VCS | VERIFIED CARBON STANDARD

A Global Benchmark for Carbon

Approved VCS Methodology

Module VMD0040

Version 1.0, 22 April 2014

Sectoral Scope 14

Leakage from Displacement of Grazing Activities

Methodology developed by:

Food and Agriculture Organization of the United Nations

Methodology prepared by:

World Agroforestry Center

UNIQUE forestry and land use

Northwest Institute of Plateau Biology, Chinese Academy of Sciences

Table of Contents

ACKNOWLEDGEMENTS

This methodology was developed by the following contributors:

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

1 SOURCES

The following have informed the development of this module:

- CDM *A/R methodological tool Estimation of GHG Emissions Related to Displacement of Grazing Activities in A/R CDM Project Activity*
- CDM *Guidelines for Sampling and Surveys for CDM Project Activities and Programme of Activities*
- VCS methodology module *VMD0032 Estimation of Emissions from Activity-shifting Leakage*

2 SUMMARY DESCRIPTION OF THE MODULE

This module is applicable to the estimation of activity shifting leakage in projects where there may be displacement of grazing activity from the project area in a project adopting Sustainable Grassland Management (SGM) practices. Displacement of grazing outside the project area is likely to cause an increase in livestock GHG emissions outside the project area, and may cause a decrease in some carbon pools (eg, due to the effects of overgrazing). This module provides step-wise procedures to determine whether the land to which grazing will be relocated are identified or unidentified, and specifies procedures for the ex-ante and ex-post estimation of GHG emissions due to leakage in identified and unidentified grasslands, forests and/or croplands to which livestock may be relocated.

This module is referenced by, and is part of, VCS methodology *VM0026 Sustainable Grassland Management.*

3 DEFINITIONS

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

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

Forest Land
Land that meets the forest definitions as defined by the Designated National Authority (DNA) of the project host country. If there is no national forest definition available, the FAO forest definition must be used[1]

Grazing Agent
A person or organization responsible for decision-making regarding grazing management

[1] Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010).

Grazing Displacement
The relocation of livestock from within the project area to outside the project area after the project start date. If the livestock are transported directly to a slaughter house after leaving the project area, this is not considered grazing displacement

Non-Project Participant
A grazing agent whose livestock grazed in the project area prior to project implementation but who is not designated as a project participant

Project Participant
A grazing agent who has agreed to take part in implementation of project activities as a project participant

Reference Region
The smallest territorial administrative division encompassing all areas of land included in the sustainable grassland management project activity for which data on land cover are publicly available[2]

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

Zero-grazing system
A production system in which livestock are permanently housed and do not graze, and forage is brought to the animals

4 APPLICABILITY CONDITIONS

This module is applicable to the estimation of activity shifting leakage in projects where there may be displacement of grazing activity from within the project area of a project adopting Sustainable Grassland Management practices to an area outside the project area.

This module is applicable under the following condition:

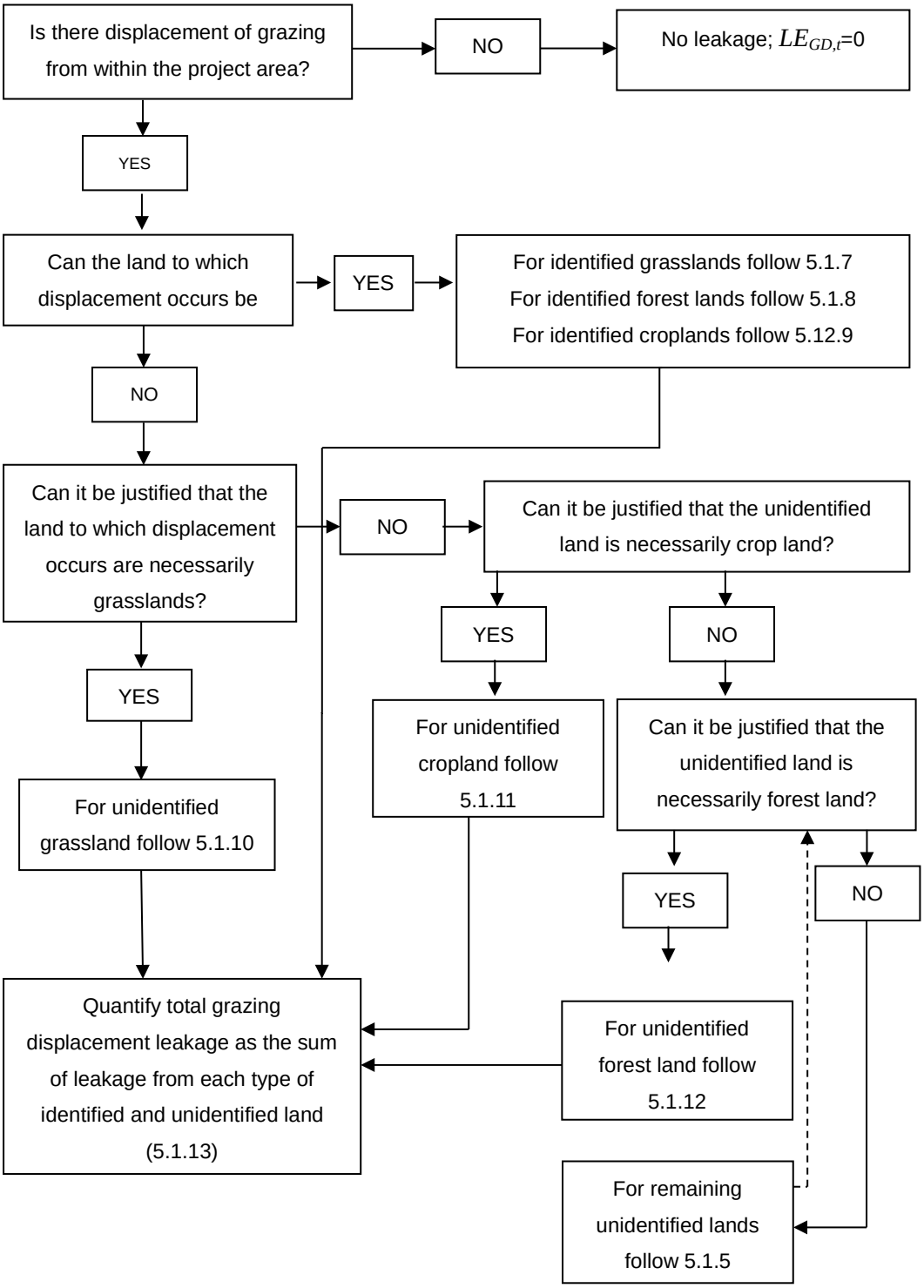
- The project area is subject to livestock grazing in the baseline scenario.

5 PROCEDURES

This module specifies procedures for the assessment and quantification of leakage emissions due to grazing displacement, procedures for monitoring activities causing leakage emissions, and procedures for quantification of leakage emissions due to grazing displacement. Procedures for the assessment are summarized in Figure 1. Note that in this module leakage emissions are denoted by the parameter $LE_{GD,t}$.

[2] The use of this term in this module is distinct from the use of this term in relation to any REDD methodologies.

Figure 1: Decision-Tree to Identify Procedures for Estimating Leakage Emissions



5.1 Assessment of Grazing Displacement

5.1.1 Assess whether Grazing Displacement Takes Place

Project proponents must identify whether adoption of the project activities involves planned displacement of livestock from within the project area or is likely to cause displacement of livestock grazing from within the project area that is measurable and attributable to the adoption of sustainable grazing management practices within the project area. If there is likely to be displacement of grazing activity, then proceed to Section 5.1.2. If there is no displacement of grazing activity, then there is no leakage due to grazing displacement, the value of $LE_{GD,t}$ = 0.

5.1.2 Survey of Grazing Displacement and Relocation Plans

A survey must be conducted of all grazing agents whose livestock graze in the project area prior to the project start date. The period covered by this survey must be consistent with the baseline period used to quantify baseline emissions within the project area (ie, covering the five year period prior to the project start date, or if management records for this period are unavailable, at a minimum covering the one year prior to the project start date). This survey must cover a full census or representative sample of project participants and project non-participants whose livestock graze in the project area during the baseline period covered by the survey. Where sample surveys are used, sampling approaches must enable estimation of the sample mean within a 95 percent confidence interval to a precision of 15 percent. For both types of grazing agent, the survey must quantify the number and type of livestock and the duration of each year that these livestock graze in the project area. The survey must additionally collect data on the number and type of livestock, and duration, that livestock under the control of project participants graze outside the project area during the period covered by the survey. For both types of grazing agent, the survey must also collect information on intended location of grazing after implementation of the project.

5.1.3 Prepare a Grazing Displacement Management Plan

On the basis of the survey of grazing displacement and relocation plans, prepare a grazing displacement management plan. The grazing displacement management plan must record planned grazing activities for all livestock that are to be relocated to lands outside the project area and that are under the control of project participants. The grazing displacement management plan must also record planned grazing activities for livestock under the control of agents who are not project participants but whose livestock grazed inside the project area in the baseline and whose livestock will not graze inside the project area after project implementation begins. Where grazing plans for project non-participants are not available, the future location of grazing must be listed as *unidentified*. For both types of agent, the grazing displacement management plan must record for the years after the project start date, the following data:

- The identity of each grazing agent;
- The number and type of livestock to be relocated;

- The number of days each year which they will graze outside the project area (measured in days, or the whole year if appropriate);
- The location and area in hectares of each land parcel to which grazing will be relocated;
- A unique identifier code (where applicable) for each land parcel to which grazing will be relocated;
- The type of land (grassland, forest land, cropland) of each parcel to which grazing will be relocated, and where appropriate note the status (eg, degradation level) of the lands to which grazing will be relocated; and
- Any planned actions to avoid loss of above- or belowground carbon pools on the land parcels to which grazing will be relocated.

There may be situations in which project participants are not able to provide full and complete details on planned grazing activities outside the project area. For example, the specific land parcels available for use by project participants may change from year to year. If such situations occur, at a minimum the grazing displacement management plan must record the number and type of livestock to be relocated and the type of land (grassland, forest land, cropland) to which grazing is planned to be displaced. In this case, the type of land (grassland, forest land, cropland) to which grazing may be displaced must be categorized as *unidentified grassland*, *unidentified forest land* or *unidentified cropland* following the application of procedures outlined in Sections 5.1.4 and 5.1.5.

There may be situations in which the planned relocation of grazing activities cannot be identified for livestock under the control of non-project participants whose livestock grazed inside the project area in the baseline. For example the specific land parcels available for use outside the project area may change from year to year, or if the non-project participant may not reside close to the project area and cannot be contacted during the survey at reasonable cost. If such situations occur, the grazing displacement management plan must record the number and type of livestock to be relocated and record the type of land as unidentified, and follow Sections 5.1.4 and 5.1.5 to determine the type of unidentified land.

For all grazing agents who could not be interviewed in the grazing displacement survey, alternative information sources must be sought to record in the grazing displacement management plan an estimate of the number and type of livestock to be relocated and record the land as ‘unidentified’, and the type of unidentified land to which livestock may be displaced must be determined by following Sections 5.1.4 and 5.1.5.

5.1.4 Determine whether Lands to which Livestock are Displaced are Identified or Unidentified

The land to which livestock grazing activity is displaced must be categorized as *identified* if either of the following conditions are met:

- The geographical location outside the project area to which livestock will be relocated is known prior to relocation by project participants or non-project participants is recorded in the grazing displacement management plan; or
- Livestock are in a zero-grazing system prior to the start of project activities and will

stay in a zero-grazing system after displacement from within the project area.

The land to which livestock grazing activity is displaced must be categorized as *unidentified* if both of the following conditions are met:

- The grazing displacement management plan does not record the geographic location to which livestock under the control of project participants or non-project participants will be relocated; and,
- The process of identifying the specific land areas to which livestock will be relocated would be either logistically not feasible or not feasible at reasonable cost (eg, the location of grazing displacement is not known by the grazing agent themselves or because project non-participants are scattered over wide distances and not contactable at reasonable cost).

For unidentified land, assessment procedures mandate the use of conservative assumptions that do not underestimate the effects of grazing displacement on carbon stocks in unidentified lands, and in the case of land that remains unidentified after monitoring begins, conservative assumptions that do not underestimate leakage emissions caused by grazing displacement must also be used.

5.1.5 Define the Type of Land to which Grazing will be Relocated

For land that in Section 5.1.4 was categorized as *identified*, identify whether the land to which grazing will be relocated is:

- Identified grassland;
- Identified forest land; or
- Identified cropland.

Definitions of these land use categories are given in Section 3 of this module and VCS *Program Definitions*.

If in Section 5.1.4 the land to which grazing will be relocated has been categorized as *unidentified*, the project proponent must provide justification to demonstrate that (eg, due to the nature of the production system) the land to which livestock will be relocated is grassland, cropland or forest land. Based on the justifications, the unidentified lands must be categorized as:

- Unidentified grassland;
- Unidentified forest land; or
- Unidentified cropland.

If the lands remain unidentified but the project proponent cannot justify that the lands to which livestock will be displaced either necessarily grassland, cropland or forest land, then the project proponent must assume that the land to which livestock are likely to be displaced is *unidentified forest land* in the smallest territorial administrative division encompassing all areas of land included in the SGM project activity for which data on land cover are publicly available. The territory identified is referred in this module as the *reference region*. Satellite images, remote sensing data or other land use or land cover data produced by agencies of

the host country government may be used to characterize forest land in the reference region. *Unidentified forest land* in the reference region must be characterized on the basis of the area-weighted average of forest types in the reference region. For example, if within the reference region forest type A covers 40 percent of total forest land and forest type B covers 60 percent of total forest land, then 'unidentified forest land' in the reference region must be characterized as the area-weighted average of forest types A and B in the reference region.

For a single project, it is possible that the land to which grazing is displaced includes both identified and unidentified lands, and grassland, forest land and/or cropland. For each type of land determined, the appropriate procedures in Section 5.2.1 must be followed.

5.2 Estimation of Emissions

If the identified land to which grazing will be relocated is in a different country from the country where the sustainable grassland management project is implemented, GHG emissions from displacement of grazing activity do not need to be quantified. If any lands to which grazing will be displaced are 'unidentified', it is not permissible to assume that unidentified lands are in another country.

If the land to which grazing will be relocated is in the same country as the country where the sustainable grassland management project is implemented the quantification of emission must follow the procedures described below. For all land parcels that are identified grassland, quantification of emissions must follow the procedures outlined in Section 5.2.1. For all land parcels that are identified forest land, quantification of emissions must follow the procedures outlined in Section 5.2.2. For all land parcels that are identified cropland, quantification of emissions must follow the procedures outlined in Section 5.2.3. For all land parcels that are unidentified grassland, quantification of emissions must follow the procedures outlined in Section 5.2.4. For all land parcels that are unidentified cropland, quantification of emissions must follow the procedures outlined in Section 5.2.5. For all land parcels that are unidentified forest land, quantification of emissions must follow the procedures outlined in Section 5.2.6. The sum of grazing displacement leakage emissions from all types of land to which grazing is relocated is calculated in Section 5.2.7.

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

5.2.1 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Identified Grasslands

Step 1: Assess the risk of soil carbon loss

For each parcel of identified grassland, assess whether it is plausible that relocation of grazing activities to that parcel may lead to overgrazing and may cause loss of soil carbon stocks. Soil carbon loss from overgrazing of identified grassland must be quantified when

more than 50 percent of available biomass is consumed in a given year by livestock grazing on the parcel of land.[3]

The following procedures must be used in assessing whether more than 50 percent of available biomass is consumed in a given year by livestock grazing on the parcel of land:

Step 1a: Identify and estimate the area (ha) of each parcel *k* of identified grassland to which livestock grazing will be displaced in each year *t* ($Area_{GID,k,t}$).

Step 1b: Calculate for each parcel (*k*) to which grazing will be relocated the aboveground biomass available for sustainable grazing (ie, assuming 50 percent of biomass is not removed) using:

$$DMI_{GID,k,t} = \left(ANPP_{GID,k,t} \times Area_{GID,k,t}\right) \times 0.5 \quad (1)$$

Where:

$DMI_{GID,k,t}$	=	Biomass available to support sustainable grazing in identified grassland parcel *k* in year *t* (kg)
$ANPP_{GID,k,t}$	=	Aboveground net primary production in parcel *k* of identified grassland to which grazing activities will be relocated in year *t* (kg/ha)
$Area_{GID,k,t}$	=	Area of parcel *k* of identified grassland to which grazing activities will be relocated in year *t* (ha)
k	=	Index of each parcel of identified grassland to which grazing activities will be relocated

Step 1c: Estimate the total population of each type of livestock that will be grazing on each parcel of identified grassland. This should include the population that is recorded in the grazing displacement management plan as planned to be displaced to each parcel, and (if relevant) the population of livestock that were already grazing in each parcel prior to implementation of the project:

$$P_{GID\_tot,k,t} = \sum_{l=1}^{L} \left(P_{GID,l,k,t} + P_{l,GID\_prior,l,k,t}\right) \quad (2)$$

Where:

$P_{GID\_tot,k,t}$	=	Total population of all types of livestock that will be grazing in identified grassland parcel *k* in each year *t* (head)
$P_{GID,l,k,t}$	=	Population of each type of livestock *l* that will be displaced to identified grassland parcel *k* in year *t* (head)
$P_{GID\_prior,l,k,t}$	=	Population of each type of livestock *l* that were already grazing prior to implementation of the project in identified grassland parcel *k* in year *t* (head)
l	=	Index of grazing livestock types

Step 1d: Calculate the total biomass consumption by all livestock that will be grazing on each parcel of identified grassland:

$$BCD_{GID,tot,k,t} = P_{GID,tot,k,t} \times \sum_{l=1}^{L} DMI_{day,l} \times Days_{GID,l,k,t} \quad (3)$$

[3] While this level of biomass removal will not lead to SOC loss in all grassland types (eg, see McSherry and Ritchie 2013), it is a conservative assumption.

Where:

$\mathrm{BCD_{GID,tot,k,t}}$	=	Total biomass consumption demand of all livestock of all types grazing on parcel *k* in year *t* (kg)
$P_{GID,l,k,t}$	=	Population of each type of livestock *l* that will be displaced to identified grassland parcel *k* in year *t* (head)
$\mathrm{DMI_{day,l}}$	=	Daily dry matter intake requirements for each livestock type *l* (kg dm/(head*day))
$\mathrm{Days_{GID,l,k,t}}$	=	Days in year *t* that livestock of each type *l* will be grazing on parcel *k* (days)

Step 1e: Calculate for each parcel *k* the proportion of available biomass ($\mathrm{DMI_{GID,k,t}}$) that is projected to be consumed by the total number of livestock that will be grazing on that parcel ($\mathrm{BCD_{GID,tot,k,t}}$):

$$\mathrm{BCR_{GID,tot,k,t}} = \mathrm{BCD_{GID,tot,k,t}}/\mathrm{DMI_{GID,k,t}} \quad (4)$$

Where:

$\mathrm{BCR_{GID,tot,k,t}}$	=	Biomass consumption ratio in year *t* projected for each parcel of identified grassland *k* (percent)
$\mathrm{BCD_{GID,tot,k,t}}$	=	Total biomass consumption demand of all livestock of all types grazing on parcel *k* in year *t* (kg)
$DMI_{GID,k,t}$	=	Biomass available to support sustainable grazing in identified grassland parcel *k* in year *t* (kg)

For each parcel *k*, if the proportion is ≤1, overgrazing can be estimated to be negligible and leakage emissions from the grassland soil carbon pool need not be accounted for. For each parcel *k*, if the proportion is >1, then soil carbon loss has to be accounted for in the parcel (see 5.2.1 Step 2c below for quantification of change in soil carbon).

Step 2: Estimate leakage emissions due to relocation of grazing activities to identified grassland parcels

For displacement of grazing to identified grassland plots, leakage emissions accounted for include CH_4 emissions due to enteric fermentation of relocated livestock (5.2.1 Step 2a), CH_4 and N_2O emissions from manure deposition on identified grasslands (5.2.1 Step 2b), and for all identified grassland parcels where $\mathrm{BCD_{GID,tot,k,t}}$ >1, CO_2 emissions due to loss of soil carbon (5.2.1 Step 2c).

Step 2a: Estimate methane emissions from livestock enteric fermentation

Taking the total population of each type of livestock relocated to identified grasslands, and the total number of days in the year on which each type of livestock is relocated to identified grasslands outside the project area (where neither term includes those livestock that were grazing outside the project area prior to implementation of the project), calculate the leakage emissions due to enteric fermentation by livestock relocated to all identified grasslands outside the project area using:

$$LE_{GID,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{GID,l,t} \times Days_{GID,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (5)$$

Where:

$LE_{GID,CH4_{EF},t}$	=	Leakage emissions in year *t* from enteric fermentation by livestock relocated to identified grasslands (t CO_2e)
$P_{GID,l,t}$	=	Population of each grazing livestock type *l* in year *t* displaced outside the project area to identified grasslands (head)
$\text{Days}_{GID,l,t}$	=	Days in year *t* that livestock of each type of livestock *l* graze outside the project area on identified grasslands (days)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock type *l* per year (kg CH_4/(head*year))
1000	=	Conversion factor for t CH_4 to kg CH_4
365	=	Conversion factor for years to days
l	=	Index of grazing livestock types

Step 2b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure and urine deposition on grassland caused by relocating the livestock to identified grasslands outside the project area using:

$$LE_{GID_{MD},t} = LE_{GID\_N2O_{MD},t} + LE_{GID\_CH4_{MD},t} \quad (6)$$

Where:

$LE_{GID_{MD},t}$	=	Leakage emissions from manure and urine deposited on identified grassland in year *t* (t CO_2e)
$LE_{GID,N2O_{MD},t}$	=	Leakage N_2O emissions from manure and urine deposited on identified grasslands in year *t* (t CO_2e)
$LE_{GID,CH4_{MD},t}$	=	Leakage CH_4 emissions from manure and urine deposited on identified grasslands in year *t* (t CO_2e)

$LE_{GID\_N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using:

$$LE_{GID,N2O_{MD},t} = GWP_{N2O} \times (LE_{GID_D,N2O_{MD},t} + LE_{GID_{ID},N2O_{MD},t}) \quad (7)$$

Where:

$LE_{GID,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine deposited on identified grasslands in year *t* (t CO_2e)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2e/t N_2O)
$LE_{GID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on identified grasslands in year *t* (t N_2O)
$LE_{GID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on identified grasslands in year t (t N_2O)

Leakage direct N_2O emission from manure and urine deposited on identified grasslands ($LE_{GID_D,N2O_{MD},t}$) is calculated using the following Equations 8 and 9. Equation 8 calculates direct N_2O emissions from livestock types classified as cattle (dairy, non-dairy and buffalo), poultry and pigs. Equation 9 calculates direct N_2O emissions .from livestock types classified

as sheep and other animals. These equations must be summed up where both kinds of livestock are present.

$$LE_{GID_D,N2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,GID,t,l1} \times EF_{3,PRP,CPP} \times \frac{44}{28} \quad (8)$$

and/or

$$LE_{GID_D,N2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,GID,t,l2} \times EF_{3,PRP,SO} \times \frac{44}{28} \quad (9)$$

Where:

$LE_{GID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on identified grasslands in year *t* (t N_2O)
$F_{MD,GID,t,l1}$	=	Annual amount of nitrogen in cattle, poultry and pig manure and urine deposited on identified grasslands in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,GID,t,l2}$	=	Annual amount of nitrogen in sheep and other animal manure and urine deposited on identified grasslands in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on grasslands during year *t* (kg N_2O-N/kg N input)
$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on grasslands (kg N_2O-N/kg N input)

$$F_{MD,GID,t,l} = \frac{P_{GID,l,t} \times W_l \times Nex_l \times H_{GID,l,t} \times Days_{GID,l,t} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (10)$$

Where:

$F_{MD,GID,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on identified grasslands in year *t* for livestock of each type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{GID,l,t}$	=	Total population of grazing livestock type *l* in year *t* displaced outside the project area to identified grasslands (head)
W_l	=	Average weight of livestock of each type *l* displaced to identified grasslands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion factor for t livestock mass to kg livestock mass
$H_{GID,l,t}$	=	Average grazing hours per day during grazing season for each type of livestock *l* displaced to identified grassland in year *t* (hours)
24	=	Conversion factor for days to hours
$Days_{GID,l,t}$	=	Grazing days in year *t* for livestock of each type l displaced to identified grasslands (days)
1000_b	=	Conversion factor for t N to kg N
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N deposited on identified grasslands is calculated using:

$$LE_{GID_{ID},N2O_{MD},t} = \sum_{l=1}^{L} F_{MD,GID,l,t} \times Frac_{GAS,MD,l} \times EF_4 \times \frac{44}{28} \quad (11)$$

Where:

$LE_{GID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on identified grasslands in year *t* (t N_2O)
$F_{MD,GID,l,t}$	=	Annual amount of nitrogen in manure and urine deposited on identified grasslands in year *t* for livestock of each type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
EF_4	=	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces (kg N_2O-N/(kg NH3-N + NOx-N volatilized))

CH_4 emission from manure management due to displacement of livestock to identified grasslands is calculated using:

$$LE_{GID,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{GID,l,t} \times H_{GID,l,t} \times Days_{GID,l,t}}{24 \times 365 \times 1000} \quad (12)$$

Where:

$LE_{GID,CH4_{MD},t}$	=	Leakage CH_4 emissions from manure and urine deposited on identified grasslands in year *t* (t CO_2e)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type *l* in manure management system m (kg CH_4/(head*yr))
$P_{GID,l,t}$	=	Population of livestock type *l* in year *t* displaced to identified grasslands (head)
$H_{GID,l,t}$	=	Average grazing hours per day during grazing season for each type of livestock *l* displaced to identified grassland in year *t* (hours)
$Days_{GID,l,t}$	=	Grazing days in year *t* for livestock of each type *l* displaced to identified grasslands (days)
1000	=	Conversion factor for t CH_4 to kg CH_4

Step 2c: Estimate leakage emissions due to loss of soil carbon

If relocation of livestock to any parcel *k* does not result in overgrazing ($BCR_{GID\_tot,k,t} \leq 1$), $LE_{OG,GID,t} = 0$.

For each identified grassland parcel where $BCR_{GID\_tot,k,t}$>1, t CO_2 is emitted due to soil carbon loss. Leakage emissions per year can be estimated as follows:

$$LE_{OG,GID,k,t} = \frac{Area_{GID,k,t} \times SOC_{REF,k} \times (1 - F_{MG,SD}) \times \frac{44}{12}}{D_{GID,SOC}} \quad (13)$$

Where:

$LE_{OG,GID,k,t}$	=	Leakage emissions from parcel *k* due to overgrazing in year *t* (t CO_2e)
$Area_{GID,k,t}$	=	Area of each parcel of identified grassland *k* where overgrazing is estimated to occur in year *t* (ha)

$SOC_{REF,k}$	=	Reference soil organic carbon stocks for identified grassland parcel *k* (t C/ha)
$F_{MG,SD}$	=	Relative stock change factor for severely degraded grassland (dimensionless)
$D_{GID,SOC}$	=	Years required for overgrazing to change carbon stocks in identified grasslands from their current state to the status of severely degraded carbon stocks (years)

$$LE_{OG,GID,t} = \sum_{k}^{K} LE_{OG,GID,k,t} \quad (14)$$

Where:

$LE_{OG,GID,k,t}$	=	Leakage emissions from parcel *k* due to overgrazing in year *t* (t CO_2e)
$LE_{OG,GID,t}$	=	Leakage emissions due to overgrazing in all parcels in year *t* (t CO_2e)

Step 3: Calculate total leakage emissions from relocation of grazing to identified grasslands

Total leakage emissions from displacement of grazing to identified grasslands must be calculated as:

$$LE_{GID,t} = LE_{OG,GID,t} + LE_{GID,CH4_{EF},t} + LE_{GID_{MD},t} \quad (15)$$

Where:

$LE_{GID,t}$	=	Leakage due to displacement of livestock to identified grasslands in year *t* (t CO_2e)
$LE_{OG,GID,t}$	=	Leakage due to soil carbon loss resulting from overgrazing due to displacement of livestock to identified grasslands in year *t* (t CO_2e)
$LE_{GID,CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to identified grasslands in year *t* (t CO_2e)
$LE_{GID_{MD},t}$	=	Leakage due to N_2O and CH_4 emissions in manure and urine deposited on grasslands by livestock displaced to identified grasslands in year *t* (t CO_2e)

5.2.2 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Identified Forest Lands

This step estimates leakage emissions due to displacement of livestock to identified forest land (LE_{FID}).

Step 1: Assess risk of biomass loss and emissions due to biomass burning

Relocation of grazing activities to forest land may cause deforestation and/or forest degradation. Forest clearance may also involve burning of woody biomass. The project proponent must justify whether the planned relocation of livestock to forest land will involve partial or full clearance of forest and whether felled biomass will be burned. Support for justifications provided may include descriptions of prior examples of relocation of livestock or grazing in forest land by the same grazing agent or by similar grazing agents in the project region. Where relocation of livestock to identified forest land will involve full or partial deforestation and / or burning of forest biomass, the procedures in 5.2.2 Steps 2c and Step

2d must be followed to estimate emissions due to deforestation/degradation and burning of forest biomass.

Step 2: Estimate leakage emissions due to relocation of grazing activities to identified forest lands

Leakage emissions due to relocation of grazing activities to identified forest lands include CH_4 emissions due to enteric fermentation (5.2.2 Step 2a), CH_4 and N_2O emissions due to manure management (5.2.2 Step 2b); CO_2 emissions due to biomass loss in deforestation/forest degradation (5.2.2 Step 2c) and CH_4 and N_2O emissions from biomass burning (5.2.2 Step 2d).

Step 2a: Estimate methane emissions from livestock enteric fermentation

Identify the number, sex and types of livestock displaced from the project area to outside the project area. Calculate the leakage emissions due to enteric fermentation outside the project area caused by relocating the livestock to outside the project area using:

$$LE_{FID,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{FID,l,t} \times Days_{FID,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (16)$$

Where:

$LE_{FID,CH4_{EF},t}$	=	CH_4 leakage emissions from enteric fermentation by livestock displaced to identified forest lands in year *t* (t CO_2e)
$P_{FID,l,t}$	=	Population of livestock of each type *l* in year *t* displaced to identified forest lands (head)
$Days_{FID,l,t}$	=	Days in year *t* that livestock of each type *l* will be grazing on identified forest land (days)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock of each type *l* per year *t* (kg CH_4/(ha*year))
l	=	Index of livestock type
1000	=	Conversion for kg to *t*
365	=	Conversion factor for years to days

Step 2b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure management outside the project area caused by relocating the livestock to identified forest lands using:

$$LE_{FID_{MD},t} = LE_{FID,N2O_{MD},t} + LE_{FID,CH4_{MD},t} \quad (17)$$

Where:

$LE_{FID_{MD},t}$	=	Leakage emissions from manure management in identified forest in year *t* (t CO_2e)
$LE_{FID,N2O_{MD},t}$	=	Leakage N_2O emissions from manure and urine deposited on identified forest soils in year *t* (t CO_2e)
$LE_{FID,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine deposited on identified forest soils in year *t* (t CO_2e)

$LE_{FID,N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using the following:

$$LE_{FID,N2O_{MD},t} = GWP_{N2O} \times (LE_{FID_D,N2O_{MD},t} + LE_{FID_{ID},N2O_{MD},t}) \quad (18)$$

Where:

$LE_{FID,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine deposited on identified forest soil in year *t* (t CO_2e)
GWP_{N_2O}	=	Global-warming potential for N_2O (t CO_2e/t N_2O)
$LE_{FID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on identified forest soil in year *t* (t N_2O)
$LE_{FID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on identified forest soil in year *t* (t N_2O)

Leakage direct N_2O emission from manure and urine deposited on identified forest soil ($LE_{FID_D N2O_{MD},t}$) is calculated using:

$$LE_{FID_D,N2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,FID,t,l1} \times EF_{3,PRP,CPP} \times \frac{44}{28} \quad (19)$$

and/or

$$LE_{FID_D,N2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,FID,t,l2} \times EF_{3,PRP,SO} \times \frac{44}{28} \quad (20)$$

Where:

$LE_{FID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on identified forest soil in year *t* (t N_2O)
$F_{MD,FID,t,l1}$	=	Annual amount of nitrogen in cattle, poultry and pig manure and urine deposited on identified forest soil in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,FID,t,l2}$	=	Annual amount of nitrogen in sheep and other animal manure and urine deposited on identified forest soil in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on forest soil (kg N_2O-N/kg N input)
$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on forest soil (kg N_2O-N/kg N input)

$$F_{MD,FID,t,l1or2} = \frac{P_{l,FID,t} \times W_l \times Nex_l \times H_{FID,t} \times Days_{FID,t,l} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (21)$$

Where:

$F_{MD,FID,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on identified forest soil in year t for livestock of each type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{FID,l,t}$	=	Population of livestock of each type *l* displaced to identified forest lands in year *t* (head)
W_l	=	Average weight of livestock *l* displaced to identified forest lands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion factor for nitrogen excretion (kg/t livestock mass) to nitrogen excretion (kg/kg livestock mass)

$H_{FID,l,t}$	=	Average grazing hours per day for each type of livestock displaced to identified forest land in year t (hours)
24	=	Conversion factor for days to hours
$Days_{FID,l,t}$	=	Grazing days in year *t* for livestock of each type *l* displaced to identified forest lands (days)
1000_b	=	Conversion factor for kg to t
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N deposited on identified forest soils is calculated using:

$$LE_{FID_{ID},N2O_{MD},t} = \sum_{l=1}^{L} \mathrm{F_{MD,FID,t,l}} \times Frac_{GAS,MD,l} \times \mathrm{EF_4} \times \frac{44}{28} \quad (22)$$

Where:

$LE_{FID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on identified forest soil in year *t* (t N_2O)
$\mathrm{F_{MD,FID,t,l}}$	=	Annual amount of nitrogen in manure and urine deposited on identified forest soil in year t for livestock of each type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
EF_4	=	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity (kg N_2O-N/(kg NH3-N + NOx-N volatilized))

CH_4 emission from due to manure management from displacement of livestock to identified forest lands is calculated using):

$$LE_{FID,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{FID,l,t} \times H_{FID,l,t} \times Days_{FID,l,t}}{24 \times 365 \times 1000} \quad (23)$$

Where:

$LE_{FID,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine deposited on identified forest soils in year *t* (t CO_2e)
GWP_{CH_4}	=	Global-warming potential for CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type *l* in manure management system *m* (kg CH_4/(head*yr)
$P_{FID,l,t}$	=	Population of livestock of each type *l* displaced to identified forest lands in year *t* (head)
$H_{FID,l,t}$	=	Average grazing hours per day for each type of livestock displaced to identified forest land in year *t* (hours)
$Days_{FID,l,t}$	=	Grazing days in year *t* for livestock of each type *l* displaced to identified forest lands (days)
1000	=	Conversion factor for kg to t

Step 2c: Estimate CO_2 emissions from deforestation and forest degradation

Identify and estimate the area (ha) of forest land in each year in the project scenario to which livestock grazing is planned to be displaced ($Area_{FID,k,t}$), and for each parcel (*k*) of forest land where deforestation or forest degradation is expected to occur, determine the current forest biomass stock ($FB_{FID_{REF},k}$). For each parcel, the equilibrium biomass stock of deforested or degraded forest land after deforestation or degradation ($FB_{FID_{EQ},k}$) must be determined using the procedures described below.

Based on descriptions of prior relocation of grazing activity to forest land or prior examples of forest clearance by the same or similar grazing agents in the project region, a list must be made that presents the possible outcomes for forest biomass stocks remaining at least 5 years after the introduction of grazing activities. Where full clearance of forest is planned or selected as the most likely outcome, the equilibrium biomass stock of deforested forest land after deforestation ($FB_{FID_{EQ},k}$) is 0. Where partial clearance of forest or forest degradation is included in the list of possible outcomes, FB_{FID_EQ} must be determined on the basis of measurements conducted on similar land plots in the project region or studies specific to the region of biomass stocks remaining at least 5 years after the introduction of grazing activities. Where measurements are conducted, a sampling scheme must be used that produces estimates of the biomass stocks remaining at least five years after the introduction of grazing activities that lead to conservative estimates of leakage emissions. Where cyclical post-displacement land use systems are identified among the list of possible outcomes, a conservative estimate of forest biomass stocks in a single cycle must be determined. For each parcel to which livestock grazing is planned to be displaced, the project proponent must justify which of the possible outcomes is most likely to apply to each parcel, and must justify that the value of FB_{FID_EQ} selected for each parcel gives a conservative estimate of leakage CO_2 emissions due to deforestation or forest degradation following displacement of grazing activities. The justification of which possible outcome is most likely for each site should be based on assessment of a range of factors (eg, the nature of post-displacement livestock production systems and land uses, topography, road access, etc.), which must be determined by the project proponent as representing the main factors influencing post-displacement outcomes in the project region.

Leakage emissions due to deforestation of identified forest lands ($LE_{FID\_CO2,t}$) are calculated using:

$$LE_{FID,CO2,t} = \frac{\sum_k Area_{FID,k} \times (FB_{FID_{REF},k} - FB_{FID_{EQ},k}) \times 0.5 \times \frac{44}{12}}{D_{FID}} \quad (24)$$

Where:

$LE_{FID,CO2,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to identified forest lands in year *t* (t CO_2e)
$Area_{FID,k}$	=	Area of identified forest land in parcel *k* deforested or degraded to feed livestock (ha)
$FB_{FID_{REF},k}$	=	Forest biomass stocks prior to deforestation or degradation of forest land parcel k to which livestock are displaced (t dm/ha)
$FB_{FID_{EQ},k}$	=	Long-term equilibrium biomass stocks of forest land parcel *k* after deforestation or degradation due to livestock displacement (t dm/ha)
0.5	=	IPCC default carbon fraction for woody biomass (t C/t dm)

$44/12$	=	Conversion factor for C to CO_2e (t CO_2e/t C)
D_{FID}	=	Years required for transition from the reference forest biomass stocks to the long-term equilibrium forest biomass stocks (year)

Forest biomass stocks per hectare in each forest parcel *k* prior to relocation of grazing livestock must be estimated using:

$$FB_{FID_{REF},k} = B_{AB,FID,REF,k} \times (1 + R) + B_{Litter,FID,REF,k} + B_{Deadwood,FID,REF,k} \quad (25)$$

Where:

$FB_{FID_{REF},k}$	=	Forest biomass stocks prior to deforestation or degradation of forest land parcel k to which livestock are displaced (t dm/ha)
$B_{AB,FID,REF,k}$	=	Aboveground biomass in forest parcel *k* prior to deforestation (t dm/ha)
R	=	Root-to-shoot ratio (t dm aboveground/t dm belowground)
$B_{Litter,FID.REF,k}$	=	Litter on forest land plot *k* to which livestock are displaced (t dm/ha)
$B_{Deadwood,FID,RE}$	=	Dead wood on forest land parcel *k* to which livestock are displaced (t dm/ha)

Forest biomass stocks per hectare in each forest parcel *k* at least 5 years after relocation of grazing livestock must be estimated as follows:

$$FB_{FID_{EQ},k} = B_{AB,FID,EQ,k} \times (1 + R) + B_{Litter,FID,EQ,k} + B_{Deadwood,FID,EQ,k} \quad (26)$$

Where:

$FB_{FID_{EQ},k}$	=	Long-term equilibrium biomass stocks of forest land parcel *k* after deforestation or degradation due to livestock displacement (t dm/ha)
$B_{AB,FID,EQ,k}$	=	Aboveground biomass in forest parcel *k* at least 5 years after introduction of grazing in identified forest land (t dm/ha)
R	=	Root-to-shoot ratio (t dm aboveground/t dm belowground)
$B_{Litter,FID.EQ,k}$	=	Litter on forest land plot *k* at least 5 years after introduction of grazing in identified forest land (t dm/ha)
$B_{Deadwood,FID,EQ}$	=	Dead wood on forest land parcel *k* at least 5 years after introduction of grazing in identified forest land (t dm/ha)

Step 2d: Estimate GHG emissions from biomass burning

It must be assumed that deforested biomass is burned, either during the forest clearing process or due to fuelwood collection subsequent to deforestation, and CH_4 and N_2O emissions that result can be calculated using the following:

$$LE_{FID_{fire},t} = \left(\left(\frac{\sum_k Area_{FID,k,t} \times M_{BFID,k,t} \times C_f \times EF_{CH4} \times GWP_{CH4}}{1000}\right) + \left(\frac{\sum_k Area_{FID,k,t} \times M_{BFID,k,t} \times C_f \times EF_{N2O} \times GWP_{N2O}}{1000}\right)\right) \div D_{FID,fire} \quad (27)$$

Where:

$LE_{FID_{fire},t}$	=	Leakage due to non-CO_2 emissions from biomass burning resulting from deforestation after displacement of livestock to identified forest lands in year *t* (t CO_2e)
$Area_{FID,k,t}$	=	Area of identified forest land in plot *k* deforested or degraded in year *t* (ha)
$M_{BFID,k,t}$	=	Biomass available for burning in parcel *k* in year *t* of identified forest land to which livestock are displaced (t dm/ha)
C_f	=	Combustion factor (dimensionless)

EF_{CH4}	=	CH_4 emission factor for biomass burning (g CH_4/kg dm burnt)
EF_{N2O}	=	N_2O emission factor for biomass burning (g N_2O/kg dm burnt)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
1000	=	Conversion factor for kg to t
$D_{FID,fire}$	=	Years required for available biomass to be burned (years)

Step C: Calculate total leakage emissions from identified forest lands

Calculate the total leakage emissions from all sources of leakage caused by displacement of grazing to identified forest lands using the following:

$$LE_{FID,t} = LE_{FID,CO2,t+} + LE_{FID,fire,t} + LE_{FID,CH4_{EF},t} + LE_{FID_{MD},t} \quad (28)$$

Where:

$LE_{FID,t}$	=	Leakage due to displacement of livestock to identified forest lands in year *t* (t CO_2e)
$LE_{FID,CO2,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to identified forest lands in year *t* (t CO_2e)
$LE_{FID,fire,t}$	=	Leakage due to non-CO_2 emissions from biomass burning resulting from deforestation after displacement of livestock to identified forest lands in year *t* (t CO_2e)
$LE_{FID,CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to identified forest lands in year *t* (t CO_2e)
$LE_{FID_{MD},t}$	=	Leakage due to N_2O and CH_4 emissions in manure management by livestock displaced to identified forest lands in year *t* (t CO_2e)

5.2.3 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Identified Croplands

Where livestock grazing activity is displaced to cropland, leakage emissions from CH_4 due to enteric fermentation and leakage emissions from CH_4 and N_2O due to manure management of displaced livestock) must be accounted for (see 5.2.3 Steps 2a and 2b). Displacement of livestock to annual croplands is assumed not to cause leakage emissions due to loss of any carbon pool. Displacement of livestock to perennial croplands is assumed to cause leakage emission from CO_2 and non-CO_2 due to loss of perennial tree crops on lands to which livestock are displaced (see 5.2.3 Steps 2c and 2d).

Step 1: Assess risk of perennial tree biomass loss and GHG emissions due to displacement of livestock to croplands containing perennial tree crops

If grazing activities are relocated to identified croplands planted with perennial tree crops, it must be assumed that perennial tree crop biomass is lost. Leakage emissions from loss of perennial tree crops must be estimated following procedures in 5.2.3 Steps 2c and Step 2d.

Step 2: Estimate leakage emissions due to relocation of grazing activities to identified croplands

Step 2a: Estimate methane emissions from livestock enteric fermentation

Identify the number, sex and types of livestock displaced from the project area to annual and perennial croplands outside the project area. Calculate the leakage emissions due to enteric fermentation outside the project area caused by relocating the livestock to croplands outside the project area using:

$$LE_{CID,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{CID,l,t} \times Days_{CID,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (29)$$

Where:

$LE_{CID,CH4_{EF},t}$	=	CH_4 leakage emissions from enteric fermentation of livestock displaced to identified cropland in year *t* (t CO_2e)
$P_{CID,l,t}$	=	Population of grazing livestock of each type *l* displaced to identified croplands in year *t* (head)
l	=	Index of livestock type
$\mathrm{Days}_{CID,l,t}$	=	Days in year *t* that livestock of each type *l* graze on identified croplands in year *t* (days)
$\mathrm{GWP}_{\mathrm{CH4}}$	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock type *l* per year (kg CH_4/(ha*year))

Step 2b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure management outside the project area caused by relocating the livestock to croplands outside the project area. If manure management systems change after livestock are displaced to croplands, project proponents should consult the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to select the most appropriate emission factors for use in the following:

$$LE_{CID_{MD},t} = LE_{CID,N2O_{MD},t} + LE_{CID,CH4_{MD},t} \quad (30)$$

Where:

$LE_{CID_{MD},t}$	=	Leakage emissions from manure management in identified cropland in year *t* (t CO_2e)
$LE_{CID,N2O_{MD},t}$	=	Total leakage N_2O emissions from manure and urine managed in identified croplands in year *t* (t CO_2e)
$LE_{CID,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine managed in identified cropland in year *t* (t CO_2e)

$LE_{CID,N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using:

$$LE_{CID,N2O_{MD},t} = GWP_{N2O} \times (LE_{CID_D,N2O_{MD},t} + LE_{CID_{ID},N2O_{MD},t}) \quad (31)$$

Where:

$LE_{CID,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine managed in identified croplands year *t* (t CO_2e)
$\mathrm{GWP}_{\mathrm{N2O}}$	=	Global Warming Potential of N_2O (t CO_2e/t N_2O)
$LE_{CID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine managed in identified croplands in year *t* (t N_2O)
$LE_{CID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine managed in

identified croplands in year *t* (t N_2O)

Leakage direct N_2O emission from manure and urine managed in identified croplands ($LE_{CID_D,N2O_{MD},t}$) is calculated using:

$$LE_{CID_D,N2O_{MD},t} = \sum_l^L F_{MD,CID,t,l} \times EF_{3.l.m} \times \frac{44}{28} \quad (32)$$

Where:

$LE_{CID_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine managed in identified croplands in year *t* (t N_2O)
$F_{MD,CID,t,l}$	=	Annual amount of nitrogen in livestock manure and urine managed in identified croplands in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,l,m}$	=	N_2O emission factor for each type of livestock *l* in each manure management system *m* (kg N_2O-N/kg N input)

$$F_{MD,CID,t,l} = \frac{P_{CID,l,t} \times W_l \times Nex_l \times H_{CID,l,t} \times Days_{CID,l,t} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (33)$$

Where:

$F_{MD,CID,l,t}$	=	Annual amount of nitrogen in manure and urine managed in croplands in year *t* for livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{CID,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to identified croplands (head)
W_l	=	Average weight of livestock *l* displaced to identified croplands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion for nitrogen excretion (kg/t livestock mass) to nitrogen excretion (kg/kg livestock mass)
$H_{CID,l,t}$	=	Average grazing hours per day for livestock displaced to identified cropland in year *t* (hours)
24	=	Conversion factor for days to hours
$Days_{CID,l,t}$	=	Grazing days in year t for livestock type *l* displaced to identified croplands (days)
1000_b	=	Conversion factor for kg to t
$Frac_{GAS,MD,l}$	=	Fraction of volatilisation from manure and urine deposited by livestock as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N managed in identified croplands is calculated using:

$$LE_{CID_{ID},N2O_{MD},t} = \sum_{l=1}^{L} F_{MD,CID,l,t} \times Frac_{GAS,MD,l} \times EF_4 \times \frac{44}{28} \quad (34)$$

Where:

$LE_{CID_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine managed in identified croplands in year *t* (t N_2O)

$F_{MD,CID,l,t}$	=	Annual amount of nitrogen in manure and urine managed in croplands in year *t* for livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by livestock as NH_3 and NO_x (kg N volatilized/kg of N deposited)
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 NH3-N + NOx-N volatilized))

CH_4 emission from due to manure management after displacement of livestock to identified croplands is calculated using:

$$LE_{CID,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{CID,l,t} \times H_{CID,l,t} \times Days_{CID,l,t}}{24 \times 365 \times 1000} \quad (35)$$

Where:

$LE_{CID,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine managed in identified cropland in year *t* (t CO_2e)
GWP_{CH4}	=	Global Warming Potential of CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type l in manure management system m (kg CH_4/(head*yr))
$P_{CID,l,t}$	=	Population of livestock type *l* in year *t* displaced to identified crop lands (head)
$H_{CID,l,t}$	=	Average grazing hours per day for livestock displaced to identified cropland in year *t* (hours)
$Days_{CID,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to identified croplands (days)
1000	=	Conversion factor for kg to t

Step 2c: Estimate CO_2 emissions from perennial tree crop biomass loss

Identify and measure the area (ha) of perennial crop land in the project scenario to which livestock grazing will be displaced ($Area_{PCID,k,t}$). Croplands with only annual crops must not be included in this area estimate. This module assumes that displacement of grazing livestock to perennial croplands will cause biomass loss, which can be estimated as follows:

$$LE_{PCID,t} = \frac{\sum_k Area_{PCID,k,t} \times B_{PCID,k} \times (1+R) \times 0.5 \times \frac{44}{12}}{D_{PCID}} \quad (36)$$

Where:

$LE_{PCID,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to identified perennial croplands in year *t* (t CO_2e)
$Area_{PCID,k,t}$	=	Area of identified perennial cropland in plot *k* deforested to feed livestock in year *t* (ha)
$B_{PCID,k}$	=	Aboveground biomass of perennial cropland to which livestock are displaced (t dm/ha)
R	=	Root-to-shoot ratio (t dm aboveground/t dm belowground)
0.5	=	IPCC default carbon fraction for woody biomass (t C/t dm)
$44/12$	=	Conversion factor for C to CO_2e (t CO_2e/t C)
D_{PCID}	=	Years required for deforestation of perennial cropland to take place (years)

Emissions due to loss of litter, dead wood and soil carbon on perennial croplands are assumed to be negligible given that prior to relocation of livestock, perennial croplands are typically managed.

Step 2d: Emissions due to burning of perennial tree biomass

It must be assumed that perennial trees in croplands to which livestock are relocated are burned, either during the tree clearing process or due to fuelwood collection subsequent to displacement of grazing, and CH_4 and N_2O emissions that result can be calculated using the following:

$$LE_{PCID,fire,t} = \left(\left(\frac{\sum_k Area_{PCID,k,t} \times M_{BPID,k,t} \times C_f \times EF_{CH4} \times GWP_{CH4}}{1000}\right) + \left(\frac{\sum_k Area_{PCID,k,t} \times M_{BPID,k,t} \times C_f \times EF_{N2O} \times GWP_{N2O}}{1000}\right)\right) \div D_{PC_{fire}} \quad (37)$$

Where:

$LE_{PCID,fire,t}$	=	Leakage due to non-CO_2 emissions from biomass burning after displacement of livestock to identified perennial croplands in year *t* (t CO_2e)
$Area_{PCID,k,t}$	=	Area of identified perennial cropland land in parcel *k* deforested in year *t* (ha)
$M_{BPID,k,t}$	=	Biomass available for burning in parcel *k* of identified perennial cropland in year *t* to which livestock are displaced (t dm/ha)
C_f	=	Combustion factor (dimensionless)
EF_{CH4}	=	CH_4 emission factor for biomass burning (g CH_4/kg dm burnt)
EF_{N2O}	=	N_2O emission factor for biomass burning (g N_2O/kg dm burnt)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
1000	=	Conversion factor for kg to t
$D_{PC,fire}$	=	Years required for available biomass in perennial cropland to be burned (years)

Step 3: Calculated total leakage emissions from identified croplands

Total leakage emissions from identified croplands must be calculated as

$$LE_{CID,t} = LE_{PCID,t} + LE_{CID,CH4_{EF},t} + LE_{CID_{MD},t} + LE_{PCID_{fire},t} \quad (38)$$

Where:

$LE_{CID,t}$	=	Leakage due to displacement of livestock to identified croplands in year *t* (t CO_2e)
$LE_{PCID,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to identified perennial croplands in year *t* (t CO_2e)
$LE_{CID,CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to identified croplands in year t (t CO_2e)
$LE_{CID_{MD},t}$	=	Leakage due to N_2O and CH_4 emissions in manure management by livestock displaced to identified croplands in year *t* (t CO_2e)
$LE_{PCID,fire,t}$	=	Leakage due to non-CO_2 emissions from biomass burning after displacement of livestock to identified perennial croplands in year *t* (t CO_2e)

5.2.4 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Unidentified Grasslands

Estimation of leakage emissions due to grazing displacement to unidentified grasslands must be made using the procedures outlined below.

Step 1: Estimate the area of grassland needed to sustain the population of livestock relocated to unidentified grasslands

$$DMI_{GUI,t} = \sum_{l=1}^{L} \left(\frac{DMI_{day,l} \times P_{GUI,l,t}}{1000} \right) \times Days_{GUI,l,t} \quad (39)$$

Where:

$DMI_{GUI,t}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* relocated to unidentified grasslands in year *t* (t dm)
$DMI_{day,l}$	=	Daily dry matter intake requirement of each type of livestock *l* (kg dm/(head*day))
$P_{GUI,l,t}$	=	Population of livestock of each type relocated to unidentified grasslands in year *t* (head)
$Days_{GUI,l,t}$	=	Days that the population of each type of relocated livestock of type *l* graze in unidentified grassland in year *t* (days)

Project proponents must identify the region and vegetation type(s) to which livestock are most likely to be relocated. The total area of unidentified grassland required to sustain the population of livestock relocated to unidentified grassland is to be calculated as:

$$Area_{GUI,t} = \frac{DMI_{GUI,t}}{ANPP_{GUI,REF}} \quad (40)$$

Where:

$Area_{GUI,t}$	=	Area required to sustain the population of livestock displaced to unidentified grasslands in year *t* (ha)
$DMI_{GUI,t}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* relocated to unidentified grasslands in year *t* (t dm)
$ANPP_{GUI,REF}$	=	Aboveground net primary productivity in the reference region that is the likely location of unidentified grasslands to which livestock are relocated (t dm/ha)

Step 2: Assess the risk of soil carbon loss due to overgrazing in unidentified grasslands

Given the estimated area needed to sustain the livestock population that will be displaced to unidentified grasslands, project proponents must assess the risk that displacement leads to overgrazing in the unidentified grasslands. The default assumption is that relocation to unidentified grasslands will lead to overgrazing. If project proponents can provide documentation demonstrating that that baseline livestock grazing densities in the region to which displacement is most likely to occur are low enough to accommodate the increased population due to grazing displacement without causing consumption to exceed 50 percent of available biomass, or that there is sufficient unutilized grassland in the region to

accommodate the increased population due to grazing displacement without causing consumption to exceed 50 percent of available biomass, then it can be assumed that overgrazing does not occur and leakage due to soil carbon loss does not need to be accounted for. Otherwise, it is assumed that overgrazing will occur, resulting in CO_2 emissions from loss of soil carbon and the project proponent must follow procedures in 5.2.4 Step 3c.

Step 3: Estimate emissions from livestock displacement to unidentified grasslands

Step 3a: Estimate methane emissions from enteric fermentation by livestock displaced to unidentified grasslands

Calculate the leakage emissions due to enteric fermentation by livestock displaced to all unidentified grasslands outside the project area using:

$$LE_{GUI,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{GUI,l,t} \times Days_{GUI,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (41)$$

Where:

$LE_{GUI,CH4_{EF},t}$	=	Leakage emissions in year *t* from enteric fermentation by livestock displaced to unidentified grasslands (t CO_2e)
$P_{GUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified grasslands (head)
$\mathrm{Days}_{GUI,l,t}$	=	Days in year *t* that livestock of each type *l* grazes on unidentified grassland (days)
$\mathrm{GWP}_{\mathrm{CH4}}$	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock type *l* per year (kg CH_4/(ha*year))
l	=	Index of grazing livestock types

Step 3b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure deposition on grassland caused by relocating the livestock to unidentified grasslands outside the project area using:

$$LE_{GUI_{MD},t} = LE_{GUI,N2O_{MD},t} + LE_{GUI,CH4_{MD},t} \quad (42)$$

Where:

$LE_{GUI_{MD},t}$	=	Leakage emissions from manure and urine deposited on unidentified grassland in year *t* (t CO_2e)
$LE_{GUI,N2O_{MD},t}$	=	Leakage N_2O emissions from manure and urine deposited on unidentified grasslands in year *t* (t CO_2e)
$LE_{GUI,CH4_{MD},t}$	=	Leakage CH_4 emissions from manure and urine deposited on unidentified grasslands in year *t* (t CO_2e)

$LE_{GUI\_N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using:

$$LE_{GUI,N2O_{MD},t} = GWP_{N2O} \times (LE_{GUI_D,N2O_{MD},t} + LE_{GUI_{ID},N2O_{MD},t}) \quad (43)$$

Where:

$LE_{GUI,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine deposited on unidentified grasslands in year *t* (t CO_2e)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
$LE_{GUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on unidentified grasslands in year *t* (t N_2O)
$LE_{GUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on unidentified grasslands in year *t* (t N_2O)

Leakage direct N_2O emission from manure and urine deposited on unidentified grasslands ($LE_{GUI_D,N2O_{MD},t}$) is calculated using:

$$LE_{GUI_D,N2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,GUI,l1} \times EF_{3,PRP,CPP} \times \frac{44}{28} \quad (44)$$

and/or

$$LE_{GUI_D,N2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,GUI,t,l2} \times EF_{3,PRP,SO} \times \frac{44}{28} \quad (45)$$

Where:

$LE_{GUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on unidentified grasslands in year *t* (t N_2O)
$F_{MD,GUI,t,l1}$	=	Annual amount of nitrogen in cattle, poultry and pig manure and urine deposited on unidentified grasslands in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,GUI,t,l2}$	=	Annual amount of nitrogen in sheep and other animal manure and urine deposited on unidentified grasslands in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on grasslands (kg N_2O-N/kg N input)
$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on grasslands (kg N_2O-N/kg N input)

$$F_{MD,GUI,t,l} = \frac{P_{GUI,l,t} \times W_l \times Nex_l \times H_{GUI,l,t} \times Days_{GUI,l,t} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (46)$$

Where:

$F_{MD,GUI,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on unidentified grasslands by livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{GUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified grasslands (head)
W_l	=	Average weight of livestock *l* displaced to unidentified grasslands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion factor for nitrogen excretion (kg/t livestock mass) to nitrogen excretion (kg/kg livestock mass)
$H_{GUI,l,t}$	=	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified grassland in year *t* (hours)
24	=	Conversion day to hour
$Days_{GUI,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to unidentified grasslands (days)

1000_b	=	Conversion factor for kg to t
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N deposited on unidentified grasslands is calculated using:

$$LE_{GUI_{ID},N2O_{MD},t} = \sum_{l=1}^{L} F_{MD,GUI,t,l} \times Frac_{GAS,MD,l} \times EF_4 \times \frac{44}{28} \quad (47)$$

Where:

$LE_{GUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on unidentified grasslands in year *t* (t N_2O)
$F_{MD,GUI,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on unidentified grasslands by livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
EF_4	=	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity (kg N_2O-N/(kg NH3-N + NOx-N volatilized))

CH_4 emission from manure management due to displacement of livestock to unidentified grasslands is calculated using:

$$LE_{GUI,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{GUI,l,t} \times H_{GUI,l,t} \times Days_{GUI,l,t}}{24 \times 365 \times 1000} \quad (48)$$

Where:

$LE_{GUI,CH4_{MD},t}$	=	Leakage CH_4 emissions from manure and urine deposited on unidentified grasslands in year *t* (t CO_2e)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type *l* in manure management system *m* (kg CH_4/(head*yr)
$P_{GUI,l,t}$	=	Population of livestock type *l* in year *t* displaced to unidentified grasslands (head)
$H_{GUI,l,t}$	=	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified grassland in year *t* (hours)
$Days_{GUI,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to unidentified grasslands (days)
1000	=	Conversion factor for kg to t

Step 3c: Estimate leakage emissions due to loss of soil carbon

GHG emissions due to loss of soil carbon though relocation of grazing to unidentified grasslands are to be calculated as:

$$LE_{OG,GUI,t} = \frac{Area_{GUI,t} \times SOC_{REF} \times (1 - F_{MG,SD}) \times \frac{44}{12}}{D_{SOC}} \quad (49)$$

Where:

$\mathrm{LE_{OG,GUI,t}}$	=	Total leakage emissions due to overgrazing in unidentified grasslands in year *t* (t CO_2e)
$\mathrm{Area_{GUI,t}}$	=	Area required to sustain the population of livestock displaced to unidentified grasslands in year *t* (ha)
$\mathrm{SOC_{REF}}$	=	Reference soil organic carbon stocks for the region (t C/ha)
$\mathrm{F_{MG,SD}}$	=	Relative stock change factor for severely degraded grassland (dimensionless)
$44/12$	=	Conversion factor for C to CO_2e (t CO_2e/t C)
D_{SOC}	=	Years required for overgrazing to change carbon stocks from their current state to the status of severely degraded carbon stocks (years)

Step 4: Calculate total leakage emissions from relocation of grazing to unidentified grasslands

Total leakage emissions from relocation of grazing to unidentified grasslands must be calculated as:

$$LE_{GUI,t} = \mathrm{LE_{OG,GUI,t}} + LE_{GUI,CH4_{EF},t} + LE_{GUI_{MD},t} \quad (50)$$

Where:

$LE_{GUI,t}$	=	Leakage due to displacement of livestock to unidentified grasslands in year *t* (t CO_2e)
$\mathrm{LE_{OG,GUI,t}}$	=	Leakage due to soil carbon loss resulting from overgrazing due to displacement of livestock to unidentified grasslands in year *t* (t CO_2e)
$LE_{GUI,CH4_{\mathrm{EF}},t}$	=	Leakage due to enteric fermentation by livestock displaced to unidentified grasslands in year *t* (t CO_2e)
$LE_{GUI_{MD},t}$	=	Leakage due to N_2O and CH_4 emissions in manure and urine deposited on grasslands by livestock displaced to unidentified grasslands in year *t* (t CO_2e)

5.2.5 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Unidentified Croplands

The following procedures are used to estimate leakage emissions due to displacement of livestock grazing activity to unidentified croplands.

If livestock grazing activity is displaced to unidentified cropland, leakage emissions arise from CH_4 due to enteric fermentation outside the project area (5.2.5 Step 3a); from CH_4 and N_2O due to manure management of displaced livestock (5.2.5 Step 3b); and from CO_2 and non-CO_2 emissions from loss and subsequent burning of perennial tree crops on lands to which livestock are displaced. If livestock are displaced to croplands with no perennial plants, no carbon stock losses are accounted for.

Step 1: Determine the proportion of displaced livestock likely to be displaced to perennial croplands

Using data on land use and land cover in the reference region surrounding the SGM project area, identify the proportion of total croplands that are under perennial crops. Publicly available data (eg, satellite images, remote sensing data or other land use or land cover data produced by agencies of the host country government) must be used. It will be assumed that the proportion of total livestock displaced in each year to perennial croplands is the same as

the proportion of perennial croplands in total croplands in the administrative division encompassing all areas of land included in the SGM project. For example, if perennial croplands are 30 percent of total croplands in the administrative area, then 30 percent of livestock displaced to unidentified croplands are assumed to be displaced to perennial croplands. The remaining livestock displaced to unidentified croplands are assumed to be displaced to annual croplands.

Step 2: Determine the area of unidentified perennial croplands required to support the displaced livestock

All woody biomass on perennial croplands to which livestock are likely to be displaced is assumed to be lost. To determine the area of perennial croplands required to support the displaced livestock, the following procedures must be used.

$$\mathrm{DMI_{PCUI,t}} = \sum_{l=1}^{L} \left(\frac{\mathrm{DMI_{day,l}} \times \mathrm{P_{PCUI,l,t}}}{1000} \right) \times \mathrm{Days_{PCUI,l,t}} \quad (51)$$

Where:

$\mathrm{DMI_{PCUI,t}}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* relocated to unidentified perennial croplands in year *t* (t dm)
$\mathrm{DMI_{day,l}}$	=	Daily dry matter intake requirement of each type of livestock *l* (kg dm/(head*day))
$\mathrm{P_{PCUI,l,t}}$	=	Population of livestock of each type relocated to unidentified perennial croplands in year *t* (head)
$\mathrm{Days_{PCUI,l,t}}$	=	Days that the population of each type of livestock *l* graze in unidentified perennial croplands in year *t* (days)

The total area of unidentified perennial croplands required to sustain the population of livestock to be relocated to unidentified perennial croplands is to be calculated as:

$$\mathrm{Area_{PCUI,t}} = \frac{\mathrm{DMI_{PCUI,t}}}{\mathrm{ANPP_{REF\_PCUI}}} \quad (52)$$

Where:

$\mathrm{Area_{PCUI,t}}$	=	Area required to sustain the population of livestock displaced to unidentified perennial croplands in year *t* (ha)
$\mathrm{DMI_{PCUI,t}}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* relocated to unidentified perennial croplands in year *t* (t dm)
$\mathrm{ANPP_{REF\_PCUI}}$	=	Aboveground net primary productivity of herbaceous biomass in perennial croplands in the region to which livestock are likely to be displaced to perennial croplands (t dm/ha)

Step 3: Estimate leakage emissions due to relocation of grazing activities to unidentified croplands

Step 3a: Estimate methane emissions from livestock enteric fermentation

Identify the number, sex and types of livestock displaced from the project area to annual and perennial croplands outside the project area:

$$P_{CUI,l,t} = P_{ACUI,l,t} + P_{PCUI,l,t} \quad (53)$$

Where:

$P_{CUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified croplands (head)
$P_{ACUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified annual croplands (head)
$P_{PCUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified perennial croplands (head)
l	=	Index of livestock type

$P_{ACUI,l,t}$ and $P_{PCUI,l,t}$ must be determined following the procedure outlined in 5.2.5 Step 1 (ie, based on the total number of livestock to be displaced to unidentified croplands and the factions of total cropland that are either annual croplands or perennial croplands in the administrative division encompassing the SGM project).

Calculate the leakage emissions due to enteric fermentation outside the project area caused by relocating the livestock to croplands outside the project area using:

$$LE_{CUI,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{CUI,l,t} \times Days_{CUI,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (54)$$

Where:

$LE_{CUI\_CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to unidentified croplands in year *t* (t CO_2e)
$P_{CUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified croplands (head)
l	=	Index of livestock type
$Days_{CUI,l,t}$	=	Days in year t that livestock of each type *l* will be grazing in unidentified cropland (days)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock of each type *l* per year (kg CH_4/(ha*year))

Step 3b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure management outside the project area caused by relocating the livestock to unidentified croplands outside the project area. Project proponents should note that if manure management systems change after livestock are relocated to croplands, then the appropriate emission factors for the manure management systems in cropland areas must be used, and these may differ from the emission factors used for estimations inside the project area.

$$LE_{CUI_{MD},t} = LE_{CUI,N2O_{MD},t} + LE_{CUI,CH4_{MD},t} \quad (55)$$

Where:

$LE_{CUI_{MD},t}$	=	Leakage emissions from manure management in unidentified croplands in year *t* (t CO_2e)
$LE_{CUI,N2O_{MD},t}$	=	Leakage N_2O emissions from manure and urine managed in unidentified cropland soils in year *t* (t CO_2e)
$LE_{CUI,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine managed in unidentified cropland soils in year *t* (t CO_2e)

$LE_{CUI\_N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using:

$$LE_{CUI,N2O_{MD},t} = GWP_{N2O} \times (LE_{CUI_D,N2O_{MD},t} + LE_{CUI_{ID},N2O_{MD},t}) \quad (56)$$

Where:

$LE_{CUI,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine managed in unidentified croplands in year *t* (t CO_2e)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
$LE_{CUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine managed in unidentified croplands in year *t* (t N_2O)
$LE_{CUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine managed on unidentified croplands in year *t* (t N_2O)

Leakage direct N_2O emissions from manure and urine managed in unidentified croplands ($LE_{CUI\_D,N2O_{MD},t}$) is calculated using:

$$LE_{CUI_D,N2O_{MD},t} = \sum_l^L F_{MD,CUI,l,t} \times EF_{3,l,m} \times \frac{44}{28} \quad (57)$$

Where:

$LE_{CUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine managed in unidentified croplands in year *t* (t N_2O)
$F_{MD,CUI,l,t}$	=	Annual amount of nitrogen in manure and urine managed in unidentified croplands for livestock type *l* in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,l,m}$	=	N_2O emission factor for each type of livestock l in each manure management system m (kg N_2O-N/kg N input)

$$F_{MD,CUI,l,t} = \frac{P_{CUI,l,t} \times W_l \times Nex_l \times H_{CUI,l,t} \times Days_{CUI,l,t} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (58)$$

Where:

$F_{MD,CUI,l,t}$	=	Annual amount of nitrogen in manure and urine managed in unidentified croplands for livestock type *l* in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{CUI,l,t}$	=	Population of grazing livestock type *l* in year t displaced outside the project area to unidentified croplands (head)
W_l	=	Average weight of livestock *l* displaced to unidentified croplands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion factor for nitrogen excretion (kg/t livestock mass) to nitrogen excretion (kg/kg livestock mass)
$H_{CUI,l,t}$	=	Average grazing hours per day for livestock of each type *l* displaced to unidentified cropland in year *t* (hours)
24	=	Conversion factor for day to hours
$Days_{CUI,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to unidentified croplands (days)
1000_b	=	Conversion factor for kg to t

$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N deposited on unidentified cropland soils is calculated using:

$$LE_{CUI_{ID},N2O_{MD},t} = \sum_{l=1}^{L} F_{MD,CUI,l,t} \times Frac_{GAS,MD,l} \times EF_4 \times \frac{44}{28} \quad (59)$$

Where:

$LE_{CUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine managed on unidentified croplands in year *t* (t N_2O)
$F_{MD,CUI,l,t}$	=	Annual amount of nitrogen in manure and urine managed in unidentified croplands for livestock type *l* in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
EF_4	=	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity (kg N_2O-N/(kg NH3-N + NOx-N volatilized))

CH_4 emission from due to manure management after displacement of livestock to unidentified croplands is calculated using:

$$LE_{CUI,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{CUI,l,t} \times H_{CUI,l,t} \times Days_{CUI,l,t}}{24 \times 365 \times 1000} \quad (60)$$

Where:

$LE_{CUI,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine managed in unidentified cropland soils in year *t* (t CO_2e)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type *l* in manure management system m (kg CH_4/(head*year)
$P_{CUI,l,t}$	=	Population of livestock type *l* in year *t* displaced to unidentified croplands (head)
$H_{CUI,l,t}$	=	Average grazing hours per day for livestock of each type *l* displaced to unidentified cropland in year *t* (hours)
$Days_{CUI,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to unidentified croplands (days)
1000	=	Conversion factor for kg to t

Step 3c: Estimate CO_2 emissions from perennial crop biomass loss

The area (ha) of perennial crop land in the project scenario to which livestock grazing will be displaced ($Area_{PCUI,t}$) was estimated in 5.2.5 Step 2 above. Croplands with only annual crops must not be included in this area estimate. This module assumes that displacement of grazing livestock to perennial croplands will cause biomass loss, which can be estimated as follows:

$$LE_{PCUI,t} = \frac{\sum_k Area_{PCUI,t} \times B_{PCUI} \times (1+R) \times 0.5 \times \frac{44}{12}}{D_{PCUI}} \quad (61)$$

Where:

$LE_{PCUI,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to unidentified perennial croplands in year *t* (t CO_2e)
$Area_{PCUI,t}$	=	Area of unidentified perennial cropland deforested to feed livestock in year *t* (ha)
B_{PCUI}	=	Aboveground biomass of unidentified perennial cropland to which livestock are displaced (t dm/ha)
R	=	Root-to-shoot ratio (t dm aboveground/t dm belowground)
0.5	=	IPCC default carbon fraction for woody biomass (t C/t dm)
$44/12$	=	Conversion factor for C to CO_2e (t CO_2e/t C)
D_{PCUI}	=	Years over which biomass is lost (years)

Given that prior to relocation of livestock, perennial croplands are managed, and therefore emissions due to loss of litter, dead wood and soil carbon on perennial croplands are assumed to be negligible.

Step 3d: Emissions due to burning of perennial tree biomass

It must be assumed that perennial trees in croplands to which livestock are relocated are burned, either during the tree clearing process or due to fuelwood collection subsequent to displacement of grazing, and CH_4 and N_2O emissions that result can be calculated using

$$LE_{PCUI,fire,t} = \left(\left(\frac{Area_{PCUI,t} \times M_{BPUI,t} \times C_f \times EF_{CH4} \times GWP_{CH4}}{1000}\right) + \left(\frac{Area_{PCUI,t} \times M_{BPUI,t} \times C_f \times EF_{N2O} \times GWP_{N2O}}{1000}\right)\right) \div D_{PCUI,fire} \quad (62)$$

Where:

$LE_{PCUI,fire,t}$	=	Leakage due to non-CO_2 emissions from biomass burning after displacement of livestock to unidentified perennial croplands in year *t* (t CO_2e)
$Area_{PCUI,t}$	=	Area of unidentified perennial cropland land deforested in year *t* (ha)
$M_{BPIU,t}$	=	Biomass available for burning in unidentified perennial cropland in year t to which livestock are displaced (t dm / ha)
C_f	=	Combustion factor (dimensionless)
EF_{CH4}	=	CH_4 emission factor for biomass burning (g CH_4/kg dm burnt)
EF_{N2O}	=	N_2O emission factor (g N_2O/kg dm burnt)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
1000	=	Conversion factor for kg to t
$D_{PCUI,fire}$	=	Years required for available biomass in perennial cropland to be burned (years)

Step 4: Calculated total leakage emissions from unidentified croplands

Total leakage emissions from identified croplands must be calculated as

$$LE_{CUI,t} = LE_{PCUI,t} + LE_{CUI,CH4_{EF},t} + LE_{CUI_{MD},t} + LE_{PCUI,fire,t} \quad (63)$$

Where:

$LE_{CUI,t}$	=	Leakage due to displacement of livestock to unidentified croplands in

year *t* (t CO_2e)

$LE_{PCUI,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to unidentified perennial croplands in year *t* (t CO_2e)
$LE_{CUI\_CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to unidentified croplands in year *t* (t CO_2e)
$LE_{CUI_{MD},t}$	=	Leakage due to N_2O and CH_4 emissions in manure management by livestock displaced to unidentified croplands in year *t* (t CO_2e)
$LE_{PCUI\_fire,t}$	=	Leakage due to N_2O and CH_4 emissions in manure management by livestock displaced to unidentified croplands in year *t* (t CO_2e)

5.2.6 Estimation of Leakage Emissions due to Displacement of Livestock Grazing to Unidentified Forest Lands

The following procedures are used to estimate leakage emissions due to displacement of livestock grazing activity to unidentified forest lands.

If livestock grazing activity is displaced to unidentified forest land it is assumed that leakage emissions arise from CH_4 due to enteric fermentation outside the project area (5.2.6 Step 2a); from CH_4 and N_2O due to manure management of displaced livestock (5.2.6 Step 2b); from CO_2 emissions from deforestation on lands to which livestock are displaced (5.2.6 Step 2c); and CH_4 and N_2O due to burning of woody biomass (5.2.6 Step 2d).

Step 1: Determine the area of unidentified forest lands required to support the displaced livestock

All woody biomass on unidentified forest lands to which livestock are displaced must be assumed to be lost. To determine the area of forest lands required to support the displaced livestock, the following procedures must be used.

$$\mathrm{DMI_{FUI,t}} = \sum_{l=1}^{L}\left(\frac{\mathrm{DMI_{day,l}} \times \mathrm{P_{FUI,l,t}}}{1000}\right) \times \mathrm{Days_{FUI,l,t}} \quad (64)$$

Where:

$\mathrm{DMI_{FUI,t}}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* displaced to unidentified forest lands in year *t* (t dm)
$\mathrm{DMI_{day,l}}$	=	Daily dry matter intake requirement of each type of livestock *l* (kg dm/(head*day))
$\mathrm{P_{FUI,l,t}}$	=	Population of livestock of each type *l* displaced to unidentified forest lands in year t (head)
$\mathrm{Days_{FUI,l,t}}$	=	Days that the population of each type of livestock *l* displaced to unidentified forest lands in year *t* (days)

The total area of unidentified forest lands required to sustain the population of livestock displaced to unidentified forest lands is to be calculated as:

$$\mathrm{Area_{FUI,t}} = \frac{\mathrm{DMI_{FUI,t}}}{\mathrm{ANPP_{REF\_FUI}}} \quad (65)$$

Where:

$\mathrm{Area_{FUI,t}}$	=	Area required to sustain the population of livestock displaced to unidentified forest lands in year *t* (ha)

$\mathrm{DMI}_{\mathrm{FUI,t}}$	=	Dry matter intake required to sustain the total number of livestock of all types *l* displaced to unidentified forest lands in year *t* (t dm)
$\mathrm{ANPP}_{\mathrm{REF\_FUI}}$	=	Aboveground net primary productivity of herbaceous biomass in deforested forest lands in the administrative division to which livestock are likely to be displaced to forest lands (t dm / ha)

Following the requirements in 5.1.5, where unidentified forest land is characterized on the basis of forest cover in a reference region, $\mathrm{ANPP}_{\mathrm{REF\_FUI}}$ must be calculated as the area-weighted average of the different forest types present in the reference region.

Step 2a: Estimate methane emissions from livestock enteric fermentation

Identify the number, sex and types of livestock displaced from the project area to unidentified forest land. Calculate the leakage emissions due to enteric fermentation outside the project area caused by relocating the livestock to unidentified forest land using:

$$LE_{FUI,CH4_{EF},t} = \frac{\sum_{l=1}^{L} P_{FUI,l,t} \times Days_{FUI,l,t} \times GWP_{CH4} \times EF_l}{1000 \times 365} \quad (66)$$

Where:

$LE_{FUI,CH4_{EF},t}$	=	CH_4 leakage emissions from enteric fermentation by livestock displaced to unidentified forest lands in year *t* (t CO_2e)
$P_{FUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified forest lands (head)
l	=	Index of livestock type
$\mathrm{Days}_{FUI,l,t}$	=	Days in year *t* that livestock of each type *l* grazing in unidentified forest lands (days)
$\mathrm{GWP}_{\mathrm{CH4}}$	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
EF_l	=	Enteric CH_4 emission factor per head of livestock type l per year (kg CH_4/(ha*year))

Step 2b: Estimate GHG emissions from manure management

Calculate the N_2O and CH_4 leakage emissions due to manure management outside the project area caused by displacing the livestock to unidentified forest lands using:

$$LE_{FUI_{MD},t} = LE_{FUI,N2O_{MD},t} + LE_{FUI,CH4_{MD},t} \quad (67)$$

Where:

$LE_{FUI_{MD},t}$	=	Leakage emissions from manure management from livestock grazing in unidentified forest land in year *t* (t CO_2e)
$LE_{FUI,N2O_{MD},t}$	=	Leakage N_2O emissions from manure and urine deposited on unidentified forest soils in year *t* (t CO_2e)
$LE_{FUI,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine deposited on unidentified forest soils in year *t* (t CO_2e)

$LE_{FUI\_N2O_{MD},t}$ is calculated as the sum of direct N_2O emissions and indirect N_2O emissions using the following:

$$LE_{FUI,N2O_{MD},t} = GWP_{N2O} \times (LE_{FUI_D,N2O_{MD},t} + LE_{FUI_{ID},N2O_{MD},t}) \quad (68)$$

Where:

$LE_{FUI,N2O_{MD},t}$	=	Leakage N_2O emission from manure and urine deposited on unidentified forest soil in year *t* (t CO_2e)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
$LE_{FUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on unidentified forest soil in year *t* (t N_2O)
$LE_{FUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on unidentified forest soil in year *t* (t N_2O)

Leakage direct N_2O emission from manure and urine deposited on unidentified forest soil ($LE_{FUI\_D,N2O_{MD},t}$) is calculated using:

$$LE_{FUI_D,N2O_{MD},t} = \sum_{l1=1}^{L1} F_{MD,FUI,t,l1} \times EF_{3,PRP,CPP} \times \frac{44}{28} \quad (69)$$

and/or

$$LE_{FUI_D,N2O_{MD},t} = \sum_{l2=1}^{L2} F_{MD,FUI,t,l2} \times EF_{3,PRP,SO} \times \frac{44}{28} \quad (70)$$

Where:

$LE_{FUI_D,N2O_{MD},t}$	=	Leakage direct N_2O emissions from manure and urine deposited on unidentified forest soil in year *t* (t N_2O)
$F_{MD,FUI,t,l1}$	=	Annual amount of nitrogen in cattle, poultry and pig manure and urine deposited on unidentified forest soil in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$F_{MD,FUI,t,l2}$	=	Annual amount of nitrogen in sheep and other animal manure and urine deposited on unidentified forest soil in year *t*, adjusted for volatilization as NH_3 and NO_x (t N)
$EF_{3,PRP,CPP}$	=	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on unidentified forest soil (kg N_2O-N/kg N input)
$EF_{3,PRP,SO}$	=	N_2O emission factor for sheep and other animals manure and urine deposited on unidentified forest soil (kg N_2O-N/kg N input)

$$F_{MD,FUI,t,l} = \frac{P_{FUI,l,t} \times W_l \times Nex_l \times H_{FUI,l,t} \times Days_{FUI,l,t} \times (1 - Frac_{GAS,MD,l})}{1000_a \times 24 \times 1000_b} \quad (71)$$

Where:

$F_{MD,FUI,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on unidentified forest soil in year *t* for livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$P_{FUI,l,t}$	=	Population of grazing livestock type *l* in year *t* displaced outside the project area to unidentified forest lands (head)
W_l	=	Average weight of livestock *l* displaced to unidentified forest lands (kg/head)
Nex_l	=	Nitrogen excretion from livestock type *l* (kg N/(t animal mass*day))
1000_a	=	Conversion factor for nitrogen excretion (kg/1000 kg livestock mass) to nitrogen excretion (kg/kg livestock mass)
$H_{FUI,l,t}$	=	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified forest land in year *t* (hours)
24	=	Conversion factor for day to hour

$Days_{FUI,l,t}$	=	Grazing days in year *t* for livestock type *l* displaced to unidentified forest lands (days)
1000_b	=	Conversion factor for kg to t
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
t	=	Year
l	=	Index of grazing livestock types

Leakage from indirect N_2O emissions from atmospheric deposition of N volatilized from urine and manure N deposited on unidentified forest soils is calculated using:

$$LE_{FUI_{ID},N2O_{MD},t} = \sum_{l=1}^{L} F_{MD,FUI,t,l} \times Frac_{GAS,MD,l} \times EF_4 \times \frac{44}{28} \quad (72)$$

Where:

$LE_{FUI_{ID},N2O_{MD},t}$	=	Leakage indirect N_2O emissions from manure and urine deposited on unidentified forest soil in year *t* (t N_2O)
$F_{MD,FUI,t,l}$	=	Annual amount of nitrogen in manure and urine deposited on unidentified forest soil in year *t* for livestock type *l*, adjusted for volatilization as NH_3 and NO_x (t N)
$Frac_{GAS,MD,l}$	=	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x (kg N volatilized/kg of N deposited)
EF_4	=	N_2O emission factor for atmospheric deposition of manure N on soils and water surfaces under project activity (kg N_2O-N/(kg NH3-N + NOx-N volatilized))

CH_4 emission from due to manure management from displacement of livestock to unidentified forest lands is calculated using:

$$LE_{FUI,CH4_{MD},t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} EF_{l,m} \times P_{FUI,l,t} \times H_{FUI,l,t} \times Days_{FUI,l,t}}{24 \times 365 \times 1000} \quad (73)$$

Where:

$LE_{FUI,CH4_{MD},t}$	=	Project CH_4 emission from manure and urine deposited on unidentified forest soils in year *t* (t CO_2e)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
$EF_{l,m}$	=	CH_4 emission factor per head of livestock type *l* in manure management system *m* (kg CH_4/(head*yr)
$P_{FUI,l,t}$	=	Population of livestock type *l* in year *t* displaced to unidentified forest lands (head)
$H_{FUI,l,t}$	=	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified forest land in year *t* (hours)
$Days_{FUI,l,t}$	=	Grazing days in year t for livestock type *l* displaced to unidentified forest lands (days)
1000	=	Conversion factor for kg to t

Step 2c: Estimate CO_2 emissions from deforestation

Biomass loss caused by displacement of grazing livestock to unidentified forest lands can be estimated as follows:

For the forests in the administrative division encompassing the SGM project activities, on the basis of measurements in the region reported in peer-reviewed publications or national forest

inventories, determine the current forest biomass stock (FB_{UI_REF}). Following the requirements in Section 5.1.5, where unidentified forest land is characterized on the basis of forest cover in a reference region, FB_{UI_REF} must be calculated as the area-weighted average forest biomass stock of the different forest types present in the reference region. Based on descriptions of prior relocation of grazing activity to forest land or prior examples of forest clearance by the same or similar grazing agents in the project region, a list must be made that presents the possible outcomes for forest biomass stocks remaining at least 5 years after the introduction of grazing activities. The project proponent must justify which of the possible outcomes is most likely to apply to unidentified forest land to which grazing is displaced. The project proponent must also justify a conservative value for the equilibrium biomass stock of deforested forest land after deforestation (FB_{UI_EQ}). Where full clearance of forest is likely, the equilibrium biomass stock of deforested forest land after deforestation (FB_{UI_EQ}) is zero. Where partial clearance of forest or forest degradation is determined as a likely outcome of relocation of grazing activities, FB_{UI_EQ} must be determined on the basis of measurements conducted on similar land plots or studies specific to the project region of biomass carbon stocks remaining at least five years after the introduction of grazing activities, and the project proponent must justify the conservativeness of the value of FB_{UI_EQ} chosen.

Leakage emissions due to deforestation of identified forest lands ($LE_{FUI\_CO2,t}$) are calculated as follows:

$$LE_{FUI,CO2,t} = \frac{Area_{FUI,t} \times (FB_{UI,REF} - FB_{UI,EQ}) \times 0.5 \times \frac{44}{12}}{D_{FUI}} \quad (74)$$

Where:

$LE_{FUI,CO2,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to unidentified forest lands in year *t* (t CO_2e)
$Area_{FUI,t}$	=	Area of unidentified forest land deforested to feed livestock in year *t* (ha)
$FB_{UI,REF}$	=	Forest biomass stocks prior to deforestation of unidentified forest land to which livestock are likely to be displaced (t dm/ha)
$FB_{FUI,EQ}$	=	Long-term equilibrium biomass stocks of unidentified forest land after full or partial deforestation due to livestock displacement (t dm/ha)
0.5	=	IPCC default carbon fraction for woody biomass (t C/t dm)
$44/12$	=	Conversion factor for C to CO_2e (t CO_2e/t C)
D_{FUI}	=	Years required for transition from the reference forest biomass stocks to the long-term equilibrium forest biomass stocks (years)

Forest biomass stocks per hectare in unidentified forest land in the reference region prior to relocation of grazing livestock must be estimated as follows:

$$FB_{UI_{REF}} = B_{AB,UI\_REF} \times (1 + R) + B_{Litter,UI,REF} + B_{Deadwood,UI,REF} \quad (75)$$

Where:

$FB_{UI,REF}$	=	Forest biomass stocks prior to deforestation of unidentified forest land to which livestock are likely to be displaced (t dm/ha)
$B_{AB,UI,REF}$	=	Aboveground biomass in forests in the reference region prior to deforestation (t dm/ha)
R	=	Root-to-shoot ratio (t dm aboveground/t dm belowground)
$B_{Litter.UI,REF}$	=	Litter on forest land in the reference region to which livestock are likely

to be displaced (t dm/ha)

$B_{Deadwood,UI,REF}$ = Dead wood on forest lands in the reference region to which livestock are likely to be displaced (t dm/ha)

Following the requirements in Section 5.1.5, where unidentified forest land is characterized on the basis of forest cover in a reference region, B_{AB,UI_REF}, R_{UI_REF}, $B_{Litter.UI\_REF}$ and $B_{Deadwood,UI\_REF}$ must be calculated as the area-weighted average of the different forest types present in the reference region.

Step 2d: Estimate GHG emissions from forest biomass burning

It must be assumed that deforested biomass is burned, either during the forest clearing process or due to fuelwood collection subsequent to deforestation, calculate the CH_4 and N_2O emissions that result using:

$$LE_{FUI,fire,t} = \left(\left(\frac{Area_{FUI,t} \times M_{BFUI,t} \times C_f \times EF_{CH4} \times GWP_{CH4}}{1000}\right) + \left(\frac{Area_{FUI,t} \times M_{BFUI,t} \times C_f \times EF_{N2O} \times GWP_{N2O}}{1000}\right)\right) \div D_{FUI,fire} \quad (76)$$

Where:

$LE_{FUI,fire,t}$	=	Leakage due to non-CO_2 emissions due to biomass burning resulting from deforestation after displacement of livestock to unidentified forest lands in year *t* (t CO_2e)
$Area_{FUI,t}$	=	Area of unidentified forest land deforested to feed livestock in year *t* (ha)
$M_{BFUI,t}$	=	Biomass available for burning in year *t* of unidentified forest land to which livestock are likely to be displaced (t dm/ha)
C_f	=	Combustion factor (dimensionless)
EF_{CH4}	=	CH_4 emission factor for biomass burning (g CH_4/kg dm burnt)
EF_{N2O}	=	N_2O emission factor (g N_2O/kg dm burnt)
GWP_{CH4}	=	Global-warming potential of CH_4 (t CO_2e/t CH_4)
GWP_{N2O}	=	Global-warming potential of N_2O (t CO_2e/t N_2O)
$D_{FUI,fire}$	=	Years required for available biomass to be burned in unidentified forest land that is likely to be deforested (years)

Step 3: Calculated total leakage emissions from displacement to unidentified forest

Calculate the total leakage emissions from all sources of leakage caused by displacement of grazing to unidentified forest lands using:

$$LE_{FUI,t} = LE_{FUI,CO2,t+} + LE_{FUI,fire,t} + LE_{FUI,CH4_{EF},t} + LE_{FUI_{MD},t} \quad (77)$$

Where:

$LE_{FUI,t}$	=	Leakage due to displacement of livestock to unidentified forest lands in year t (t CO_2e)
$LE_{FUI,CO2,t}$	=	Leakage due to biomass loss resulting from displacement of livestock to unidentified forest lands in year t (t CO_2e)
$LE_{FUI,fire,t}$	=	Leakage due to non-CO_2 emissions from biomass burning resulting from deforestation after displacement of livestock to unidentified forest lands in year t (t CO_2e)
$LE_{FUI,CH4_{EF},t}$	=	Leakage due to enteric fermentation by livestock displaced to unidentified forest lands in year t (t CO_2e)

$LE_{FUI_{MD},t}$ = Leakage due to N_2O and CH_4 emissions in manure management by livestock displaced to unidentified forest lands in year t (t CO_2e)

5.2.7 Calculation of Project Leakage Emissions due to Grazing Displacement

Leakage emissions due to grazing displacement in year *t* ($LE_{GD,t}$) must be calculated using:

$$LE_{GD,t} = LE_{GID,t} + LE_{FID,t} + LE_{CID,t} + LE_{GUI,t} + LE_{CUI,t} + LE_{FUI,t} \quad (78)$$

Where:

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

$LE_{GID,t}$ = Leakage due to emissions from displacement of grazing to identified grasslands in year *t* (t CO_2e)

$LE_{FID,t}$ = Leakage due to emissions from displacement of grazing to identified forest in year *t* (t CO_2e)

$LE_{CID,t}$ = Leakage due to emissions from displacement of grazing to identified cropland in year *t* (t CO_2e)

$LE_{GUI,t}$ = Leakage due to emissions from displacement of grazing to unidentified grasslands in year *t* (t CO_2e)

$LE_{CUI,t}$ = Leakage due to emissions from displacement of grazing to unidentified cropland in year *t* (t CO_2e)

$LE_{FUI,t}$ = Leakage due to emissions from displacement of grazing to unidentified forest in year *t* (t CO_2e)

6 DATA AND PARAMETERS

Where grazing displacement has been determined as likely to take place (as determined in Section 5.1.1), for each type of identified land, a random sample of identified land plots of each type of identified land (ie, grassland, forest, cropland) must be monitored on an annual basis. Where sampling is conducted, sampling and stratification procedures must attain a precision of 15 percent at the 95 percent confidence level. Monitoring plans must include procedures for managing data quality that are consistent with internationally accepted guidance documents such as IPCC (2003) G*ood Practice Guidance for Land Use, Land Use Change and Forestry* (Chapter 5) or IPCC (2000) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (Chapter 8).

For identified lands, annual monitoring must be conducted to collect and record data for the parameters listed in Table 1 and described in Section 6.2, unless values from other sources are used due to lack of local data as allowed in Section 5.2.1 to Section 5.2.6. Leakage emissions in each year for each type of identified land must be quantified using the procedures set out in the relevant section listed in the final column of Table 1. The results of monitoring must be extrapolated to the total area of each type of land affected by grazing displacement in each year using appropriate, unbiased methods.

Table 1: Procedures for Monitoring of Leakage from Grazing Displacement to Identified Lands

Identified Grassland

Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$\mathrm{ANPP}_{\mathrm{GID,k,t}}$	kg/(ha* year)	Aboveground net primary production in year *t* in each parcel to which grazing is displaced	Annual	Follow procedures in 5.2.1 Step 1, and where appropriate in 5.2.1 Step 2c
$Area_{GID,k,t}$	hectare	Area of parcel k of identified grassland to which grazing activities will be relocated in year t	Annual for first five years	Follow procedures in 5.2.1 Step 1, and where appropriate in 5.2.1 Step 2c
$P_{GID,l,k,t}$	head	Population of grazing livestock of each type *l* displaced to each parcel *k* in year t	Annual	Follow procedures in 5.2.1 Step 1, and where appropriate in 5.2.1 Step 2c; follow procedures in 5.2.1 Steps 2a and 2b
$\mathrm{Days}_{\mathrm{GID,l,k,t}}$	days	Number days in year *t* that livestock of each type *l* graze on parcel *k*	Annual	Follow procedures in 5.2.1 Step 1, and where appropriate in 5.2.1 Step 2c; follow procedures in 5.2.1 Steps 2a and 2b
$H_{GID,l,t}$	hours	Average grazing hours per day for each livestock type *l* in identified grassland in year *t*	Annual	Follow procedures in 5.2.1 Step 2b
Identified Forest				
Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$P_{l,FID,t}$	head	Population of each type of livestock *l* displaced to identified forest land in year *t*	Annual	Follow procedures in 5.2.2 Steps 2a and 2b
$\mathrm{Days}_{FID,l,t}$	days	Days that livestock of each type *l* graze on *identified* forest land in year *t*	Annual	Follow procedures in 5.2.2 Steps 2a and 2b
$H_{FID,l,t}$	hours	Average grazing hours per day for each livestock type *l* in identified forest land in year *t*	Annual	Follow procedures in 5.2.2 Step 2b

$Area_{FID,k}$	hectares	Area of identified forest land in each parcel *k* deforested due to grazing displacement	Annual for first five years	Follow procedures in 5.2.2 Step 2c
$B_{AB,FID,k,t}$	t d /ha	Aboveground biomass in forest parcel *k* in year *t*	Annual for first five years	Follow procedures in 5.2.2 Step 2c
$M_{BFID,k,t}$	t dm/ha	Fuel available for burning in parcel *k* in year t of identified forest land to which livestock are displaced	Annual for first five years	Follow procedures in 5.2.2 Step 2d
Identified Cropland				
Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$P_{CID,l,t}$	head	Population of each type of livestock *l* displaced to identified cropland in year *t*	Annual	Follow procedures in 5.2.3 Steps 2a and 2b
$\mathrm{Days}_{CID,l,t}$	days	Days that livestock of each type *l* graze on identified cropland in year *t*	Annual	Follow procedures in 5.2.3 Steps 2a and 2b
$H_{CID,l,t}$	hours	Average grazing hours per day for each livestock type *l* in identified cropland in year *t*	Annual	Follow procedures in 5.2.3 Step 2b
$Area_{PCID,k,t}$	hectares	Area of each parcel k of perennial cropland to which grazing is displaced in each year *t*	Annual for first five years	Follow procedures in 5.2.3 Step 2c
$B_{PCID,k,t}$	t dm/ha	Aboveground biomass of each parcel k of perennial cropland to which livestock are displaced in each year *t*	Annual for first five years	Follow procedures in 5.2.3 Step 2c

$M_{BPID,k,t}$	t dm ha	Fuel available for burning in parcel *k* in year t of identified perennial cropland to which livestock are displaced	Annual for first five years	Follow procedures in 5.2.3 Step 2d

Where grazing displacement has been determined as likely to take place (Section 5.1.1), and unidentified lands have been determined as the likely location of grazing displacement (Section 5.1.4 and 5.1.5), leakage monitoring surveys must be conducted on a random sample of grazing agents (including both project participants and non-participants) who have some or all livestock that are displaced to any type (ie, grassland, forest, cropland) of unidentified land. The survey must collect and record data on the parameters listed in Table 2 and described in Section 6.2. Where displacement is a one-off event in the SGM project implementation process, the parameters in Table 2 should be recorded when the displacement occurs, and must be entered in leakage monitoring data for each year of project implementation. Where displacement is an annual event (eg, livestock are displaced from the project area only in one grazing season each year, returning to within the project area after that grazing season), the project proponent must monitor the parameters in Table 2 on an annual basis through surveys conducted in the project area.

Leakage emissions in each year for each type of unidentified land must be quantified using the procedures set out in the Step(s) listed in the final column of Table 2. The results of monitoring must be extrapolated to the total area of each type of unidentified land affected by grazing displacement in each year using appropriate, unbiased methods. Where project non-participants cannot be identified for survey, extrapolation on the basis of data from similar grazing agents must be used.

Table 2: Procedures for Monitoring of Leakage from Grazing Displacement to Identified Lands

Unidentified Grassland				
Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$P_{GUI,l,t}$	head	Total population of each type of livestock *l* displaced to unidentified grasslands in each year *t*	Annual	Follow procedures in 5.2.4 Steps 1 to 2
$\mathrm{Days}_{\mathrm{GUI,l,t}}$	days	Number days in year *t* that livestock of each type *l* graze on unidentified grasslands	Annual	Follow procedures in 5.2.4 Steps 1 to 4

Unidentified Cropland				
Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$P_{CUI,l,t}$	head	Population of each type of livestock *l* displaced to unidentified cropland in each year *t*	Annual	Follow procedures in 5.2.5 Steps 1 to 4
$\mathrm{Days}_{CUI,l,t}$	days	Days that livestock of each type *l* graze on unidentified cropland in year *t*	Annual	Follow procedures in 5.2.5 Steps 1 to 4
$M_{BPUI,t}$	t dm/ha	Fuel available for burning in year t of unidentified perennial cropland to which livestock are displaced	Annual for first five years	Follow procedures in 5.2.5 Step 2d
Unidentified Forest				
Parameter	Unit	Description	Frequency	Quantification of Leakage Emissions
$P_{FUI,l,t}$	head	Total population of each type of livestock *l* displaced to unidentified forest in each year *t*	Annual	Follow procedures in 5.2.6 Steps 1 to 3
$\mathrm{Days}_{\mathrm{FUI,l,t}}$	days	Number days in year *t* that livestock of each type *l* graze on unidentified forest	Annual	Follow procedures in 5.2.6 Steps 1 to 3
$M_{BFUI,t}$	t dm/ha	Fuel available for burning in year t of unidentified forest land to which livestock are displaced	Annual for first five years	Follow procedures in 5.2.6 Step 2d

6.1 Data and Parameters Available at Validation

Data / Parameter	$P_{GID,prior,l,k,t}$
Data unit	Head
Description	Population of each type of livestock *l* that were already grazing

	prior to implementation of the project in identified grassland parcel *k* in year *t*
Equations	2
Source of data	Documented management records or sample survey
Justification of choice of data or description of measurement methods and procedures applied	Prior to relocation of grazing, survey and record the numbers of grazing livestock by type in each plot. Where sample surveys are used, the sample size must ensure precision at t a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Comments	

Data / Parameter	$\mathrm{DMI}_{\mathrm{day,l}}$
Data unit	kg dm/(head*day)
Description	Daily dry matter intake requirements for each livestock type *l*
Equations	3, 39, 51 and 64
Source of data	Peer-reviewed of nationally published studies or calculated from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	$\mathrm{DMI}_{\mathrm{day,l}}$ for each type of livestock must be derived from published region-specific peer-reviewed studies, national studies or national standards. Where these are unavailable, the value may be calculated using the methods presented in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, Chapter 10.
Comments	

Data / Parameter	GWP_{CH4}
Data unit	t CO_2e/t CH_4
Description	Global warming potential of methane
Equations	5, 12, 16, 23, 27, 29, 35, 37, 41, 48, 54, 60, 62, 66, 73 and 76
Source of data	*IPCC Second Assessment Report*
Value applied	21
Justification of choice of data or description of measurement methods and procedures applied	
Comments	

Data / Parameter	EF_l
Data unit	kg CH_4/(head*year)

Description	Enteric CH_4 emission factor per head of livestock type l per year
Equations	5, 16, 29, 41, 54 and 66
Source of data	Peer-reviewed scientific literature or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.10 or 10.11, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. When data from IPCC sources are used, project proponents must refer to the tables in Annex 10A.1 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the value selected reflects the underlying animal characteristics appropriate to the selected value.
Comments	

Data / Parameter	GWP_{N2O}
Data unit	t CO_2e/t N_2O
Description	Global warming potential for nitrous oxide
Equations	7, 18, 27, 31, 37, 43, 56, 62, 68 and 76
Source of data	*IPCC Second Assessment Report*
Value applied	310
Justification of choice of data or description of measurement methods and procedures applied	
Comments	

Data / Parameter	$EF_{3,PRP,CPP}$
Data unit	kg N_2O-N/kg N deposited on or applied to grassland
Description	N_2O emission factor for cattle (dairy, non-dairy and buffalo), poultry and pigs manure and urine deposited on or applied to grassland
Equations	8, 19, 32, 44, 57 and 69
Source of data	Peer-reviewed scientific literature or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied.

procedures applied	Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.1, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	$EF_{3,PRP,SO}$
Data unit	kg N_2O-N/kg N deposited on or applied to grassland
Description	N_2O emission factor for sheep and other animals manure and urine deposited on or applied to grassland
Equations	9, 20, 32, 45, 57 and 70
Source of data	Peer-reviewed scientific literature or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.1, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	W_l
Data unit	kg/head
Description	Average weight of livestock of each type *l* displaced to identified grasslands
Equations	10, 21, 33, 46, 58 and 71
Source of data	Peer-reviewed scientific literature or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	Data from the peer-reviewed scientific literature or expert judgment that are specific to the project region. The project proponent must justify why the values chosen are conservative (ie, would not tend to underestimate leakage emissions).
Comments	

Data / Parameter	Nex_l
Data unit	kg N deposited on or applied to grassland(t animal mass*day)
Description	Nitrogen excretion from livestock type *l*
Equations	10, 21, 33, 46, 58 and 71

Source of data	Peer-reviewed scientific literature or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default values recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.19, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	$Frac_{GAS,MD,l}$
Data unit	kg N volatilized/kg of N deposited
Description	Fraction of volatilization from manure and urine deposited by grazing animals as NH_3 and NO_x
Equations	10, 11, 21, 22, 33, 34, 46, 47, 58, 59, 71 and 72
Source of data	Peer-reviewed scientific literature or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	EF_4
Data unit	kg N_2O-N/(kg NH_3-N + NO_x-N volatilized)
Description	N_2O emission factor for atmospheric deposition of urine and manure N on soils and water surfaces
Equations	11, 22, 34, 47, 59 and 72
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for

	AFOLU, must be followed.
Comments	

Data / Parameter	$SOC_{REF,k}$
Data unit	t C/ha
Description	Reference soil organic carbon stocks for identified grassland parcel *k*
Equations	13
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.3, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. The value selected must consider the degradation status of the grasslands to which livestock will be relocated. Justification for the conservativeness of the value chosen must be given.
Comments	

Data / Parameter	$F_{MG,SD}$
Data unit	Dimensionless
Description	Relative stock change factor for severely degraded grassland
Equations	13 and 49
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the region or country are available, such data must be applied. Justification for the conservativeness of the value chosen must be given. Where detailed data are unavailable, the default stock change value for severely degraded grassland given by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 6.2, Chapter 6, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. If $F_{MG,SD}$is taken from the IPCC guidance, in order to ensure conservativeness, the lower bound of the uncertainty range associated with the IPCC default factor (ie, 0.42) must be used.
Comments	Relative stock change factors as applied in Volume 4 of the

	2006 IPCC Guidelines for National Greenhouse Gas Inventories represent the carbon stock in the altered condition (eg, after onset of severe degradation) as a proportion of the reference carbon stock.

Data / Parameter	$D_{GID,SOC}$
Data unit	Years
Description	Years required for overgrazing to change carbon stocks in identified grasslands from their current state to the status of severely degraded carbon stocks
Equations	13
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the region or country are available, such data must be applied. If no such studies are available, the IPCC default value of 20 years must be used (*2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, Chapter 6).
Comments	

Data / Parameter	$B_{AB,FID,REF,k}$
Data unit	t dm/ha
Description	Aboveground biomass in forest parcel *k* prior to deforestation
Equations	25
Source of data	Field measurements, peer-reviewed scientific literature, national forest inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values must be based on measurements in each forest plot that is planned to be deforested, or on published studies in similar intact forests in the project region. Where no local studies of measurements have been undertaken, values from national forest inventories or values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 4.7, Chapter 4, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	R
Data unit	t dm belowground biomass/t dm aboveground biomass
Description	Root-to-shoot ratio
Equations	25, 26, 36, 61 and 75

Source of data	Default values in the CDM A/R Methodological Tool for *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
Value applied	0.26 for tree species; 0.4 for shrub species
Justification of choice of data or description of measurement methods and procedures applied	
Comments	

Data / Parameter	$B_{Litter,FID.REF,k}$
Data unit	t dm/ha
Description	Litter on forest land plot *k* to which livestock are displaced
Equations	25
Source of data	National forest inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values from national forest inventories or values reported in Table 2.2 in Chapter 2 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$B_{Deadwood,FID,REF,k}$
Data unit	t dm/ha
Description	Dead wood on forest land parcel *k* to which livestock are displaced
Equations	25
Source of data	National forest inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values from national forest inventories or values reported in Table 2.2 in Chapter 2 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$B_{Litter,FID.EQ,k}$
Data unit	t dm/ha
Description	Litter on forest land plot *k* at least 5 years after introduction of grazing
Equations	26
Source of data	National forest inventories or IPCC sources
Justification of choice of	Values from national forest inventories or values reported in

data or description of measurement methods and procedures applied	Table 2.2 in Chapter 2 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$B_{Deadwood,FID,EQ,k}$
Data unit	t dm/ha
Description	Dead wood on forest land parcel *k* at least 5 years after introduction of grazing
Equations	26
Source of data	National forest inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values from national forest inventories or values reported in Table 2.2 in Chapter 2 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	D_{FID}
Data unit	Years
Description	Years required for transition from the reference forest biomass stocks to the long-term equilibrium forest biomass stocks
Equations	24
Source of data	Regional peer-reviewed studies, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or an expert judgement of prior deforestation events conducted by the same or similar grazing agents in the project region. Where this is unknown the value must be assumed to be between 1 and 5 years. Justification for the conservativeness of the value selected must be provided.
Comments	Deforestation occurring more than 5 years after relocation of livestock from the project area is assumed to be not attributable to the adoption of Sustainable Grassland Management activities.

Data / Parameter	C_f
Data unit	t dm burnt/t biomass
Description	Combustion factor
Equations	27, 37, 62 and 76
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*

Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.6, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	EF_{CH4}
Data unit	g CH_4 kg/dm burnt
Description	CH_4 emission factor for biomass burning
Equations	27, 37, 62 and 76
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.5, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	$\mathrm{EF_{N2O}}$
Data unit	g N_2O/kg dm burnt
Description	N_2O emission factor for biomass burning
Equations	27, 37, 62 and 76
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.5, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	$D_{FID,fire}$
Data unit	Years
Description	Years required for available biomass to be burned
Equation	27
Source of data	Peer-reviewed scientific literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or an expert judgement of annual rates of biomass burning in prior deforestation events conducted by the same or similar grazing agents in the project region. Where this is unknown may be assumed to have a value between 1 and 5 years and all biomass available for burning must be assumed to be burned within 5 years of grazing displacement. Justification for the conservativeness of the value selected must be provided.
Comments	

Data / Parameter	$EF_{3,l,m}$
Data unit	kg N_2O-N/kg N input
Description	N_2O emission factor for each type of livestock *l* in each manure management system *m*
Equations	32 and 57
Source of data	Peer-reviewed scientific studies or default values from *IPCC Guidelines for National Greenhouse Gas Inventories*
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies, specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.21, Chapter 10, Volume 4 or Table 11.3, Chapter 11, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed.
Comments	

Data / Parameter	$EF_{l,m}$
Data unit	kg CH_4/(head*yr)
Description	CH_4 emission factor per head of livestock type *l* in manure management system *m*
Equations	12, 23, 35, 48, 60 and 73
Source of data	Peer-reviewed scientific studies or default values from *IPCC*

	Guidelines for National Greenhouse Gas Inventories
Justification of choice of data or description of measurement methods and procedures applied	Where detailed data from peer-reviewed scientific studies specific to the project area or country are available, such data must be applied. Where detailed data are unavailable, the default value recommended by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 10.14 – 10.16, Chapter 10, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be followed. Tables 10.14-10.16, may be used after appropriate consideration of supporting data in Annex 10.A2 of that Chapter.
Comments	

Data / Parameter	D_{PCID}
Data unit	Years
Description	Years required for deforestation of perennial cropland to take place
Equations	36
Source of data	Peer-reviewed scientific literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or expert judgement of prior events leading to loss of perennial crops conducted by the same or similar grazing agents in the project region. Where this is unknown the value must be assumed to be between 1 and 5 years. Justification for conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$D_{PC,fire}$
Data unit	Years
Description	Years required for available biomass in perennial cropland to be burned
Equations	37
Source of data	Peer-reviewed scientific literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value may be determined on the basis of peer-reviewed studies, publications by the host national government or expert judgement of annual rates of biomass burning in prior grazing displacement events conducted by the same or similar grazing agents in the project region. Where this is unknown the value must be assumed to be

	between 1 and 5 years and all biomass available for burning must be assumed to be burned within 5 years of grazing displacement. Justification for conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$\mathrm{ANPP}_{\mathrm{GUI,REF}}$
Data unit	t dm/ha
Description	Aboveground net primary productivity in the reference region that is the likely location of unidentified grasslands to which livestock are relocated
Equations	40
Source of data	Peer-reviewed studies or studies published by a government agency
Justification of choice of data or description of measurement methods and procedures applied	Values must come from published studies in the project region, or from published national studies. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$H_{GUI,l,t}$
Data unit	Hours
Description	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified grassland in year t
Equations	46 and 48
Source of data	Documented management records or sample survey
Justification of choice of data or description of measurement methods and procedures applied	Apply the same value as other estimates of grazing hours per day in identified grasslands outside or inside the project area. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$\mathrm{SOC}_{\mathrm{REF}}$
Data unit	t C/ha
Description	Reference soil organic carbon stocks for the region
Equations	49
Source of data	Peer-reviewed literature or IPCC sources
Justification of choice of data or description of measurement methods and	Values must be taken from region-specific or national studies. Where no regional or national studies are available, values provided by the *2006 IPCC Guidelines for National Greenhouse*

procedures applied	*Gas Inventories* (Table 5.3, Chapter 5, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU must be used. Such values must consider the degradation status of the grasslands to which livestock will be relocated. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	D_{SOC}
Data unit	Years
Description	Years required for overgrazing to change carbon stocks from their current state to the status of severely degraded carbon stocks
Equations	49
Source of data	Peer-reviewed literature or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	The value must be estimated based on region specific studies. Where region specific studies are not available, the default value of 20 years from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Chapter 6, Volume 4) must be used.
Comments	

Data / Parameter	$ANPP_{REF,PCUI}$
Data unit	t dm/ha
Description	Aboveground net primary productivity of herbaceous biomass in perennial croplands in the region to which livestock are likely to be displaced to perennial croplands
Equations	52
Source of data	Peer-reviewed literature
Justification of choice of data or description of measurement methods and procedures applied	Values must come from published studies in the reference region, or from published regional or national studies. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$H_{CUI,l,t}$
Data unit	Hours
Description	Average grazing hours per day for livestock of each type *l* displaced to unidentified cropland in year t
Equations	58 and 60
Source of data	Documented management records or sample survey or peer-reviewed studies

Justification of choice of data or description of measurement methods and procedures applied	Apply the same value as estimates of grazing hours per day in identified croplands outside the project area, or be based on peer-reviewed literature reports where these exist, or on expert judgment. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	B_{PCUI}
Data unit	t dm/ha
Description	Aboveground biomass of unidentified perennial cropland to which livestock are displaced
Equations	61
Source of data	Peer-reviewed literature or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	The value must be based on measurements conducted in the project region reported in peer-reviewed literature, or on national studies. Where no regional studies have been undertaken, average values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 5.3, Chapter 5, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used.
Comments	

Data / Parameter	D_{PCUI}
Data unit	Years
Description	Years over which perennial biomass is lost after grazing displacement to unidentified perennial croplands
Equations	61
Source of data	Peer-reviewed literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or expert judgement. Where this is unknown the value must be assumed to be between 1 and 5 years. Justification for conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$D_{PCUI,fire}$
Data unit	Years
Description	Years required for available biomass in perennial cropland to be

	burned
Equations	62
Source of data	Peer-reviewed literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national governmentor expert judgement of biomass burning in prior grazing displacement events conducted by the same or similar grazing agents in the project region. Where this is unknown the value must be assumed to be between 1 and 5 years and all biomass available for burning must be assumed to be burned.
Comments	

Data / Parameter	$\mathrm{ANPP}_{\mathrm{REF,FUI}}$
Data unit	t dm/ha
Description	Aboveground net primary productivity of herbaceous biomass in deforested forest lands in the administrative division to which livestock are likely to be displaced to forest lands
Equations	65
Source of data	Peer-reviewed literature or regional or national forest inventories
Justification of choice of data or description of measurement methods and procedures applied	Values must come from field measurements reported in peer-reviewed studies in the reference region, or from published regional or national studies, such as forest inventories. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$H_{FUI,l,t}$
Data unit	Hours
Description	Average grazing hours per day during grazing season for livestock of each type *l* displaced to unidentified forest land in year *t*
Equations	71 and 73
Source of data	Documented management records or sample survey or peer-reviewed studies
Justification of choice of data or description of measurement methods and procedures applied	Apply the same value as estimates of grazing hours per day in identified forest lands outside the project area, or be based on peer-reviewed literature reports where these exist, or on expert judgment. Justification for the conservativeness of the value chosen must be provided.
Comments	

Data / Parameter	$FB_{UI,EQ}$
Data unit	t dm/ha
Description	Long-term equilibrium biomass stocks of unidentified forest land after full or partial deforestation due to livestock displacement
Equations	74
Source of data	Peer-reviewed literature, national forest inventories or other publications by the host national government
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed literature, national forest inventories or other publications by the host national government for the project region reporting measurements conducted on similar land plots at least 5 years after the introduction of grazing activities.
Comments	

Data / Parameter	D_{FUI}
Data unit	Years
Description	Years required for transition from the reference forest biomass stocks to the long-term equilibrium forest biomass stocks
Equations	74
Source of data	Peer-reviewed literature , publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or expert judgement. Where this is unknown the value must be assumed to be between 1 and 5 years. Justification for conservativeness of the value chosen must be provided. Deforestation occurring more than 5 years after relocation of livestock from the project area is assumed to be not attributable to the adoption of sustainable grassland management activities.
Comments	

Data / Parameter	B_{AB,UI_REF}
Data unit	t dm/ha
Description	Aboveground biomass in forests in the reference region prior to deforestation
Equations	75
Source of data	Peer-reviewed literature, national inventories or IPCC sources
Justification of choice of data or description of	The value must be determined on the basis of measurements in the region reported in peer-reviewed publications. Where

measurement methods and procedures applied	regional studies have not been undertaken, values from national forest inventories or values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 4.7, Chapter 4, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$B_{Litter.UI\_REF}$
Data unit	t dm/ha
Description	Litter on forest land in the reference region to which livestock are likely to be displaced
Equations	75
Source of data	National inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values from national forest inventories or values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.2, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$B_{Deadwood,UI\_REF}$
Data unit	t dm/ha
Description	Dead wood on forest lands in the reference region to which livestock are likely to be displaced
Equations	75
Source of data	National inventories or IPCC sources
Justification of choice of data or description of measurement methods and procedures applied	Values from national forest inventories or values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.2, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.
Comments	

Data / Parameter	$D_{FUI,fire}$
Data unit	Years
Description	Years required for available biomass to be burned in unidentified forest land that is likely to be deforested
Equations	76

Source of data	Peer-reviewed literature, publications by the host national government or expert judgment
Justification of choice of data or description of measurement methods and procedures applied	The value must be determined on the basis of peer-reviewed studies, publications by the host national government or expert judgement. Where this is unknown the value must be assumed to be between 1 and 5 years. All biomass available for burning is assumed to be burned within 5 years after deforestation.
Comments	

6.2 Data and Parameters Monitored

Data / Parameter	$\mathrm{ANPP}_{\mathrm{GID,k,t}}$
Data unit	kg dm/ha
Description	Aboveground net primary production in parcel *k* of identified grassland to which grazing activities will be relocated in year *t*
Equations	1
Source of data	Field measurements or peer –reviewed studies
Description of measurement methods and procedures to be applied	Data on ANPP must be derived from field measurements or from studies conducted in the project region specific to the vegetation type of each plot. If direct measurements are not made, the conservativeness of the values chosen must be justified.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	The sample collection should be carried out by experts or well-trained staff. Where the difference between the recorded and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary biomass should be re-measured.
Comments	

Data / Parameter	$Area_{GID,k,t}$
Data unit	ha
Description	Area of parcel *k* of identified grassland to which grazing activities will be relocated in year *t*
Equations	1 and 13
Source of data	Field measurements
Description of measurement methods and procedures to be applied	Data on the area of identified plots must be derived from field measurements taken in the first year in which displacement to the plot occurs.
Frequency of monitoring/recording	Annual for first five years

QA/QC procedures to be applied	Where the difference between the recorded grazed area and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the grazed area should be re-measured.
Comments	

Data / Parameter	$P_{GID,l,k,t}$
Data unit	Head
Description	Population of each type of livestock *l* displaced to identified grassland parcel *k* in year *t*
Equations	2, 3, 5, 10 and 12
Source of data	Project records
Description of measurement methods and procedures to be applied	Record annually or seasonally numbers of grazing livestock by type in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$\mathrm{Days}_{\mathrm{GID,l,k,t}}$
Data unit	Days
Description	Number days in year *t* that livestock of each type *l* graze on parcel *k* of identified grassland
Equations	3, 5, 10 and 12
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$H_{GID,l,t}$
Data unit	Hours
Description	Average grazing hours per day for each livestock type *l* in identified grassland in year *t*
Equations	10 and 12
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of hours per day livestock of each type graze in identified grassland. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$Area_{GID,k,t}$
Data unit	ha
Description	Area of parcel *k* of identified grassland to which grazing activities will be relocated in year *t*
Equations	1 and 13
Source of data	Field measurements
Description of measurement methods and procedures to be applied	Data on the area of identified plots must be derived from field measurements taken in the first year in which displacement to the plot occurs.
Frequency of monitoring/recording	Annual for first five years
QA/QC procedures to be applied	Where the difference between the recorded grazed area and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the grazed area should be re-measured.
Comments	

Data / Parameter	$P_{FID,l,t}$
Data unit	Head
Description	Population of each type of livestock *l* displaced to identified forest land in year *t*
Equations	16, 21 and 23
Source of data	Project records

Description of measurement methods and procedures to be applied	Record annually or seasonally numbers of grazing livestock by type in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$\mathrm{Days}_{\mathrm{FID,l,t}}$
Data unit	Days
Description	Number days in year *t* that livestock of each type *l* graze on identified forest land
Equations	16, 21 and 23
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$H_{FID,l,t}$
Data unit	Hours
Description	Average grazing hours per day for each livestock type *l* in identified forest land in year *t*
Equations	21 and 23
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of hours per day livestock of each type graze in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied

Comments	

Data / Parameter	$Area_{FID,k,t}$
Data unit	ha
Description	Area of parcel *k* of identified forest land to which grazing activities will be relocated in year *t*
Equations	24 and 27
Source of data	Field measurements
Description of measurement methods and procedures to be applied	Data on the area of identified plots must be derived from field measurements taken in the first year in which displacement to the plot occurs.
Frequency of monitoring/recording	Annual for first five years
QA/QC procedures to be applied	Where the difference between the recorded grazed area and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the grazed area should be re-measured.
Comments	

Data / Parameter	$B_{AB,FID,EQ,k}$
Data unit	t dm/ha
Description	Aboveground biomass in forest parcel *k* at least 5 years after introduction of grazing
Equations	26
Source of data	Field measurements, peer-reviewed scientific literature or national forest inventories
Description of measurement methods and procedures to be applied	Values must be based on measurements in forest plots that were similar to the plots that are planned to be deforested or degraded and sampling schemes must be used that produce estimates of biomass stocks remaining at least 5 years after the introduction of grazing activities that lead to conservative estimates of leakage emissions. Where no local studies of measurements have been undertaken, values from national forest inventories or values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 4.7, Chapter 4, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.
Frequency of monitoring/recording	Annual for first five years
QA/QC procedures to be	Quality control/quality assurance (QA/QC) procedures

applied	prescribed under national forest inventory must be applied. Where such procedures are not available, QA/QC procedures from published handbooks, or from the IPCC, 2003 *Good Practice Guidance for Land Use, Land Use Change and Forestry* (or the most recent version of IPCC good practice guidance for AFOLU) must be applied.
Comments	

Data / Parameter	$M_{BFID,k,t}$
Data unit	t dm/ha
Description	Fuel available for burning in parcel *k* in year t of identified forest land to which livestock are displaced
Equations	27
Source of data	Field measurements, forest inventories, scientific peer-reviewed publications or IPCC sources.
Description of measurement methods and procedures to be applied	Where project proponents have access to the lands to which grazing is displaced, project proponents must measure the dead organic matter and aboveground biomass before and after fire management in each of the first 5 years after grazing displacement began. Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the available fuel measured before and after fire management is the amount of fuel burnt. Where measurements are not feasible (eg, due to lack of access), values for $M_{BFID,k,t}$ must be taken from forest inventories or peer-reviewed scientific literature specific to the project region. Justification for conservativeness of the values chosen must be provided. Where data from forest inventories or peer-reviewed scientific literature are unavailable, the mean default value plus one standard error provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 2.4, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used.
Frequency of monitoring/ recording	Annual for first 5 years after grazing displacement began
QA/QC procedures to be applied	Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be used for guidance on sampling methods and QA/QC procedures.
Comments	Fuel includes dead organic matter plus live biomass available for burning in the forest land to which livestock are displaced.

Data / Parameter	$P_{CID,l,t}$
Data unit	Head
Description	Population of each type of livestock *l* displaced to identified crop land in year *t*
Equations	29, 33 and 35
Source of data	Project records
Description of measurement methods and procedures to be applied	Record annually or seasonally numbers of grazing livestock by type in each parcel. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$\mathrm{Days}_{\mathrm{CID,l,t}}$
Data unit	Days
Description	Number days in year *t* that livestock of each type *l* graze on identified crop land
Equations	29, 33 and 35
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in each parcel. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$H_{CID,l,t}$
Data unit	Hours
Description	Average grazing hours per day for livestock of each type *l* displaced to identified crop land in year *t*
Equations	33 and 35
Source of data	Documented management records or sample survey
Description of	Record annually or seasonally number of hours per day

measurement methods and procedures to be applied	livestock of each type grazing in each plot. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$Area_{PCID,k,t}$
Data unit	ha
Description	Area of parcel *k* of identified perennial cropland to which grazing activities will be relocated in year *t*
Equations	36 and 37
Source of data	Field measurements
Description of measurement methods and procedures to be applied	Data on the area of identified plots must be derived from field measurements taken in each of the first five years after displacement to the plot began.
Frequency of monitoring/recording	Annual for first five years
QA/QC procedures to be applied	Where the difference between the recorded grazed area and the new reading is more than 10 percent, reasons for the difference must be discussed with the staff responsible for taking both measurements, and if necessary the grazed area should be re-measured.
Comments	

Data / Parameter	$B_{PCID,k}$
Data unit	t dm/ha
Description	Aboveground biomass of perennial cropland to which livestock are displaced
Equations	36
Source of data	Field measurements, peer-reviewed literature or IPCC sources
Description of measurement methods and procedures to be applied	Values must be based on measurements in each perennial cropland plot that is planned to be grazed or on published studies in similar perennial croplands in the project region. Where no local studies or measurements have been undertaken, values provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Table 5.3, Chapter 5, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used. Justification for why the value chosen is conservative must be provided.

Frequency of monitoring/recording	Annual for first five years
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory must be applied. Where such procedures are not available, QA/QC procedures from published handbooks, or from the IPCC, 2003 *Good Practice Guidance for Land Use, Land Use Change and Forestry* (or the most recent version of IPCC good practice guidance for AFOLU) must be applied.
Comments	

Data / Parameter	$M_{BPID,k,t}$
Data unit	t dm/ha
Description	Fuel available for burning in parcel *k* in year t of identified perennial cropland to which livestock are displaced
Equations:	37
Source of data	Field measurements, forest inventories or scientific peer-reviewed publications.
Description of measurement methods and procedures to be applied	Where project proponents have access to the lands to which grazing is displaced, project proponents must measure the dead organic matter and aboveground biomass before and after fire management in each of the first 5 years after grazing displacement began. Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the available fuel measured before and after fire management is the amount of fuel burnt. Where measurements are not feasible (eg, due to lack of access), values for $M_{BPID,k,t}$ must be taken from forest inventories or peer-reviewed scientific literature specific to the project region. Justification for conservativeness of the values chosen must be provided.
Frequency of monitoring/ recording	Annual for first 5 years after grazing displacement began
QA/QC procedures to be applied	Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be used for guidance on sampling methods and QA/QC procedures.
Comments	Fuel includes dead organic matter plus live biomass available for burning in the forest land to which livestock are displaced to.

Data / Parameter	$P_{GUI,l,t}$
Data unit	Head

Description	Total population of livestock of each type relocated to unidentified grasslands in year *t*
Equations	39, 41, 46 and 48
Source of data	Project records
Description of measurement methods and procedures to be applied	Record annually or seasonally numbers of grazing in unidentified grasslands. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$\mathrm{Days}_{\mathrm{GUI,l,t}}$
Data unit	Days
Description	Days that the population of each type of relocated livestock of type *l* graze in unidentified grassland in year *t*
Equations	39, 41, 46 and 48
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in unidentified grassland. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$P_{PCUI,l,t}$
Data unit	Head
Description	Total population of livestock of each type relocated to unidentified perennial croplands in year *t*
Equations	51 and 53
Source of data	Project records
Description of measurement methods and procedures to be applied	The value must be determined following the procedure in 5.1.11 Step A (ie, based on the total number of livestock to be displaced to unidentified croplands and the fraction of perennial

	croplands in total croplands in the reference region).
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$P_{ACUI,l,t}$
Data unit	Head
Description	Total population of livestock of each type relocated to unidentified annual croplands in year *t*
Equations	53
Source of data	Project records
Description of measurement methods and procedures to be applied	The value must be determined following the procedure in 5.1.11 Step A (ie, based on the total number of livestock to be displaced to unidentified croplands and the fraction of annual croplands in total croplands in the reference region).
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$Days_{PCUI,l,t}$ and $Days_{CUI,l,t}$
Data unit	Days
Description	Days that the population of each type of livestock *l* graze in unidentified perennial croplands ($Days_{PCUI,l,t}$) or unidentified croplands ($Days_{CUI,l,t}$) in year *t*
Equations	51, 54, 58 and 60
Source of data	Documented management records or sample survey
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in unidentified cropland. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$M_{BPUI,t}$
Data unit	t dm/ha
Description	Fuel available for burning in year t of unidentified perennial cropland to which livestock are displaced
Equations:	62
Source of data	Field measurements, forest inventories or scientific peer-reviewed publications.
Justification of choice of data or description of measurement methods and procedures applied	Where project proponents have access to the lands to which grazing is displaced, project proponents must measure the dead organic matter and aboveground biomass before and after fire management in each of the first 5 years after grazing displacement began. Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the available fuel measured before and after fire management is the amount of fuel burnt. Where measurement is not feasible, values for $M_{BPUI,t}$ must be taken from forest inventories or peer-reviewed scientific literature specific to the project region. Justification for conservativeness of the values chosen must be provided.
Frequency of monitoring/ recording	Annual for first 5 years after grazing displacement began
QA/QC procedures to be applied	Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be used for guidance on sampling methods and QA/QC procedures.
Comments	Fuel includes dead organic matter plus live biomass available for burning in the forest land to which livestock are displaced to.

Data / Parameter	$P_{FUI,l,t}$
Data unit	Head
Description	Total population of livestock of each type *l* displaced to unidentified forest lands in year *t*
Equations	64, 66, 71 and 73
Source of data	Project records
Description of measurement methods and procedures to be applied	Record annually or seasonally numbers of grazing in unidentified forest lands. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Based on the grazing numbers, annual or seasonal average population of grazing livestock by type must be calculated.
Frequency of monitoring/recording	Annual

QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$\mathrm{Days}_{\mathrm{FUI,l,t}}$
Data unit	Days
Description	Days that the population of each type of livestock *l* displaced to unidentified forest lands in year *t*
Equations	64, 66, 71 and 73
Source of data	Project records
Description of measurement methods and procedures to be applied	Record annually or seasonally number of days livestock of each type graze in unidentified forest land. Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied
Comments	

Data / Parameter	$M_{BFUI,t}$
Data unit	t dm/ha
Description	Fuel available for burning in year *t* of unidentified forest land to which livestock are displaced
Equations:	76
Source of data	Field measurements, forest inventories, scientific peer-reviewed publications or IPCC sources.
Justification of choice of data or description of measurement methods and procedures applied	Where project proponents have access to the lands to which grazing is displaced, project proponents must measure the dead organic matter and aboveground biomass before and after fire management in each of the first 5 years after grazing displacement began. Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the available fuel measured before and after fire management is the amount of fuel burnt. Where measurement is not feasible, values for $M_{BFUI,t}$ must be taken from forest inventories or peer-reviewed scientific literature specific to the project region. Justification for conservativeness of the values chosen must be provided. Where data from forest inventories or peer-reviewed scientific literature are unavailable, the mean default value plus one standard error using provided by the *2006 IPCC Guidelines for*

	National Greenhouse Gas Inventories (Table 2.4, Chapter 2, Volume 4) or the most recent version of IPCC good practice guidance for AFOLU, must be used.
Frequency of monitoring/ recording	Annual for first 5 years after grazing displacement began
QA/QC procedures to be applied	Where sample surveys are used, the sample size must ensure precision at a 95 percent confidence interval with a precision of 15 percent. Guidance provided in IPCC, 2003 chapter 5 or IPCC, 2000 chapter 8 must be applied must be used for guidance on sampling methods and QA/QC procedures.
Comments	Fuel includes dead organic matter plus live biomass available for burning in the forest land to which livestock are displaced to.

7 REFERENCES

FAO. 2010. Global Assessment of Forest Resources 2010: Terms and Definitions. Rome, FAO

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

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

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

McSherry M. and Ritchie M. 2013. Effects of grazing on grassland soil carbon: a global review. Global Change Biology 19(5): 1347-1357

DOCUMENT HISTORY

Version	Date	Comment
v1.0	22 Apr 2014	Initial version