to include above ground woody biomass pools, with-project removals, $PRWP_t$, are assumed to be zero.

Carbon gain-loss approach will be applied to estimation of the change in carbon stocks in existing woody vegetation under project activity.

The change in carbon stocks of existing live woody biomass under project activity, for each species in each vegetation class of a stratum, can be written as:

$$PRWP_{p,t} = \Delta C_{PG,j,t} - \Delta C_{PL,j,t} \tag{38}$$

where:

$PRWP_t$	Project average net change in carbon stocks of existing woody biomass for species j, in year t; t CO_2 yr^{-1}
$\Delta C_{PG,j,t}$	Project average increase in carbon stocks of existing woody biomass for species j, in year t; t CO_2 yr^{-1}
$\Delta C_{PL,j,t}$	Project average loss in carbon stocks of existing woody biomass for species j, in year t; t CO_2 yr^{-1}

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

The average increase in carbon stocks in existing live woody biomass, for each species in a stratum, can be written as:

$$\Delta C_{PG,j,t} = A_{P,s,t} \times G_{j,p,t} \times CF_j \times 44/12 \quad (39)$$

where:

$\Delta C_{PG,j,t}$	Project average increase in carbon stocks of existing woody biomass for species *j*, for year *t*; $t\ CO_2\ yr^{-1}$
$A_{P,s,t}$	Area of stratum S under Project activity in year t; ha
$G_{j,p,t}$	Project average increase in existing woody biomass of species *j* in year t; $t\ d.m\ ha^{-1}\ yr^{-1}$
CF_j	Carbon fraction for species *j* (default values: *0.50*, and *0.49*, for tree and shrub species, respectively); $t\ C\ (t\ d.m.)^{-1}$
$44/12$	Ratio of molecular weights of CO_2 and C; $g\ mol^{-1}\ (g\ mol^{-1})^{-1}$

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

$$G_{j,p,t} = G_{AB,j,p,t}(1 + R_j) \quad (40)$$

where:

$G_{j,p,t}$	Project average increase in existing woody biomass of species *j*, for year *t*; $t\ d.m\ ha^{-1}\ yr^{-1}$
$G_{AB,j,p,t}$	Project average increase in existing above-ground woody biomass of species *j*, for year *t*; $t\ d.m\ ha^{-1}\ yr^{-1}$
R_j	Root: shoot ratio of species *j*; $t\ d.m.\ (t\ d.m.)^{-1}$

8.2.8 Project removals due to changes in soil organic carbon

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

Option 1: Estimate of project removals due to changes in soil organic carbon using validated model

Project equilibrium soil organic carbon density in management systems

Using an analytic model that has been accepted in scientific publications and validated for the project region (for example: CENTURY soil organic matter model[vi]) to estimate the soil organic carbon (SOC) density at equilibrium under each of the identified management practices.

The details of each management practice that are recorded will depend on the choice of the soil model selected and the type of activity being promoted.

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

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

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

$$P_{S,equil,t} = \sum_{m_G} PA_{G,m_G,t} \bullet SOC_{G,m_G,t} \tag{41}$$

$P_{S,equil,t}$	Project SOC in equilibrium year t, tC
$PA_{G,m_G,t}$	Project areas in grassland with management practice, m_G, year t, ha
$SOC_{G,m_G,t}$	Soil organic carbon density at equilibrium for grassland with management practice, m_G, at year *t*, tC ha^{-1}
m_G	An index for grassland management types, unit less

Project estimate of soil organic carbon with transitions

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

$$P_{S,t} = \frac{1}{D} \sum_{t-D+1}^{t} P_{S,equil,t} \bullet \Delta t \tag{42}$$

$P_{S,t}$	SOC under project activity in year t, tC
$P_{S,equil,t}$	SOC under project activity in equilibrium year t, tC
D	The transition period required for SOC to be at equilibrium after a change in management practice, year

Δt Time increment = 1 year

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

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

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

Estimate of project removals due to changes in soil organic carbon

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

$$PR_t = \left(P_{S,t} - P_{S,t-1}\right) \bullet \frac{44}{12} \tag{43}$$

Where

PR_t Project removals due to changes in soil organic carbon in year t, t CO_2e.

$P_{S,t}$ Estimate of the project SOC in year t, tC

Option 2: Estimate of project removals due to changes in soil organic carbon using measurement approach

Formula（42） is used to estimate soil organic carbon stock in stratum a, sampling site i, parcel of land p under project activity in year t. Using the tool “Calculation of the number of sample plots for measurements within A/R CDM project activities” to calculate the number of sample plots for measurements.

$$P_{SOC_{s,i,t}} = SOC_{s,i,t} \times BD_{s,i,t} \times Depth \times (1 - FC_{s,i,t}) \times F \tag{44}$$

where,

$P_{SOC_{s,i,t}}$ Soil organic carbon stock in the top 20 cm of soil for stratum s, sampling site i under project activity in year t, tC ha^{-1}

$SOC_{s,i,t}$ Soil organic carbon content in the top 20 cm of soil for stratum s, sampling site i, under project activity in year t, g C·$100g^{-1}$ soil.

$BD_{s,i,t}$ Soil bulk density in the top 20 cm of soil for stratum s, sampling site i, under project activity in year t, g·cm^{-3}

Depth Top soil depth, for calculating grassland soil organic carbon stock in the top 20 cm of soil, m

$FC_{s,i,t}$ Percentage of rocks, roots, and other dead residues with a diameter larger than 2mm in the top 20 cm of soil, for stratum s, sampling site i under project activity in year t, %

F Unit conversion coefficient turning soil carbon stock into t C ha^{-1}, in $10000 m^2 \cdot ha^{-1}$

s Index of stratum

i Index of sampling site

p Index of parcel of land

Equation（45）is applied to calculate average carbon stock of all monitored sites in stratum s, under project activity.

$$P_{SOC_{s,t}} = (\sum_{i=1}^{I} P_{SOC_{s,i,t}}) / I \quad (45)$$

$P_{SOC_{s,t}}$ Average carbon stock in stratum s under project activity, t Cha^{-1}

I Total number of monitored sites in stratum s, under project activity

Equation （46）is applied to calculate average carbon stock of al stratum, under project activity in year t.

$$P_t = (\sum_{s=1}^{S} P_{SOC_{s,t}} \times A_s) \quad (46)$$

P_t Total carbon stock under project activity in year t, t C

A_s Total area of stratum s

S Total number of stratum under project activity

Equation （47）is applied to calculate changes in soil organic carbon stock due to the project activity during the period of t-1 to t.

$$PR_t = (P_t - P_{t-1}) \bullet \frac{44}{12} \quad (47)$$

Where

PR_t Changes in soil organic carbon stock due to the project activity during the period of t-1 to t, t CO_2.

The changes in soil organic carbon stock due to the project activity during the project start to the first measurement will be calculated using equation (48):

$$PR_t = (P_1 - B_{SOC}) \bullet \frac{44}{12} \quad (48)$$

Where

P_1 Total carbon stock within project boundary under project activity in year t, t C

B_{SOC} Total carbon stock within project boundary under baseline scenario at the start of project activity, t C

8.2.9 Actual net GHG emissions by sources and removals by sinks

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

$$PE_t = PE_{N_2O_{SN},t} + PE_{N_2O_{NF},t} + PE_{BB,t} + PE_{CH_{4EF},t} + PE_{N_2O_{MD},t} + PE_{FC,t} - PRWP_t - PR_t \quad (49)$$

Where

PE_t Project net GHG emissions by sources and removals by sinks in year t, t CO_2e

$PE_{N_2O_{SN},t}$ Project N_2O emissions due to fertilizer use in year t, t CO_2e.

$PE_{N_2O_{NF},t}$ Project N_2O emission due to n-fixing species in year t, t CO_2e.

$PE_{BB,t}$ Project GHG emissions from biomass burning in year t under project activity, t CO_2e

$PE_{CH_{4EF},t}$ Project CH4 emission due to enteric fermentation in year t, t CO_2e.

$PE_{N_2O_{MD},t}$ Project N_2O emission from manure and urine deposited on grassland soil in year t, t CO_2e.

$PE_{FC,t}$ CO2 emissions due to the use of fossil fuels for SGM

$PRWP_t$ Project removals from woody perennials in year t, t CO_2e.

PR_t Project removals due to changes in soil organic carbon in year t, t CO_2e.

8.3 Leakage

There are four potential sources of leakage:

a) Depletion of soil organic matter, and/or increase in the use of inorganic fertilizer, and/or increase in the amount of fossil fuel for cooking outside the project boundary caused by displacement of manure from outside to inside the project boundary;

b) Increase in the use of fuel wood from non-renewable sources for cooking and heating, and/or increase in the use of fossil fuel for cooking and heating due to the decrease in the use of manure as an energy source causing leakage;

c) GHG emissions caused by displacement of grazing from the project boundary;

d) Changes in CH_4 emissions caused by the improved livestock management.

Leakages a) and b) are limited by the applicability conditions c)~d), therefore leakage emission from a) and b) can be ignored. In fact, for sustainable grassland management it is most likely that the number of livestock will decrease during the project period. So, if based on the same requirement for amount of animal products, improved management will reduce the CH4 emission due to decreasing emission intensity per unit animal products. Therefore, only GHG emissions caused by displacement of grazing will be considered. Tool for estimation of emissions due to displacement of grazing as part of SGM methodology will be used for the leakage calculation (see Annex iV).

8.4 Summary of GHG emission reduction and/or removals

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

$$\Delta R_t = BE - PE_t - LE_t \quad (50)$$

ΔR_t	Estimate of net anthropogenic GHG emissions and removals in year t, t CO_2e
PE_t	Estimate of actual net GHG emissions and removals in year t, t CO_2e
BE	Baseline emissions and removals, t CO_2e
LE_t	Leakage emission in year t, t CO_2e

9 MONITORING

9.1 Data and parameters available at validation

Table 3: Data and Parameters Available at Validation

Data/Parameter:	GWP_{N_2O}
Data unit:	Kg CO_2 e(kg N_2O)$^{-1}$
Description:	Global warming potential for N_2O
Source of data:	IPCC. GWP_{N_2O}=310
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	EF_1
Data unit:	kg N_2O-N (kg N applied)$^{-1}$
Description:	N_2O emission factor for synthetic N fertiliser use
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, default N2O emission factor recommended by 2006 IPCC Guidelines can be used (Table 11.1, volume 4 of 2006 IPCC Guidelines). EF_1=0.01
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	EF_4
Data unit:	kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$
Description:	N_2O emission factor for atmospheric deposition of N on soils and water surfaces
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, default value recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines). EF_4 =0.01
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	C_f
Data unit:	dimensionless
Description:	Combustion factor
Source of data:	Table 2.6 of Chapter 2, volume 4 of 2006 IPCC Guidelines. See table 3 in Annex I of this methodology
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	EF_{CH_4}
Data unit:	g kg^{-1} dm burnt
Description:	CH_4 emission factor for biomass burning
Source of data:	Table 2.5 in Chapter 2, volume 4 of 2006 IPCC Guidelines. See table 2 in Annex I of this methodology

Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	GWP_{CH_4}
Data unit:	Kg CO_2 e(kg CH_4)$^{-1}$
Description:	Global warming potential for CH_4
Source of data:	IPCC. GWP_{CH_4} =21
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	EF_{N_2O}
Data unit:	g N_2O kg^{-1} dry matter burned
Description:	N_2O emission factor for biomass burning
Source of data:	Table 2.5 in Chapter 2, volume 4 of 2006 IPCC Guidelines
Value applied:	See table 1 in Annex I of this methodology
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$Frac_{GAS,F,i}$
Data unit:	kg N volatilised (kg of N applied)$^{-1}$
Description:	Fraction of synthetic N fertiliser type *i* that volatilises as NH_3 and NO_x
Source of data:	Data from the peer reviewed scientific literature. When country specific values are unavailable, default data recommended by 2006 IPCC Guidelines can be used (Table 11.3, volume 4 of 2006 IPCC Guidelines). $Frac_{GAS,F,i}$=0.10
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$Frac_{GAS,MD,l}$
Data unit:	kg N volatilised (kg of N deposited)$^{-1}$

Description:	Fraction of volatilisation from dung and urine deposited by grazing animals as NH_3 and NO_x
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific data are unavailable, default values in table 11.3 of Chapter 11 of 2006 IPCC Guidelines can be used. $Frac_{GAS,MD,l}$ =0.20
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$EF_{3,PRP,CPP}$
Data unit:	kg N_2O-N (kg N deposited on or applied to grassland)$^{-1}$
Description:	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on of applied to grassland
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific data are unavailable, default values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used. $EF_{3,PRP,CPP}$ =0.02
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$EF_{3,PRP,SO}$
Data unit:	kg N_2O-N (kg N deposited on or applied to grassland)$^{-1}$
Description:	N_2O emission factor for sheep and other animals manure and urine deposited on of applied to grassland
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific data are unavailable, default values in table 11.1 of Chapter 11 of 2006 IPCC Guidelines can be used. $EF_{3,PRP,SO}$ =0.01
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	Nex_l
Data unit:	kg/1000 kg animal mass/day
Description:	Nitrogen excretion

Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When country-specific data are unavailable, default values in table 10.19 of Chapter 11 of 2006 IPCC Guidelines. See Annex II of this methodology
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	W_l
Data unit:	kg
Description:	Average weight of livestock *l*
Source of data:	Data from the peer reviewed scientific literatures that are specific for the project area. When specific data are unavailable for the project region, default values can be taken from tables 10A.1~10A.9 in Chapter 10, volume 4 of the *2006 IPCC Guidelines.* See Annex III of this methodology
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$EF_{CO_2,k}$
Data unit:	$tCO_2\ GJ^{-1}$
Description:	CO_2 emission factor by fuel type *k*
Source of data:	*2006 IPCC Guidelines*
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	NCV_k
Data unit:	$GJ\ t^{-1}$
Description:	Thermal value of fuel type *k*
Source of data:	*2006 IPCC Guidelines*
Justification of the choice of data or description of measurement methods and procedures actually applied:	

Additional comment:	

Data/Parameter:	CF_j
Data unit:	tC/tdm
Description:	Carbon fraction for species *j*
Source of data:	A/R Methodological Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities". 0.50 for tree; 0.49 for shrub species
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	R_j
Data unit:	tdm/tdm
Description:	Root:shoot ratio of species *j*
Source of data:	A/R Methodological Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities". 0.26 for tree; 0.4 for shrub species
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$G_{AB,j,B}$
Data unit:	$tdm \cdot ha^{-1} yr^{-1}$
Description:	Average increase in existing above-ground woody biomass of species *j*, under baseline.
Source of data:	GPG LULUCF, IPCC, 2003. Annex III
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$G_{AB,j,p,t}$
Data unit:	$tdm \cdot ha^{-1} yr^{-1}$
Description:	Average increase in existing above-ground woody biomass of species *j*, under project activity for year *t*.
Source of data:	GPG LULUCF, IPCC, 2003. Annex III

Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$M_{SNi,B}$
Data unit:	t N
Description:	Mass of synthetic N fertilizer type *i* applied under baseline
Source of data:	PPs
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$NC_{SNi,B}$
Data unit:	g-N (g fertilizer)$^{-1}$
Description:	Nitrogen content of synthetic N fertilizer type i applied
Source of data:	PPs
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$Area_{g,B}$
Data unit:	ha
Description:	Annual area of N-fixing species *g* under baseline
Source of data:	Expert survey within the project boundary before the start of the project activity to obtain $Area_{g,B}$ data
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	A_B
Data unit:	ha

Description:	Area burned under baseline
Source of data:	pps
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$Crop_{g,B}$
Data unit:	t dm ha^{-1}
Description:	Annual dry matter, including above ground and below ground,
Source of data:	Project participants may use $Crop_{g,B}$ from the peer reviewed scientific literatures that are specific for the project area. When country-specific factors are unavailable, expert survey within the project boundary before the start of the project activity should be carried out to obtain $Crop_{g,B}$ data.
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$N_{content,g,B}$
Data unit:	tN tm^{-1}
Description:	Fraction of N in dry matter for N-fixing species *g* under baseline
Source of data:	Project participants may use $N_{content,g,B}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $N_{content,g,B}$ data are unavailable, expert survey within the project boundary before the start of the project activity should be carried to obtain $N_{content,g,B}$ data.
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$M_{B,B}$
Data unit:	t ha^{-1}
Description:	Above ground biomass burned under baseline
Source of data:	

Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$P_{l,B}$
Data unit:	head
Description:	Population of livestock type *l* t under baseline
Source of data:	pps
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	EF_l
Data unit:	kg CH_4 head^{-1}year^{-1}
Description:	Enteric CH_4 emission factor per head of livestock type l per year
Source of data:	2006 IPCC Guidelines
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$G_{days,l,B}$
Data unit:	day
Description:	Grazing days under baseline
Source of data:	pps
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	
Data/Parameter:	H_B
Data unit:	h
Description:	Average grazing hours per day during grazing season under baseline

Source of data:	pps
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$FC_{p,j,k,B}$
Data unit:	kg yr^{-1}
Description:	Fuel consumption by type *k,* machine type *j* , parcel grassland *p*, in baseline
Source of data:	pps
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	

Data/Parameter:	$A_{B,s}$
Data unit:	ha
Description:	Area of trees and shrubs under baseline, for stratum *S*
Source of data:	PPs
Value of data	-
Justification of the choice of data or description of measurement methods and procedures actually applied:	
Additional comment:	At the start of the project

9.2 Data and Parameters Monitored

The following parameters must be monitored during the project activity. When applying all relevant equations provided in this methodology for the *ex-ante* calculation of net anthropogenic GHG removals by sinks, project participants shall 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 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.

Table 4: Data and Parameters Monitored

Data/Parameter:	$M_{SNi,p,t}$
Data unit:	t
Description:	Mass of synthetic N fertilizer type i applied under project activity in year t
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Record by participants just after the application of synthetic N fertilizer
Frequency of monitoring/recording:	Each application during crediting period in year t
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$NC_{SNi,P}$
Data unit:	g-N (g fertilizer)$^{-1}$
Description:	Nitrogen content of synthetic N fertilizer type i applied under project activity
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Record by participants just after the application of synthetic N fertilizer
Frequency of monitoring/recording:	Each application during crediting period in year t
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$A_{p,t}$
Data unit:	ha
Description:	Area burned in year t during the crediting period
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Measure and record the area burnt after the occurrence fire
Frequency of monitoring/recording:	Each burning activity in year t during crediting period
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$M_{B,p,t}$
Data unit:	tonnes ha^{-1}
Description:	Above ground biomass burned exclude litter and dead wood

	yb=nder project activity in year t.
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Each burning activity in year t during crediting period
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$P_{l,p,t}$
Data unit:	*head*
Description:	Population of livestock type *l* under project activity in year t
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Record numbers of grazing livestock by type. The sample size of household number will ensure precision at 90%/10 precision. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type will be calculated. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Seasonally
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$H_{p,t}$
Data unit:	Hours day^{-1}
Description:	Average grazing hours per day during grazing season under project activity
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Record daily. The sample size of household number will ensure precision at 90%/10 precision. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Seasonally
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$G_{days,p,t,l}$
Data unit:	days
Description:	Grazing days of livestock l in year t under project activity
Source of data:	PPs

Value of data	
Description of measurement methods and procedures to be applied:	Record grazing days in year t. The sample size of household number will ensure precision at 90%/10 precision. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Seasonally
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$Area_{g,p,t}$
Data unit:	ha
Description:	Annual area of N-fixing species *g* under project activity in year t
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Record the area of N-fixing grassland by species by all households involved. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$Crop_{g,p,t}$
Data unit:	t dm ha^{-1}
Description:	Annual dry matter, including above ground and below ground, returned grassland soils for N-fixing species *g* under project activity in year t.
Source of data:	PPs
Value of data:	
Description of measurement methods and procedures to be applied:	Measure annual dry matter, including above ground and below ground, returned grassland soils for N-fixing species *g* in year t. The sample size of household number will ensure precision at 90%/10 precision. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$N_{content,p,g}$
Data unit:	tN tdm^{-1}
Description:	Fraction of N in dry matter for N-fixing species *g* under project activity

Source of data:	Project participants may use $N_{content,p,g}$ data from the peer reviewed scientific literature that are specific for the project area. When country-specific $N_{content,p,g}$ data are unavailable, expert survey within the project boundary before the start of the project activity should be carried to obtain $N_{content,p,g}$ data.
Value of data:	
Description of measurement methods and procedures to be applied:	Collect biomass (above ground and below ground) from three plots (1m*1m) of each N-fixing species in each sampled household. Send the samples to qualified laboratory to analyze the N content in the biomass. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$PA_{G,m_G,t}$
Data unit:	ha
Description:	Project areas of grassland with management practice, m_G
Source of data:	Project proponents
Value of data:	
Description of measurement methods and procedures to be applied:	Record the area of grassland with management practice, m_G. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$SOC_{s,i,t}$
Data unit:	$g\ C \cdot 100g^{-1}$
Description:	Soil organic carbon stock in the top 20 cm of soil for stratum *s*, sampling site *i*
Source of data:	Project proponents
Value of data	
Description of measurement methods and procedures to be applied:	Collect 3 samples for each sampling site and send the samples to qualified laboratory to analyze the $SOC_{s,i,t}$. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Every five years until the end of the crediting period
QA/QC procedures to be applied:	

Any comment:	

Data Unit / Parameter	$BD_{s,i,t}$
Data unit:	$g{\cdot}cm^{-3}$
Description:	Soil bulk density in the top 20 cm of soil for stratum *s*, sampling site *i*
Source of data:	Project proponents
Value of data:	
Description of measurement methods and procedures to be applied:	Collect 3 samples for each sampling site and send the samples to qualified laboratory to analyze the $BD_{s,i,t}$. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Every five years until the end of the crediting period
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$FC_{s,i,t}$
Data unit:	%
Description:	Percentage of rocks, roots, and other dead residues with a diameter larger than 2mm in the top 20 cm of soil, for stratum *s*, sampling site *i*
Source of data:	Project proponents
Value of data	
Description of measurement methods and procedures to be applied:	Collect 3 samples for each sampling site and send the samples to qualified laboratory to analyze the $FC_{s,i,t}$. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Once in five years
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	$FC_{p,j,k,p,t}$
Data unit:	kg
Description:	Fuel consumption by type *k,* machine type *j* , parcel grassland *p*, in year *t* under project activity
Source of data:	Project proponents
Value of data	
Description of measurement methods and procedures to be applied:	Collect fuel consumption by type *k,* machine type *j*, parcel grassland *p* of each household. Archive electronically during the crediting period plus 2 years.
Frequency of monitoring/recording:	Once a year
QA/QC procedures to be applied:	

Any comment:	

Data Unit / Parameter	$A_{P,s,t}$
Data unit:	ha
Description:	Area of trees and shrubs under project activity in year t, for stratum *S*
Source of data:	PPs
Value of data	-
Description of measurement methods and procedures to be applied:	Maps, orthorectified images, field-based GPS measurements. Horizontal projected area required
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	A_s
Data unit:	ha
Description:	Total area of stratum *S*
Source of data:	PPs
Value of data	-
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter	S
Data unit:	number
Description:	Total number of stratum under project activity
Source of data:	PPs
Value of data	-
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

9.3 Description of the Monitoring Plan

All data collected as part of monitoring must be archived electronically and be kept at least for 2 years after the end of the crediting period.

9.3.1 Monitoring of Project Implementation

Information shall be provided, and recorded in the project design document (PDD), to establish that:

i. The geographic location of the project boundary is recorded for all areas of grassland;

- The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This can be achieved by field survey (e.g., using GPS), or by using georeferenced spatial data (e.g., maps, GIS datasets).

ii. Record of grassland management

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

9.3.2 Sampling Design and Stratification (Option 2)

Stratification of the project area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit. Project participants must present in the VCS-PDD an ex-ante stratification of the project area or justify the lack of it. The number and boundaries of the strata defined ex-ante may change during the crediting period (ex-post).

Updating of strata

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

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

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

Sampling framework

To determine the sample size and allocation among strata, this methodology uses the latest version of the tool for the ―Calculation of the number of sample plots for measurements within A/R CDM project activities[vii], approved by the CDM Executive Board. The targeted precision level for biomass estimation across the project is +/- 10% of the mean at a 90% confidence level. In contrast to the CDM tool note that temporary plots are permissible under this methodology.

ANNEX

Annex I: Parameters and data source if using default values recommended by IPCC

Table 1: Parameters and data source for calculating baseline and project N_2O emissions

Parameter	Value	Unit	Equation	Source of default value
GWP_{N_2O}	310	-	(1) (4) (7) (11) (12) (20) (21) (23) (28) (31)(34) (38) (39) (47) (48)	IPCC
EF_1	0.01	kg N_2O-N (kg N applied)-1	(2) (7) (29) (34)	Table 11.1, chapter 11, volume 4 of 2006 IPCC Guidelines
EF_4	0.01	kg N_2O-N (kg NH_3-N + NOx-N volatilised)$^{-1}$	(5) (17) (24) (32) (44) (51)	Table 11.3, chapter 11, volume 4 of 2006 IPCC Guidelines
EF_{N_2O}	0.21	g N_2O kg^{-1} dry matter burned	(11)(38)	Table 2.5 in Chapter 2, volume 4 of 2006 IPCC Guidelines
$EF_{3,PRP,CPP}$	0.02	kg N_2O-N (kg N deposited)$^{-1}$	(13)(20)(40)(47)	For cattle (dairy, non-dairy and buffalo), poultry and pigs, Table 11.1, chapter 11, volume 4 of 2006 IPCC Guidelines
$EF_{3,PRP,SO}$	0.01	kg N_2O-N (kg N deposited)$^{-1}$	(14)(21)(41)(48)	For sheep and other animals. Table 11.1, chapter 11, volume 4 of 2006 IPCC Guidelines
$Frac_{GAS,F,i}$	0.10	kg N (kg N applied)$^{-1}$	(3)(5)(30) (32)	Table 11.3, chapter 11, volume 4 of 2006 IPCC Guidelines
$Frac_{GAS,MD,i}$	0.20	kg N (kg N deposited)$^{-1}$	(15)(17)(42)(44)	Table 11.3, chapter 11, volume 4 of 2006 IPCC Guidelines
$Frac_{GAS,MA,i}$	0.2	kg NH_3–N + NOx–N) (kg N deposited)$^{-1}$	(22)(44) (49) (51)	Table 11.3, chapter 11, volume 4 of 2006 IPCC Guidelines
Nex_l	Annex II of this methodology	Kg N/1000kg animal mass/day	(15) (42)	Table 10.19, Chapter 10, volume 4 of 2006 IPCC Guidelines

Table 2: Parameters and data source for calculating baseline and project CH_4 emissions

Parameter	Value	Unit	Equation	Source
EF_{CH_4}	2.3	g CH_4 kg^{-1} dry matter burned	(10)(37)	Table 2.5 in Chapter 2, volume 4 of 2006 IPCC Guidelines
GWP_{CH_4}	21	Dimensionless	(10)(26)(37)(53)	IPCC
EF_l	Annex III-1~3 of this methodology	Kg CH_4 $head^{-1}yr^{-1}$	(26) (53)	Table 10.10, Table 10.10, Table 10.A2, Chapter 10, volume 4 of 2006 IPCC Guidelines

Table 3: Combustion factor (C_f) values (proportion of pre-fire biomass burned) used for calculating baseline and project N_2O and CH4 emissions due to biomass burning

Vegetation type	Sub-category	Mean	Equation	Source
Savannah Grasslands/Pasture (early dry season burns)*		0.74	(10)(11)(37)(38)	Table 2.6 in Chapter 2, volume 4 of 2006 IPCC Guidelines
Savannah Grasslands/Pasture (mid/late dry season burns)	Tropical/sub-tropical grassland	0.92		
	Tropical pasture	0.35		
	Savannah	0.86		

*Surface layer combustion only

Annex II: Nitrogen excretion

TABLE 10.19
DEFAULT VALUES FOR NITROGEN EXCRETION RATE [a] (KG N (1000 KG ANIMAL MASS)$^{-1}$ DAY^{-1})

Category of animal	Region							
	North America	Western Europe	Eastern Europe	Oceania	Latin America	Africa	Middle East	Asia
Dairy Cattle	0.44	0.48	0.35	0.44	0.48	0.60	0.70	0.47
Other Cattle	0.31	0.33	0.35	0.50	0.36	0.63	0.79	0.34
Swine[b]	0.50	0.68	0.74	0.73	1.64	1.64	1.64	0.50
Market	0.42	0.51	0.55	0.53	1.57	1.57	1.57	0.42
Breeding	0.24	0.42	0.46	0.46	0.55	0.55	0.55	0.24
Poultry	0.83	0.83	0.82	0.82	0.82	0.82	0.82	0.82
Hens >/= 1 yr	0.83	0.96	0.82	0.82	0.82	0.82	0.82	0.82
Pullets	0.62	0.55	0.60	0.60	0.60	0.60	0.60	0.60
Other Chickens	0.83	0.83	0.82	0.82	0.82	0.82	0.82	0.82
Broilers	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Turkeys	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Ducks	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Sheep	0.42	0.85	0.90	1.13	1.17	1.17	1.17	1.17
Goats	0.45	1.28	1.28	1.42	1.37	1.37	1.37	1.37
Horses (and mules, asses)	0.30	0.26	0.30	0.30	0.46	0.46	0.46	0.46
Camels[c]	0.38	0.38	0.38	0.38	0.46	0.46	0.46	0.46
Buffalo[c]	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Mink and Polecat (kg N head^{-1} yr^{-1})[d]	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
Rabbits (kg N head^{-1} yr^{-1})	8.10	8.10	8.10	8.10	8.10	8.10	8.10	8.10
Fox and Racoon (kg N head^{-1} yr^{-1})[d]	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09

The uncertainty in these estimates is ±50%.
[a]Summarized from *1996 IPCC Guidelines*, 1997; European Environmental Agency, 2002; USA EPA National NH_3 Inventory Draft Report, 2004; and data of GHG inventories of Annex I Parties submitted to the Secretariat UNFCCC in 2004.
[b]Nitrogen excretion for swine are based on an estimated country population of 90% market swine and 10% breeding swine.
[c]Modified from European Environmental Agency, 2002.
[d]Data of Hutchings *et al.*, 2001.

Annex III: Average annual aboveground biomass increment

TABLE 3A.1.5
AVERAGE ANNUAL INCREMENT IN ABOVEGROUND BIOMASS IN NATURAL REGENERATION BY BROAD CATEGORY
(tonnes dry matter/ha/year)
(To be used for G_W in Equation 3.2.5)

Tropical and Sub-Tropical Forests

Age Class	Wet	Moist with Short Dry Season	Moist with Long Dry Season	Dry	Montane Moist	Montane Dry
	R > 2000	2000>R>1000		R<1000	R>1000	R<1000
Africa						
≤20 years	10.0	5.3	2.4 (2.3 – 2.5)	1.2 (0.8 – 1.5)	5.0	2.0 (1.0 – 3.0)
>20 years	3.1 (2.3 -3.8)	1.3	1.8 (0.6 – 3.0)	0.9 (0.2 – 1.6)	1.0	1. 5 (0.5 – 4.5)
Asia & Oceania						
Continental						
≤20 years	7.0 (3.0 – 11.0)	9.0	6.0	5.0	5.0	1.0
>20 years	2.2 (1.3 – 3.0)	2.0	1.5	1.3 (1.0 - 2.2)	1.0	0.5
Insular						
≤20 years	13.0	11.0	7.0	2.0	12.0	3.0
>20 years	3.4	3.0	2.0	1.0	3.0	1.0
America						
≤20 years	10.0	7.0	4.0	4.0	5.0	1.8
>20 years	1.9 (1.2 – 2.6)	2.0	1.0	1.0	1.4 (1.0 – 2.0)	0.4

Temperate Forests

Age Class	Coniferous	Broadleaf
≤20 years	3.0 (0.5 – 6.0)	4.0 (0.5 – 8.0)
>20 years	3.0 (0.5 – 6.0)	4.0 (0.5 – 7.5)

Boreal forests

Age Class	Mixed Broadleaf-Coniferous	Coniferous	Forest-Tundra	Broadleaf
Eurasia				
≤20 years	1.0	1.5	0.4 (0.2 – 0.5)	1.5 (1.0 – 2.0)
>20 years	1.5	2.5	0.4 (0.2 - 0.5)	1.5
America				
≤20 years	1.1 (0.7 – 1.5)	0.8 (0.5 – 1.0)	0.4 (0.2 – 0.5)	1.5 (1.0 – 2.0)
>20 years	1.1 (0.7 — 1.5)	1.5 (0.5 – 2.5)	0.4 (0.2 – 0.5)	1.3 (1.0 – 1.5)

Note: R= annual rainfall in mm/yr

Note: Data are given as mean value and as the range of possible values.

Annex IV: Methane emission factor for enteric fermentation

Annex IV-1: Methane emission factor for enteric fermentation

TABLE 10.11
TIER 1 ENTERIC FERMENTATION EMISSION FACTORS FOR CATTLE[1]

Regional characteristics	Cattle category	Emission factor [2] (kg CH_4 head^{-1} yr^{-1})	Comments
North America: Highly productive commercialized dairy sector feeding high quality forage and grain. Separate beef cow herd, primarily grazing with feed supplements seasonally. Fast-growing beef steers/heifers finished in feedlots on grain. Dairy cows are a small part of the population.	Dairy	121	Average milk production of 8,400 kg head^{-1} yr^{-1}.
	Other Cattle	53	Includes beef cows, bulls, calves, growing steers/heifers, and feedlot cattle.
Western Europe: Highly productive commercialised dairy sector feeding high quality forage and grain. Dairy cows also used for beef calf production. Very small dedicated beef cow herd. Minor amount of feedlot feeding with grains.	Dairy	109	Average milk production of 6,000 kg head^{-1} yr^{-1}.
	Other Cattle	57	Includes bulls, calves, and growing steers/heifers.
Eastern Europe: Commercialised dairy sector feeding mostly forages. Separate beef cow herd, primarily grazing. Minor amount of feedlot feeding with grains.	Dairy	89	Average milk production of 2,550 kg head^{-1} yr^{-1}.
	Other Cattle	58	Includes beef cows, bulls, and young.
Oceania: Commercialised dairy sector based on grazing. Separate beef cow herd, primarily grazing rangelands of widely varying quality. Growing amount of feedlot feeding with grains. Dairy cows are a small part of the population.	Dairy	81	Average milk production of 2,200 kg head^{-1} yr^{-1}.
	Other Cattle	60	Includes beef cows, bulls, and young.
Latin America: Commercialised dairy sector based on grazing. Separate beef cow herd grazing pastures and rangelands. Minor amount of feedlot feeding with grains. Growing non-dairy cattle comprise a large portion of the population.	Dairy	63	Average milk production of 800 kg head^{-1} yr^{-1}
	Other Cattle	56	Includes beef cows, bulls, and young.
Asia: Small commercialised dairy sector. Most cattle are multi-purpose, providing draft power and some milk within farming regions. Small grazing population. Cattle of all types are smaller than those found in most other regions.	Dairy	61	Average milk production of 1,650 kg head^{-1} yr^{-1}
	Other Cattle	47	Includes multi-purpose cows, bulls, and young
Africa and Middle East: Commercialised dairy sector based on grazing with low production per cow. Most cattle are multi-purpose, providing draft power and some milk within farming regions. Some cattle graze over very large areas. Cattle are smaller than those found in most other regions.	Dairy	40	Average milk production of 475 kg head^{-1} yr^{-1}
	Other Cattle	31	Includes multi-purpose cows, bulls, and young
Indian Subcontinent: Commercialised dairy sector based on crop by-product feeding with low production per cow. Most bullocks provide draft power and cows provide some milk in farming regions. Small grazing population. Cattle in this region are the smallest compared to cattle found in all other regions.	Dairy	51	Average milk production of 900 kg head^{-1} yr^{-1}
	Other Cattle	27	Includes cows, bulls, and young. Young comprise a large portion of the population

[1] Emission factors should be derived on the basis of the characteristics of the cattle and feed of interest and need not be restricted solely to within regional characteristics.

[2] IPCC Expert Group, values represent averages within region, where applicable the use of more specific regional milk production data is encouraged. Existing values were derived using Tier 2 method and the data in Tables 10 A.1 and 10A. 2.

Annex IV-2: Methane emission factor for enteric fermentation

TABLE 10.10
ENTERIC FERMENTATION EMISSION FACTORS FOR TIER 1 METHOD[1]
(KG CH_4 HEAD^{-1} YR^{-1})

Livestock	Developed countries	Developing countries	Liveweight
Buffalo	55	55	300 kg
Sheep	8	5	65 kg - developed countries; 45 kg - developing countries
Goats	5	5	40 kg
Camels	46	46	570 kg
Horses	18	18	550 kg
Mules and Asses	10	10	245 kg
Deer	20	20	120 kg
Alpacas	8	8	65 kg
Swine	1.5	1.0	
Poultry	Insufficient data for calculation	Insufficient data for calculation	
Other (e.g., Llamas)	To be determined[1]	To be determined[1]	

All estimates have an uncertainty of ±30-50%.

Sources: Emission factors for buffalo and camels from Gibbs and Johnson (1993). Emission factors for other livestock from Crutzen *et al.*, (1986), Alpacas from Pinares-Patino *et al.*, 2003; Deer from Clark *et al.*, 2003 .

[1] One approach for developing the approximate emission factors is to use the Tier 1 emissions factor for an animal with a similar digestive system and to scale the emissions factor using the ratio of the weights of the animals raised to the 0.75 power. Liveweight values have been included for this purpose. Emission factors should be derived on the basis of characteristics of the livestock and feed of interest and should not be restricted solely to within regional characteristics.

Annex IV-3: Methane emission factor for enteric fermentation

TABLE 10A.2
DATA FOR ESTIMATING TIER 1 ENTERIC FERMENTATION CH_4 EMISSION FACTORS FOR OTHER CATTLE IN TABLE 10.11

Subcategory	Weight, kg	Weight gain, kg day^{-1}	Feeding situation	Milk, kg day^{-1}	Work, hr day^{-1}	%Pregnant	Digestibility of feed (DE%)	CH_4 conversion factor (Y_m)	Day weighted population mix %	Emission factors, kg CH_4 head^{-1} yr^{-1}
North America[a]										
Mature females	500	0.0	Pasture/Range	3.3	0.0	80%	60%	6.5%	36%	76
Mature males	800	0.0	Pasture/Range	0.0	0.0	0%	60%	6.5%	2%	81
Calves on milk	100	0.9	Pasture/Range	0.0	0.0	0%	NA	0.0%	16%	0
Calves on forage	185	0.9	Pasture/Range	0.0	0.0	0%	65%	6.5%	8%	48
Growing heifers/steers	265	0.7	Pasture/Range	0.0	0.0	0%	65%	6.5%	17%	55
Replacement/growing	375	0.4	Pasture/Range	0.0	0.0	0%	60%	6.5%	11%	66
Feedlot cattle	415	1.3	Stall fed	0.0	0.0	0%	75%	3.0%	11%	33
Western Europe										
Mature males	600	0.0	Pasture/Range	0.0	0.0	0%	60%	6.5%	22%	66
Replacement/growing	400	0.4	Pasture/Range	0.0	0.0	0%	60%	6.5%	54%	73
Calves on milk	230	0.3	Pasture/Range	0.0	0.0	0%	65%	0.0%	15%	0
Calves on forage	230	0.3	Pasture/Range	0.0	0.0	0%	65%	6.5%	8%	35
Eastern Europe[b]										
Mature females	500	0.0	Pasture/Range	3.3	0.0	67%	60%	6.5%	30%	75
Mature males	600	0.0	Pasture/Range	0.0	0.0	0%	60%	6.5%	22%	66
Young	230	0.4	Pasture/Range	0.0	0.0	0%	60%	6.5%	48%	45
Oceania[c]										
Mature females	400	0.0	Pasture/Range	2.4	0.0	67%	55%	6.5 %	51%	71
Mature males	450	0.0	Pasture/Range	0.0	0.0	0%	55%	6.5%	11%	61
Young	200	0.3	Pasture/Range	0.0	0.0	0%	55%	6.5%	38%	46

[a] Based on estimates for the United States; . [b] Based on estimates for the former USSR; [c] Based on average estimate for region.

TABLE 10A.2 (CONTINUED)
DATA FOR ESTIMATING TIER 1 ENTERIC FERMENTATION CH_4 EMISSION FACTORS FOR OTHER CATTLE IN TABLE 10.11

Subcategory	Weight, kg	Weight gain, kg day^{-1}	Feeding situation	Milk, kg day^{-1}	Work, hr day^{-1}	%Pregnant	Digestibility of feed (DE%)	CH_4 conversion factor (Y_m)	Day weighted population mix %	Emission factors, kg CH_4 head^{-1} yr^{-1}
Latin America[d]										
Mature females	400	0.0	Large areas	1.1	0.0	67%	60%	6.5%	37%	64
Mature males	450	0.0	Large areas	0.0	0.0	0%	60%	6.5%	6%	61
Young	230	0.3	Large areas	0.0	0.0	0%	60%	6.5%	58%	49
Asia[e]										
Mature females- Farming	325	0.0	Stall fed	1.1	0.55	33%	55%	6.5%	27%	50
Mature females- Grazing	300	0.0	Pasture/Range	1.1	0.00	50%	60%	6.5%	9%	46
Mature males-Farming	450	0.0	Stall fed	0.0	1.37	0%	55%	6.5%	24%	59
Mature males-Grazing	400	0.0	Pasture/Range	0.0	0.00	0%	60%	6.5%	8%	48
Young	200	0.2	Pasture/Range	0.0	0.00	0%	60%	6.5%	32%	36
Africa										
Mature females	200	0.0	Stall fed	0.3	0.55	33%	55%	6.5%	13%	32
Draft bullocks	275	0.0	Stall fed	0.0	1.37	0%	55%	6.5%	13%	41
Mature females- Grazing	200	0.0	Large areas	0.3	0.00	33%	55%	6.5%	6%	41
Bulls- Grazing	275	0.0	Large areas	0.0	0.00	0%	55%	6.5%	25%	49
Young	75	0.1	Pasture/Range	0.0	0.00	0%	60%	6.5%	44%	16
Indian Subcontinent[f]										
Mature females	125	0.0	Stall fed	0.6	0.00	33%	50%	6.5%	40%	28
Mature males	200	0.0	Stall fed	0.0	2.74	0%	50%	6.5%	10%	42
Young	80	0.1	Stall fed	0.0	0.00	0%	50%	6.5%	50%	23

[d] Based on estimates for the Brazil.; [e] Based on estimates for the China.; [f] Based on estimates for India; Source: Gibbs and Johnson (1993)

TABLE 10A.3
DATA FOR ESTIMATING TIER 1 ENTERIC FERMENTATION CH_4 EMISSION FACTORS FOR BUFFALO

Subcategory	Weight, kg	Weight gain, kg day^{-1}	Feeding situation	Milk, kg day^{-1}	Work, hr day^{-1}	%Preg-nant	Digestibility of feed (DE%)	CH_4 conversion factor (Y_m)	Day weighed population mix %	Emissions factors, kg CH_4 head^{-1} yr^{-1}
Indian Subcontinent[a]										
Adult males	350 - 550	0.00	Stall fed	0.00	1.37	0%	55%	6.5%	14%	55 - 77
Adult females	250 - 450	0.00	Stall fed	2.70	0.55	33%	55%	6.5%	40%	57 - 80
Young	100 - 300	0.15	Stall fed	0.00	0.00	0%	55%	6.5%	46%	23 - 50
Other Countries[b]										
Adult males	350 - 550	0.00	Stall fed	0.00	1.37	0%	55%	6.5%	45%	55 - 77
Adult females	250 - 450	0.00	Stall fed	0.00	0.55	25%	55%	6.5%	45%	45 - 67
Young	100 - 300	0.15	Stall fed	0.15	0.00	0%	55%	6.5%	10%	23 - 50

[a] Based on estimates for India.
[b] Based on estimates for China.
Source: Gibbs and Johnson (1993).

Annex V: Tool for estimation of emissions due to displacement of grazing as part of SGM methodology

1. Applicability, assumptions and units

Applicability

1. If the grazing animals are already in a zero-grazing system or are moved to a zero-grazing system, then the method outlined in the CDM AR tool shall be applied.
2. If grazing animals are displaced to identified forest land, then the CDM AR tool shall be applied.
3. If the grazing animals are displaced to identified cropland then the CDM AR tool shall be applied.
4. If the grazing animals are displaced to identified grassland, then the CDM AR tool shall be applied.
5. This tool can be used to estimate leakage attributable to displacement of grazing activities to unidentified grassland caused by implementation of improved grassland management project activities.
6. Project proponents must justify the assumption that unidentified lands are grasslands, rather than forest lands. Such justification may be based on evidence that there is no forest land within the radius possibly affected by displacement of grazing activities, or evidence that forest lands are not used for livestock grazing in the production system.

Assumptions

1. Following the CDM AR tool, it is assumed that if grazing animals are sold to an entity not involved in the improved grassland management project activities, or if animals are slaughtered, then there is no leakage due to grazing displacement.
2. Following applicability conditions 5 and 6, it is assumed that the unidentified grasslands are already grazed and that displacement of grazing to unidentified grasslands leads to degradation of those grasslands, thus causing GHG emissions. Soil carbon stocks are the largest carbon pool in grasslands[9], and overgrazing results in emission of carbon from the soil carbon pool into the atmosphere.

Units and Variables

Units: Because the grasslands to which livestock are displaced are unidentified, the total land area affected by or potentially affected by displacement cannot be identified. Therefore, the unit for calculating leakage is the animal unit month (AUM). AUM may be calculated with reference to any standard animal unit, e.g. Livestock Unit (LU), Tropical Livestock Unit (TLU), Animal Unit (AU), Sheep Unit (SU) etc, where local or national standards or literature values can be used to create equivalence between the dry matter intake requirements of different types and classes of animals. One AUM indicates the dry matter intake requirements for one standard animal unit over a one month period.

$$AUM = DMI_{daily,ref} \times 30 \qquad (1)$$

where

$DMI_{daily,ref}$ dry matter intake requirement of the reference type and class of animal, kg

[9] Scholes & Hall 1996. The carbon budget of tropical savannahs, woodlands and grasslands. In Global Change, effects on coniferous forests and grasslands (ed A Breymeyer et al) SCOPE 56. Pp 69-100. John Wiley Chichester.

$DMI_{daily,ref}$ may be taken from literature values, national standards or local measurements, or calculated using IPCC default data. The same type and class of animal must be used as the reference unit in all calculations using this tool.

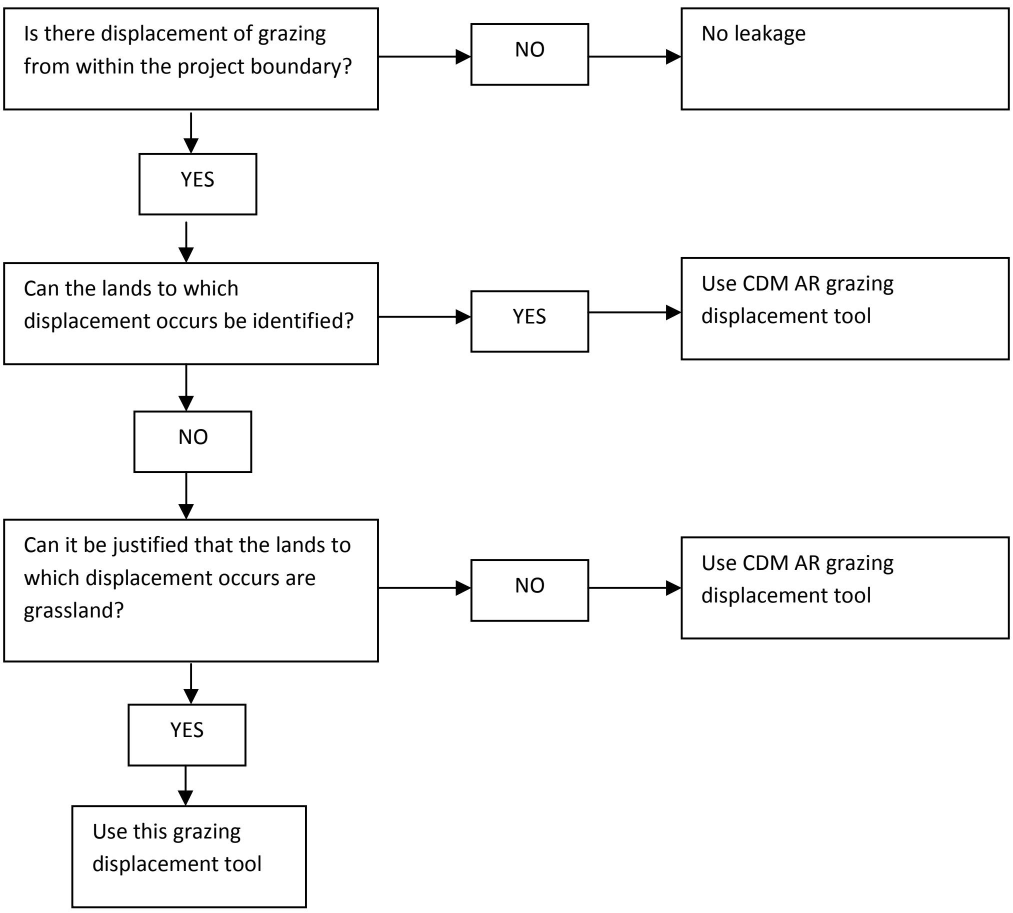
Variables:

The variable to be calculated is the percentage change in net displacement of grazing livestock (measured in AUM) from the project boundary between the baseline and the with-project scenario, $L_{ea,ep,t}$, which can only take non-negative values. Where the calculated value is negative, it is assumed that $L_{ea,ep,t} = 0$.

2. Procedure

STEP 1: DETERMINE APPLICABILITY OF THE TOOL

The applicability of this tool can be determined following the decision tree presented below. PDDs must contain justification for the assumption that unidentified lands are grasslands, and present supporting evidence. Where this tool is not applicable, or justification cannot be made, the CDM AR grazing displacement leakage tool shall be used.[10]



[10] ar-am-tool-15-v1

STEP 2: ESTIMATION OF DISPLACEMENT OF GRAZING ACTIVITIES TO UNIDENTIFIED GRASSLANDS

STEP 2.1 Calculate baseline grazing activity outside the project boundary by project participants

Calculation of livestock grazing activity by project participants outside the project boundary in the baseline scenario should be based on historical data, and shall be calculated as follows:

$$NGD_{baseline,t} = PPO_{baseline,t} - NPI_{baseline,t} \quad (2)$$

Where,

$NGD_{baseline,t}$	Net displacement of livestock grazing activities (AUM) in year *t* in the baseline
$PPO_{baseline,t}$	Total livestock units (AUM) of project participants grazing outside the project boundary in year *t* in the baseline
$NPI_{baseline,t}$	Total livestock units (AUM) owned by entities outside the project boundary grazing inside the project boundary in year *t*

$NGD_{baseline,t}$, $PPO_{baseline,t}$, and $NPI_{baseline,t}$ are expressed in animal unit months.

STEP 2.2 Calculate with-project grazing activity outside the project boundary

Ex-ante estimates of livestock grazing activity outside the project boundary shall be calculated as follows:

$$NGD_{project,t} = PPO_{project,t} - NPI_{project,t} \quad (3)$$

Where,

$NGD_{project,t}$	Net displacement of livestock grazing activities (AUM) in year *t* in the with-project scenario
$PPO_{project,t}$	total livestock units (AUM) of project participants grazing outside the project boundary in year *t* in the with-project scenario
$NPI_{project,t}$	total livestock units (AUM) owned by entities outside the project boundary grazing inside the project boundary in year *t* in the with-project scenario

and $NGD_{project,t}$, $PPO_{project,t}$ and $NPI_{project,t}$ are expressed in animal unit months.

STEP 2.3 Calculate leakage due to displacement of grazing by project activities

Leakage due to displacement of livestock grazing attributed to the project activities shall be calculated as:

$$L_{project,t} = (NGD_{project,t} - NGD_{baseline,t}) / NGD_{baseline,t} \quad (4)$$

Where,

$L_{project,t}$	leakage caused by net displacement of grazing activity in year *t* due to implementation of project activities, expressed as a percentage of baseline net displacement of grazing activity.
$NGD_{project,t}$	Net displacement of livestock grazing activities (AUM) in year *t* in the with-project scenario, expressed in animal unit months
$NGD_{baseline,t}$	Net displacement of livestock grazing activities (AUM) in year *t* in the baseline, expressed in animal unit months.

STEP 3 Ex ante discounting

If $L_{project,t}$ is negative, then it shall be assumed that $L_{ea,t} = 0$

where

$L_{ea,t}$	*Ex-ante* estimate of leakage caused by displacement of grazing activities in year *t* due to implementation of project activities.

If $L_{project,t}$ is between 0% and 50% then, $L_{ea,t} = L_{project,t}$, and the same percentage shall be deducted from the *ex-ante* estimate of project GHG emission reductions net of project emissions in year *t*, i.e. *ex-ante* estimated project emission reductions = $(Project_{removals_{ex-ante}} - Project_{emissions_{ex-ante}}) \times (1 - L_{ea,t})$.

If $L_{project,t}$ is >50%, the project shall not be eligible to use this methodology.

STEP 4 Ex-post discounting

Where leakage due to grazing displacement to unidentified grasslands is likely to occur, the PDD will include a leakage management plan. The leakage management plan will include plans for monitoring displacement of livestock ($NGD_{project,t,ep}$) in order for *ex post* estimates of displacement to be made, where,

$NGD_{project,t,ep}$	*ex post* estimate of net displacement of livestock grazing activities (AUM) in year *t* due to implementation of project activities.

The *ex post* estimate of leakage, $L_{ea,t}$ shall be calculated as:

$$L_{ea,t} = (NGD_{project,t,ep} - NGD_{baseline,t}) / NGD_{baseline,t} \quad (5)$$

If $L_{ea,t}$ is negative, then it is assumed that no leakage has taken place and thus by default $L_{ea,t}$ = 0. If $L_{ea,t}$ is between 0% and 50%, then the same percentage of GHG emission reductions net of project emissions will be deducted for period t, i.e. Ex post project verified emission reductions = $(Project_{removals} - Project_{emissions}) \times (1 - L_{ea,t}) \times (1 - L_{ea,t})$.

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10 REFERENCES AND OTHER INFORMATION

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