A/R methodological tool

"Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity"

(Version 01)

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

1. This tool can be used to estimate GHG emissions measurable and attributable to displacement of grazing activities caused by implementation of an A/R project activity.

2. The tool provides an annex with the default values for dry matter intake (DMI) and an equation for the calculation of DMI for livestock types. Further, it provides default values for annual net primary production (ANPP) by IPCC climate zones.

Definitions

3. For the purpose of this tool, the following definitions apply:

Zero-grazing system is defined as a system of feeding cattle or other livestock in which forage is brought to animals that are permanently housed instead of being allowed to graze. It is also sometimes called "cut-and-carry".

Grazing activities are defined as the grazing of animals of various types on lands and/or the production of fodder for animals in a zero-grazing system.

Displacement is defined as the relocation of grazing activities from areas of land within the project boundary to lands outside the project boundary. Animals that are sold to an entity not involved in the CDM project activity do not result in displacement attributable to the A/R CDM project activity.

Displacement management plan shall accompany the PDD to accommodate grazing activities that are displaced by the CDM activity. The plan shall provide information on the number of animals by type and time of relocation from all areas of land within the A/R CDM project boundary. If project participants know the geographical location of lands outside the project boundary to which the animals will be relocated, then this information shall also be included in the displacement management plan. The plan shall allow for *inter alia* the estimation of the number of animals by type that are displaced to lands located outside the project boundary for which the detailed geographical location is unknown.

Applicability

4. This tool is applicable for estimating GHG emissions caused by the displacement of grazing animals due to implementation of an A/R CDM project activity.

5. If the grazing animals are already in a zero-grazing system or are moved to a zero-grazing system then the grazing activity that is monitored is the production of fodder.

6. The tool can be used to estimate the emissions caused by displacement to:

- Identified Forest land;
- Identified Cropland covered with annual crops;
- Identified Grassland; and

- Unidentified land.

7. The tool is not applicable for estimating GHG emissions due to implementation of an A/R CDM project activity that causes displacement to:

- Cropland covered with perennial crops[1];
- Settlements[2];
- Wetlands; and
- Other lands – as defined by the GPG LULUCF (i.e. bare soil, rock, ice, and all unmanaged land areas that do not fall into category of forest land, cropland, grassland, settlements or wetlands.

Assumptions

8. The tool assumes that:

- The sale of grazing animals to an entity not involved in the CDM project activity or slaughter of grazing animals does not result in leakage.
- Carbon stocks in above-ground biomass, below-ground biomass, litter and dead wood pools are emitted to the atmosphere if the displacement results in deforestation, and
- Displacement of grazing activities to unidentified lands results in deforestation.

Parameters

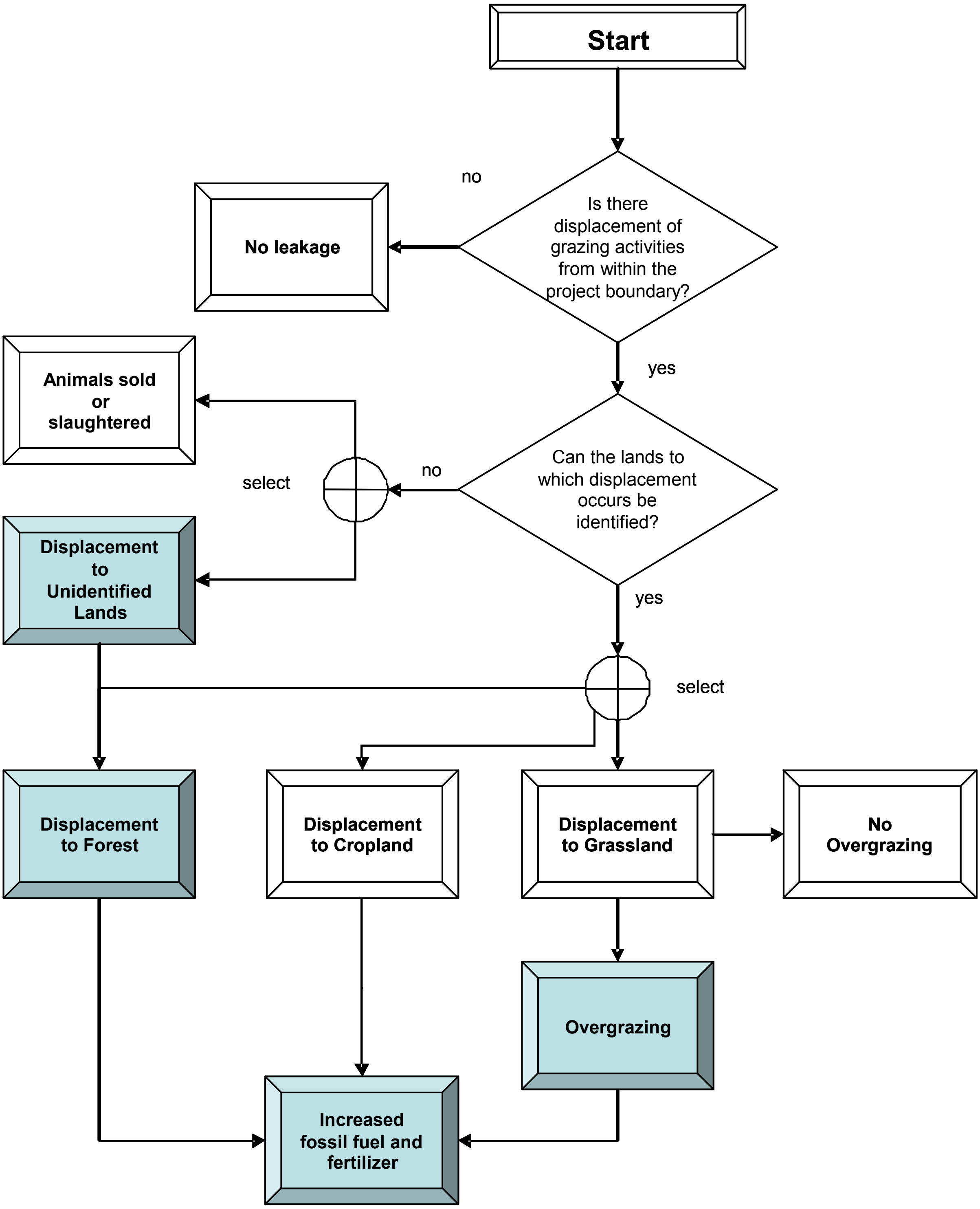
9. This tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$LK_{Displacement,t}$	$t\ CO_2e$	Leakage due to the displacement of animals in year *t*

[1] Perennial crops typical for cropland are defined in the Chapter 3.3 of the GPG LULUCF.

[2] As clarification when relocation of grazing animals is to a zero-grazing system in a settlement, one must focus on the displacement of the fodder production. The fodder production does not move to a settlement even though the animals may.

Figure 1: Flow chart for estimation process



Note: GHG emissions are caused by activities that are highlighted only. Activities not highlighted are assumed not to cause leakage.

II. PROCEDURE

The tool provides a step-wise procedure for estimating the emissions from the displacement of grazing activities.

10. **Step 1: Is there displacement of grazing activities from areas of land within the project boundary which are measurable and attributable to the afforestation or reforestation project activity?**

If yes then proceed to Step 2.

Otherwise there is no leakage related to displacement of grazing activities.

11. **Step 2: Is there displacement of grazing activities to unidentified lands?**

If yes then calculate the area of land that is required to sustain grazing activities for the for animals displaced to unidentified lands by:

$$DMI_{Unidentified,t} = \frac{\sum_{g} DMI_g * H_{Unidentified,g,t}}{1000} * 365 \quad \textbf{(1)}$$

where:

$DMI_{Unidentified,t}$	Total dry matter intake of grazing animals displaced to unidentified lands; t d.m./year
DMI_g	Daily dry matter intake per grazing animal of animal type *g*; kg d.m./head/day
$H_{Unidentified,g,t}$	Number of head of animals type *g* that are displaced to unidentified lands in year *t* and/or number of head of animals type *g* that are fed by the fodder collected from unidentified lands in year *t*; head

DMI_g values in table 3 provided in the annex can be used. Alternatively, use the equation from the annex to this tool if local data are available.

$$Area_{Unidentified,t} = \frac{DMI_{Unidentified,t}}{ANPP} \quad \textbf{(2)}$$

where:

$Area_{Unidentified,t}$	Area of unidentified land required to feed animals that are displaced in year *t*; ha
$DMI_{Unidentified,t}$	Total dry matter intake of grazing animals displaced to unidentified lands; t d.m./year
$ANPP$	Above-ground net primary productivity in tonnes dry biomass; t d.m./ha/yr

In equation 2 the values for ANPP from table 3.4.2 of IPCC GPG guidance as provided in the annex to this tool may be used. Alternatively, if local data for ANPP of grasslands are available, it can be used instead.

$Area_{Unidentified}$ will be used in Step 5.where it is assumed that the unidentified lands are forest land.

Proceed to Step 3.

12. **Step 3: Determination of GHG emissions caused by displacement to cropland**

Following the applicability condition, displacement to cropland covered by annual crops is considered to create no leakage emissions from land use change. However, there may be an increase in the amount of fertilizer used to increase productivity of land or the amount of fossil fuels needed, especially if in the situation of displacement of animals are displaced to stalls, barns, etc and the forage has to be transported from distant locations. The emissions caused by this increased use of fossil fuel and fertilizer should be calculated in Step 6.

Proceed to Step 4.

13. **Step 4: Determination of GHG emissions caused by displacement to grassland**

Based on the displacement management plan, identify the parcels of grassland that will receive displaced grazing activities in year *t*. Determine the area of each identified parcel *k* ($Area_{k,t}$).

For each parcel *k,* determine the number of grazing animals of type *g* displaced and/or the number of animals of type *g* fed by fodder for which production is displaced to parcel *k*, in year *t* ($H_{g,k,t}$).

Calculate the area required to sustain the grazing activities displaced to parcel *k* in year *t* ($A_{required,t}$) using:

$$DMI_{TOTAL,k,t} = \frac{\sum_{g} DMI_{g} * (H_{existing,g,k,t} + H_{g,k,t})}{1000} * 365 \qquad \textbf{(3)}$$

where:

$DMI_{TOTAL,k,t}$	Total dry matter intake of grazing animal on parcel *k* in year *t*; t d.m./year
DMI_g	Daily dry matter intake per grazing animal of animal type *g*; kg d.m./head/day
$H_{existing,g,k,t}$	Number of head of animal type *g* existing on parcel *k* and/or being fed by fodder produced on parcel *k* before displacement of animals in year *t*; head
$H_{g,k,t}$	Number of head of animal type *g* displaced and/or the number of animals of type *g* fed by fodder for which production is displaced to parcel *k* in year *t*; head

In equation 3, the DMI_g values provided in table 3 in the annex to this tool can be used. Alternatively, you may calculate DMI_g values using the equation from the annex if local data are available.

$$Area_{required,k,t} = \frac{DMI_{TOTAL,k,t}}{ANPP_{k}} \qquad \textbf{(4)}$$

where:

$Area_{required,k,t}$	Total area of land required for year *t* to sustain the grazing activities displaced to parcel *k*; (ha)
$DMI_{TOTAL,k,t}$	Total dry matter intake of grazing animals on parcel *k* in year *t*; t d.m./yr
$ANPP_k$	Above-ground net primary productivity of parcel *k* in tonnes dry biomass; t d.m./ha/yr

In equation 4 the values for ANPP from table 3.4.2 of IPCC GPG guidance as provided in the annex to this tool may be used to estimate $ANPP_k$. Alternatively, if local data for ANPP of parcel *k* are available, it can be used instead.

Apply the following four steps:

1) Identify all parcels where $Area_{required,k,t} > Area_{k,t}$

2) For each parcel identified above calculate:

$$LK_{Overgrazing,k,t} = Area_{k,t} * SOC_{REF,k} * (1 - F_{MG,SeverelyDegraded}) * \frac{44}{12} \tag{5}$$

3) Assume $LK_{Overgrazing,k,t} = 0$ for all parcels not identified in the Step 1;

4) Calculate the total GHG emissions related to overgrazing as:

$$LK_{Overgrazing,t} = \sum_k LK_{Overgrazing,t,k} \tag{6}$$

where:

$LK_{Overgrazing,k,t}$	Leakage due to overgrazing resulting from displacement to parcel *k* in year *t*; t CO_2e
$LK_{Overgrazing,t}$	Leakage due to overgrazing resulting from displacement in year *t*; t CO_2e
$Area_{k,t}$	Area of parcel *k* in year *t*; ha
$SOC_{REF,k}$	Reference soil organic stocks for parcel *k* - see table 3.4.4 IPCC GPG; t C / ha
$F_{MG,SeverelyDegraded}$	Stock change factor for management regime for severely degraded grassland = 0.7 - see table 3.4.5 IPCC GPG; dimensionless
$\frac{44}{12}$	Conversion factor from C to CO_2e; t CO_2e / t C

The increase in GHG emissions from displacement to grasslands that does not cause overgrazing is zero.

Proceed to step 5.

14. **Step 5: Determination of GHG emissions caused by displacement to forest land**

Identify the areas of forest land, $Area_{forest,k,t}$. used as part of a displacement management plan that will receive the displaced animals or the displaced fodder production for animals in stalls, barns, etc. in year *t*.

Calculate the CO_2 component of leakage that results from the potential deforestation using:

$$LK_{Deforestation-CO_2,t} = \left\{ \begin{array}{l} Area_{Unidentified,t} * \left[B_{AB} * \left(1 + R_{Ave}\right) + B_{Litter} + B_{Deadwood}\right] \\ + \sum_k Area_{forest,k,t} * \left[B_{AB,k} * \left(1 + R_k\right) + B_{Litter,k} + B_{Deadwood,k}\right] \end{array} \right\} * 0.5 * \frac{44}{12} \tag{7}$$

where:

$LK_{Deforestation-CO_2,t}$	Leakage due to biomass loss resulting from the displacement of animals and/or the displacement of fodder production to forest lands in year *t*; t CO_2e

$Area_{Unidentified,t}$	Area of unidentified land required to feed animals that are displaced in year *t*; ha – from equation 2
B_{AB}	Average above-ground woody biomass of forest land to which animals are displaced, t d.m./ha
B_{Litter}	Average litter on forest land to which animals are displaced; t d.m./ha
$B_{Deadwood}$	Average dead wood on forest land to which animals are displaced; t d.m./ha
R_{Ave}	Average biomass-weighted root-to-shoot ratio appropriate for biomass stock of forest land to which animals are displaced; t d.m./t d.m.
$Area_{forest,k,t}$	Area of identified forest land deforested to feed animals displaced in year *t*; ha
$B_{AB,k}$	Above-ground woody biomass of forest land parcel *k* to which animals are displaced; t d.m./ha
$B_{Litter,k}$	Litter on forest land parcel *k* to which animals are displaced; t d.m./ha
$B_{Deadwood,k}$	Dead wood on forest land parcel *k* to which animals are displaced; t d.m./ha
R_k	Root-to-shoot ratio for biomass stock of forest land parcel *k* to which animals are displaced; t d.m./t d.m.
0.5	IPCC default carbon fraction for woody biomass; t C/t d.m.
$\frac{44}{12}$	Conversion factor from C to CO_2e; t CO_2e/t C

Values of B_{AB}, B_{Litter}, $B_{Deadwood}$ and R_{Ave} should be based on local conditions supported by documented evidence or expert opinion. Alternatively, the values can be obtained from the IPCC GPG. For average litter values see Table 3.2.1. For average dead wood stocks, see Table 3.2.2 from GPG LULCF.

Values of $B_{AB,k}$, $B_{Litter,k}$, $B_{Deadwood,k}$ and R_k should be based on measurements, local conditions supported by documented evidence or expert opinion. Alternatively, one can use average values be obtained from the IPCC GPG. For average litter values see Table 3.2.1. For average dead wood stocks, see Table 3.2.2 from GPG LULCF.

Calculated the emissions from non-CO_2 greenhouse gasses that results from the potential deforestation assuming that the biomass is burnt using:

$$LK_{Deforestation-CH_4,t} = \left\{ \begin{array}{l} Area_{Unidentified,t} * \left[B_{Ave} + B_{Litter} + B_{Deadwood} \right] \\ + \sum_k Area_{forest,k,t} * \left[B_k + B_{Litter,k} + B_{Deadwood,k} \right] \end{array} \right\} * 0.5 * CE * ER_{CH_4} * \frac{16}{12} * GWP_{CH_4} \quad \textbf{(8)}$$

where:

$LK_{Deforestation,CH_4}$	Leakage related to non-CO_2 greenhouse gasses due to biomass burning resulting from the displacement of animals and/or the displacement of fodder production to forest lands; t CO_2

$Area_{Unidentified,t}$	Area of unidentified land required to feed animals that are displaced in year *t*; ha – from equation 2
B_{AB}	Average above-ground woody biomass of forest land to which animals are displaced; t d.m./ha
B_{Litter}	Average litter on forest land to which animals are displaced; t d.m./ha
$B_{Deadwood}$	Average dead wood on forest land to which animals are displaced; t d.m./ha
$Area_{forest,k,t}$	Area of identified forest land deforested to feed animals displaced in year *t*; ha
$B_{AB,k}$	Above-ground woody biomass of forest land parcel *k* to which animals are displaced; t d.m./ha
$B_{Litter,k}$	Litter on forest land parcel *k* to which animals are displaced; t d.m./ha
$B_{Deadwood,k}$	Dead wood on forest land parcel *k* to which animals are displaced; t d.m./ha
0.5	IPCC default carbon fraction for woody biomass; t C/t d.m.
CE	Average combustion efficiency for aboveground biomass (IPCC default: 0.5); dimensionless
ER_{CH4}	Emission ratio for CH_4 (use IPCC default value, 0.012)[3]; *kg C as* CH_4 *(kg C burned)*$^{-1}$
$\frac{16}{12}$	Conversion factor from C to CH_4, t CH_4/t C
GWP_{CH_4}	Global warming potential of CH_4 = 21; $t\ CO_2e\ /\ t\ CH_4$

Values of B_{AB}, B_{Litter}, $B_{Deadwood}$ and R_{Ave} should be based on local conditions supported by documented evidence or expert opinion. Alternatively, the values can be obtained from the IPCC GPG. For average litter values see Table 3.2.1. For average dead wood stocks, see Table 3.2.2 from GPG LULCF.

Values of $B_{AB,k}$, $B_{Litter,k}$, $B_{Deadwood,k}$ and R_k should be based on measurements, local conditions supported by documented evidence or expert opinion. Alternatively, one can use average values obtained from the IPCC GPG. For average litter values see Table 3.2.1. For average dead wood stocks, see Table 3.2.2 from GPG LULCF.

The N_2O emissions from leakage that results from the potential deforestation, assuming that the biomass is burnt, are considered negligible.

Calculate the leakage from deforestation using:

$$LK_{Deforestation,t} = LK_{Deforestation-CO_2,t} + LK_{Deforestation-CH_4,t} \quad \textbf{(9)}$$

[3] Table 3A.1.15, Annex 3A.1, *GPG-LULUCF* (IPCC 2003).

where:

$LK_{Deforestation,t}$	Total leakage from the displacement of animals and/or the displacement of fodder production to forest lands; t CO_2e
$LK_{Deforestation,CO_2,t}$	Leakage due to biomass loss resulting from the displacement of animals and/or the displacement of fodder production to forest lands in year *t*; t CO_2e
$LK_{Deforestation,CH_4,t}$	Leakage related to non-CO_2 greenhouse gasses due to biomass burning resulting from the displacement of animals and/or the displacement of fodder production to forest lands; t CO_2e

Proceed to Step 6:

Step 6: Determination of GHG emissions caused by an increase in fossil fuel and fertilizer use due to the displacement

15. Emission from the increase in fossil fuels for example due to the transportation of fodder or manure, and/or application of fertilizers and the increase in fertilizer use may occur annually as a result of the displacement of grazing animals or the displacement of fodder production to feed animals, should be calculated using the appropriate tool.

16. If the displacement increases the emissions from the use of fossil fuels that are measurable and attributable to the A/R CDM project activity, the estimation of this increase shall be accounted for as requested by the approved baseline and monitoring methodology.

17. If the emissions from the increase of fertilizer use for management of the land receiving the displacement are not already accounted for in the approved baseline and monitoring methodology then identify the annual increase in synthetic and organic fertilizers required as a result of the displacement, $M_{SN\text{-}Displacement,t}$ and $M_{ON\text{-}Displacement,t}$

Calculate the emissions from the increase in fertilizer use attributable to displacement using:

$$LK_{N2O-Displacement,y} = \left(F_{SN-Displacement,t} + F_{ON-Displacement,t}\right) * EF_1 * \frac{44}{28} * GWP_{N2O} \quad \textbf{(10)}$$

and

$$F_{SN-Displacement,t} = \sum_i M_{SN-Displacement,m,t} * NC_m * \left(1 - Frac_{GASF}\right) \quad \textbf{(11)}$$

and

$$F_{ON-Displacement,t} = \sum_j M_{ON-Displacement,o,t} * NC_o * \left(1 - Frac_{GASM}\right) \quad \textbf{(12)}$$

where:

$LK_{N2O-Displacement,t}$	Leakage due to increased fertilizer use in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity t CO_2e
$F_{SN-Displacement,t}$	Mass of increased synthetic fertilizer nitrogen applied in year *t* adjusted for volatilization as NH3 and NO_X; t N
$F_{ON-Displacement,t}$	Mass of increased organic fertilizer nitrogen applied in year *t* adjusted for volatilization as NH3 and NO_X; t N

$M_{SN-Displacement,m,t}$	Mass of increased synthetic fertilizer type *m* applied in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity; t
$M_{ON-Displacement,o,t}$	Mass of increased organic fertilizer type *o* applied in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity; t
EF_1	Emission factor for emissions from N inputs; t N_2O-N / t N
$\frac{44}{28}$	Ratio of molecular weights of N_2O and N; t N_2O-N / t N
GWP_{N2O}	Global Warming Potential for N_2O, (t CO_2e / t N_2O) [IPCC default = 310, valid for the first commitment period]
NC_m	Nitrogen content of synthetic fertilizer *m*; t N / t fertilizer
NC_o	Nitrogen content of organic fertilizer *o*; t N / t fertilizer
$Frac_{GASF}$	Fraction that volatilises as $NH_3$and NO_X for synthetic fertilizers; dimensionless
$Frac_{GASM}$	Fraction that volatilises as NH_3 and NO_X for organic fertilizers; dimensionless

As noted in IPCC 2006 Guidelines (table 11.1), the default emission factor (*EF1*) is 1% of applied N, and this value should be used when country-specific factors are unavailable. The default values for the fractions of synthetic and organic fertilizer nitrogen that are emitted as NO_X and NH_3 are 0.1 and 0.2 respectively in 2006 IPCC Guidelines (Table 11.3). Project participants may use emission factors from the peer reviewed scientific literature that are specific for the project area.

Step 7: Estimation of total leakage from displacement of grazing animals

18. The total leakage from the displacement of grazing animals is given by:

$$LK_{Displacement,t} = LK_{Overgrazing,t} + LK_{Deforestation,t} + LK_{N_2O-Displacement,t} \quad \textbf{(13)}$$

where:

$LK_{Displacement,t}$	The total GHG emissions of leakage due to the displacement of animals in year *t*; t CO_2e
$LK_{Overgrazing,t}$	Leakage due to overgrazing resulting from displacement in year *t*; t CO_2e
$LK_{Deforestation,t}$	Leakage due to biomass loss resulting from the displacement of animals and/or the displacement of fodder production to forest lands in year *t*; t CO_2e
$LK_{N_2O-Displacement,t}$	Leakage due to increased fertilizer use in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity t CO_2e

Appendix A

1. Annual net primary production *ANPP* can be calculated from local measurements or default values from Table 3.4.2 of IPCC good practice guidance LULUCF can be used. This table is reproduced below as Table 1.

2. The daily biomass consumption can be calculated from local measurements or estimated based on the calculated daily gross energy intake and the estimated dietary net energy concentration of diet:

$$DMI = \frac{GE}{NE_{ma}} \quad \textbf{(A.1)}$$

where:

DMI	Dry matter intake; kg d.m./head/day
GE	Daily gross energy intake; MJ/head/day
NE_{ma}	Dietary net energy concentration of diet; MJ/kg d.m.

3. Daily gross energy intake for cattle and sheep can be calculated using equations 10.3 through 10.16 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use (AFOLU)[4]. Sample calculations for typical herds in various regions of the world are provided in Table 2; input data stems from Table 10A.2 of the same 2006 IPCC Guidelines. Dietary net energy concentrations as listed in Table 3 can be calculated using the formula listed in a footnote to Table 10.8 of the same 2006 IPCC Guidelines.

[4] Paustian, K., Ravindranath, N.H., and van Amstel, A., 2007. *2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use (AFOLU)*. Intergovernmental Panel on Climate Change (IPCC).

Table 1: Table 3.4.2 from GPG LULUCF

TABLE 3.4.2

DEFAULT ESTIMATES FOR STANDING BIOMASS GRASLAND (AS DRY MATTER) AND ABOVEGROUND NET PRIMARY PRODUCTION, CLASSIFIED BY IPCC CLIMATE ZONES.

IPCC Climate Zone	Peak above- ground live biomass Tonnes d.m. ha^{-1}			Above-ground net primary production (ANPP) Tonnes d.m. ha^{-1}		
	Average	**No. of studies**	**Error[#]**	**Average**	**No. of studies**	**Error[1]**
Boreal-Dry & Wet[2]	1.7	3	±75%	1.8	5	±75%
Cold Temperate-Dry	1.7	10	±75%	2.2	18	±75%
Cold Temperate-Wet	2.4	6	±75%	5.6	17	±75%
Warm Temperate-Dry	1.6	8	±75%	2.4	21	±75%
Warm Temperate-Wet	2.7	5	±75%	5.8	13	±75%
Tropical-Dry	2.3	3	±75%	3.8	13	±75%
Tropical-Moist & Wet	6.2	4	±75%	8.2	10	±75%

Data for standing live biomass are compiled from multi-year averages reported at grassland sites registered in the ORNL DAAC NPP database [http://www.daac.ornl.gov/NPP/html_docs/npp_site.html]. Estimates for above-ground primary production are from: Olson, R. J.J.M.O. Scurlock, S.D. Prince, D.L. Zheng, and K.R. Johnson (eds.). 2001. NPP Multi-Biome: NPP and Driver Data for Ecosystem Model-Data Intercomparison. Sources available on-line at [http://www.daac.ornl.gov/NPP/html_docs/EMDI_des.html].

[1]Represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean.

[2]Due to limited data, dry and moist zones for the boreal temperate regime and moist and wet zones for the tropical temperature regime were combined.

Table 2: Data for typical cattle herds for the calculation of daily gross energy requirement

Cattle - Africa								
	Weight (kg)	**Weight Gain (kg/day)**	**Milk (kg/day)**	**Work (hrs/day)**	**Pregnant**	**DE**	**Coefficient for NE_m equation**	**Mix (of grazing)**
Mature Females	200	0.00	0.30	0	33%	55%	0.365	8%
Mature Males	275	0.00	0.00	0	0%	55%	0.370	33%
Young	75	0.10	0.00	0	0%	60%	0.361	59%
Weighted Average	**152**	**0.06**	**0.02**	**0**	**3%**	**58%**	**0.364**	**100%**
Cattle - Asia								
	Weight (kg)	**Weight Gain (kg/day)**	**Milk (kg/day)**	**Work (hrs/day)**	**Pregnant**	**DE**	**Coefficient for NE_m equation**	**Mix (of grazing)**
Mature Females	300	0.00	1.10	0	50%	60%	0.354	18%
Mature Males	400	0.00	0.00	0	0%	60%	0.370	16%
Young	200	0.20	0.00	0	0%	60%	0.345	65%
Weighted Average	**251**	**0.13**	**0.20**	**0**	**9%**	**60%**	**0.350**	**100%**
Cattle - India								
	Weight (kg)	**Weight Gain (kg/day)**	**Milk (kg/day)**	**Work (hrs/day)**	**Pregnant**	**DE**	**Coefficient for NE_m equation**	**Mix (of grazing)**
Mature Females	125	0.00	0.60	0.0	33%	50%	0.365	40%
Mature Males	200	0.00	0.00	2.7	0%	50%	0.370	10%
Young	80	0.10	0.00	0.0	0%	50%	0.332	50%
Weighted Average	**110**	**0.05**	**0.24**	**0.3**	**13%**	**50%**	**0.349**	**100%**
Cattle - Latin America								
	Weight (kg)	**Weight Gain (kg/day)**	**Milk (kg/day)**	**Work (hrs/day)**	**Pregnant**	**DE**	**Coefficient for NE_m equation**	**Mix (of grazing)**
Mature Females	400	0.00	1.10	0	67%	60%	0.343	37%
Mature Males	450	0.00	0.00	0	0%	60%	0.370	6%
Young	230	0.30	0.00	0	0%	60%	0.329	57%
Weighted Average	**306**	**0.17**	**0.41**	**0**	**25%**	**60%**	**0.337**	**100%**
Sheep								
	Weight (kg)	**Weight Gain (kg/day)**	**Milk (kg/day)**	**Wool (kg/year)**	**Pregnant**	**DE**	**Coefficient for NE_m equation**	**Mix (of grazing)**
Mature Females	45	0.00	0.70	4	50%	60%	0.217	40%
Mature Males	45	0.00	0.00	4	0%	60%	0.217	10%
Young	5	0.11	0.00	2	0%	60%	0.236	50%
Weighted Average	**25**	**0.05**	**0.28**	**3**	**20%**	**60%**	**0.227**	**100%**

Table 3: Daily energy requirement and dry matter intake calculation

Cattle

Region	Average Characteristics							Energy (MJ/head/day)										Consumption	
	Weight (kg)	Weight gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Preg-nant	DE	CF	Mainte-nance	Activity (note 1)	Growth	Lactation (note 2)	Power	Wool	Preg-nancy	REM	REG	**Gross**	NE_{ma} (MJ/kg - note 5)	**DMI** (kg/head/day)
Africa	152	0.06	0.02	0.0	3%	58%	0.364	15.7	5.7	1.2	0.0	0.0	0	0.0	0.49	0.26	**84.0**	5.2	**16.2**
Asia	251	0.13	0.20	0.0	9%	60%	0.350	22.1	8.0	2.8	0.3	0.0	0	0.2	0.49	0.28	**119.8**	5.5	**21.9**
India	110	0.05	0.24	0.3	13%	50%	0.349	11.8	4.3	1.0	0.4	0.3	0	0.2	0.44	0.19	**87.6**	4.0	**21.6**
Latin America	306	0.17	0.41	0.0	25%	60%	0.337	24.6	8.9	3.8	0.6	0.0	0	0.6	0.49	0.28	**139.5**	5.5	**25.5**

Sheep

Region	Average Characteristics							Energy (MJ/head/day)										Consumption	
	Weight (kg)	Weight gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Preg-nant	DE	CF	Mainte-nance	Activity (note 3)	Growth	Lactation (note 4)	Power	Wool	Preg-nancy	REM	REG	**Gross**	NE_{ma} (MJ/kg - note 5)	**DMI** (kg/head/day)
All regions	25	0.05	0.28	3.0	20%	60%	0.227	2.5	0.6	1.5	1.29	0	0.2	0.0	0.49	0.28	**25.0**	5.5	**4.6**

Notes

1. Assumes grazing
2. Assumes 4% milk fat
3. Assumes grazing on hilly terrain
4. Assumes 7% milk fat
5. Calculated using equation listed in Table 10.8

List of parameters and variables:

1. Defaults

Variable:	Unit:	Description:	Source of data:	Any comment:
ANPP	*(t d.m.)/ha/yr*	Above-ground net primary productivity in tonnes dry biomass	Local data or values from table 3.4.2 of IPCC GPG guidance as provided in the annex to this tool	
$ANPP_k$	*(t d.m.)/ha/yr*	Above-ground net primary productivity of parcel *k* in tonnes dry biomass	Local data or values from table 3.4.2 of IPCC GPG guidance as provided in the annex to this tool	
B_{AB}	*t dm / ha*	Average above-ground woody biomass of unidentified forest land to which animals are displaced	Estimated based on local conditions supported by documented evidence or expert opinion. Otherwise, values can be estimated from the IPCC GPG LULCF	
$B_{Deadwood}$	*t dm / ha*	Average dead wood on unidentified forest land to which animals are displaced	Estimated based on local conditions supported by documented evidence or expert opinion. Otherwise, values can be estimated from the IPCC GPG LULCF	
B_{Litter}	*t dm / ha*	Average litter on unidentified forest land to which animals are displaced	Based on local conditions supported by documented evidence or expert opinion. Otherwise, values can be estimated from the IPCC GPG LULCF	
CE	*Dimensionless*	Average combustion efficiency for aboveground biomass	IPCC	IPCC default is 0.5

Variable:	Unit:	Description:	Source of data:	Any comment:
DMI_g	*kg d.m./ head/ day*	Daily dry matter intake per grazing animal of animal type g	Calculated using the equation from the annex to this tool if local data are available. Alternatively, use default values provided in table 3 of the annex to this tool.	
EF_1	$t\ N_2O\text{-}N / t\ N$	Emission factor for emissions from N inputs	Country-specific values or IPCC	The default emission factor is 1% of applied N as per IPCC 2006 Guidelines (table 11.1). This value should be used when country-specific factors are unavailable
ER_{CH4}	*kg C as* CH_4 *(kg C burned)*$^{-1}$	Emission ratio for CH_4	IPCC	Use IPCC default value, 0.012 from table 3A.1.15, Annex 3A.1, *GPG-LULUCF* (IPCC 2003)
$F_{MG,SeverelyDegraded}$	*Dimensionless*	Stock change factor for management regime for severely degraded grassland	IPCC	IPCC default is 0.7 (table 3.4.5 IPCC GPG)
$Frac_{GASF}$	*Dimensionless*	Fraction that volatilises as $NH_3$and NO_X for synthetic fertilizers	Peer reviewed scientific literature that are specific for the project area or 2006 IPCC Guidelines (Table 11.3)	IPCC default is 0.1 as per 2006 IPCC Guidelines (Table 11.3)
$Frac_{GASM}$	*Dimensionless*	Fraction that volatilises as NH_3 and NO_X for organic fertilizers	Peer reviewed scientific literature that are specific for the project area or 2006 IPCC Guidelines (Table 11.3)	IPCC default is 0.2 as per 2006 IPCC Guidelines (Table 11.3)

Variable:	Unit:	Description:	Source of data:	Any comment:
GE	*MJ/head/day*	Daily gross energy intake	Calculated using equations 10.3 through 10.16 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use (AFOLU) or use defaults values as provided in table 2 of the appendix to this tool	
GWP_{CH4}	$t\ CO_2e\ /\ t\ CH_4$	Global warming potential of CH_4	IPCC	IPCC default is 21 (valid for the first commitment period)
GWP_{N2O}	$t\ CO2e\ /\ t\ N_2O$	Global Warming Potential for N_2O	IPCC	IPCC default is 310 (valid for the first commitment period)
NE_{ma}	*MJ/kg d.m.*	Dietary net energy concentration of diet	Calculated using the formula listed in a footnote to Table 10.8 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use (AFOLU) or use defaults values as provided in table 3 of the appendix to this tool	
R_{Ave}	*t dm / t dm*	Average biomass-weighted root-to-shoot ratio appropriate for biomass stock of forest land to which animals are displaced	Based on local conditions supported by documented evidence or expert opinion. Alternatively, default values can be estimated from the IPCC GPG LULCF	
R_k	*t dm / t dm*	Root-to-shoot ratio for biomass stock of forest land parcel *k* to which animals are displaced	Local measurements. Alternatively, default values can be estimated from the IPCC GPG LULCF	
$SOC_{REF,k}$	*t C / ha*	Reference soil organic stocks for parcel *k*	Table 3.4.4 of IPCC GPG	

2. Data and parameters estimated for the *ex-ante* and monitored for *ex-post* calculations

Data/parameter:	Data unit:	Description:	Source of data:	Measurement procedure (if any):	Monitoring frequency:	Any comment:
$Area_{k,t}$	*ha*	Area of parcel *k*	Estimated in displacement plan and measured ex-post	Measured e.g using GPS, remote sensing or other geodesic methods	Determined at year of displacement	
$Area_{forest,k,t}$	*ha*	Area of identified forest land deforested to feed animals displaced in year *t*	Estimated in displacement plan and measured ex-post	Measured e.g using GPS, remote sensing or other geodesic methods	Determined at year of displacement	
$B_{AB,k}$	*t dm / ha*	Above-ground woody biomass of forest land parcel *k* to which animals are displaced	Based on local measurements. Otherwise, values can be estimated from the IPCC GPG LULCF	If determined based on local measurements, use approach for estimating woody biomass contained in the methodology using this tool	Determined at year of displacement	
$B_{Deadwood,k}$	*t dm / ha*	Dead wood on forest land parcel *k* to which animals are displaced	Based on local measurements. Alternatively, values can be estimated from the IPCC GPG LULCF	If determined based on local measurements, use approach for estimating deadwood contained in the methodology using this tool. If the methodology does not account for changes in the deadwood pool, use other approach e.g. the one contained in section III.5.a.3 of AR-AM0002	Determined at year of displacement	
$B_{Litter,k}$	*t dm / ha*	Litter on forest land parcel *k* to which animals are displaced	Based on local measurements. Alternatively, values can be estimated from the IPCC GPG LULCF	If determined based on local measurements, use approach for estimating litter contained in the methodology using this tool. If the methodology does not account for changes in the litter pool, use other approach e.g. the one contained in section III.5.a.4 of AR-AM0002	Determined at year of displacement	

Data/parameter:	Data unit:	Description:	Source of data:	Measurement procedure (if any):	Monitoring frequency:	Any comment:
$H_{existing,g,k,t}$	*Head*	Number of head of animal type *g* existing on parcel *k* and/or being fed by fodder produced on parcel *k* before displacement of animals in year *t*	Estimated in displacement plan and monitored	E.g. through animal census	Determined at year of displacement	
$H_{g,k,t}$	*Head*	Number of head of animal type *g* displaced and/or the number of animals of type *g* fed by fodder for which production is displaced to parcel *k* in year *t*	Estimated in displacement plan and monitored	E.g. through animal census	Determined at year of displacement	
$H_{Unidentified,g,,t}$	*Head*	Number of head of animals type *g* that are displaced to unidentified lands in year *t* and number of head of animals type *g* that are fed by the fodder collected from unidentified lands in year *t*	Estimated in displacement plan and monitored	E.g. through animal census	Determined at year of displacement	
$M_{ON\text{-}Displacement,o,t}$	*t*	Mass of increased organic fertilizer type *o* applied in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity	Estimated ex-ante and measured ex-post	E.g. through invoices or other verifiable evidence		

Data/parameter:	Data unit:	Description:	Source of data:	Measurement procedure (if any):	Monitoring frequency:	Any comment:
$M_{SN\text{-}Displacement,m,t}$	*t*	Mass of increased synthetic fertilizer type *m* applied in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity	Estimated ex-ante and measured ex-post	E.g. through invoices or other verifiable evidence		
NC_m	*t N / t fertilizer*	Nitrogen content of synthetic fertilizer *m*	Factory data	From factory data or other verifiable evidence		
NC_o	*t N / t fertilizer*	Nitrogen content of organic fertilizer *o*	Factory data	From factory data or other verifiable evidence		

3. Other variables:

Variable:	Unit:	Description:
$Area_{required,k,t}$	*ha*	Total area of land required for year *t* to sustain the grazing activities displaced to parcel *k*
$Area_{Unidentified,t}$	*ha*	Area of unidentified land required to feed animals that are displaced in year *t*
$DMI_{TOTAL,k,t}$	*t d.m./year*	Total dry matter intake of grazing animals on parcel *k* in year *t*
$DMI_{Unindentified,\ t}$	*t d.m./year*	Total dry matter intake of grazing animals displaced to unidentified lands
$F_{ON\text{-}Displacement,t}$	*t N*	Mass of increased organic fertilizer nitrogen applied in year *t* adjusted for volatilization as NH_3 and NO_X
$F_{SN\text{-}Displacement,t}$	*t N*	Mass of increased synthetic fertilizer nitrogen applied in year *t* adjusted for volatilization as NH3 and NO_X,
$LK_{Deforestation,t}$	$t\ CO_2e$	Total leakage from the displacement of animals and/or the displacement of fodder production to forest lands
$LK_{Deforestation\text{-}CO2,t}$	*t CO2e*	Leakage due to biomass loss resulting from the displacement of animals and/or the displacement of fodder production to forest lands in year *t*
$LK_{Deforestation,CH4}$	$t\ CO_2$	Leakage from non-CO_2 greenhouse gasses due to biomass burning resulting from the displacement of animals and/or the displacement of fodder production to forest lands
$LK_{Displacement,t}$	$t\ CO_2e$	Leakage due to the displacement of animals in year *t*
$LK_{N2O\text{-}Displacement,t}$	$t\ CO_2e$	Leakage due to increased fertilizer use in year *t* on all parcels to which grazing activities have been displaced since the start of the project activity
$LK_{Overgrazing,t}$	$t\ CO_2e$	Leakage due to overgrazing resulting from displacement in year *t*

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History of the document

Version	Date	Nature of revision
01	EB 36, Annex 19, 30 November 2007	Initial adoption