Draft 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:

1. 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.
2. 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
3. Displacement of grazing activities to unidentified lands results in deforestation.

Parameters

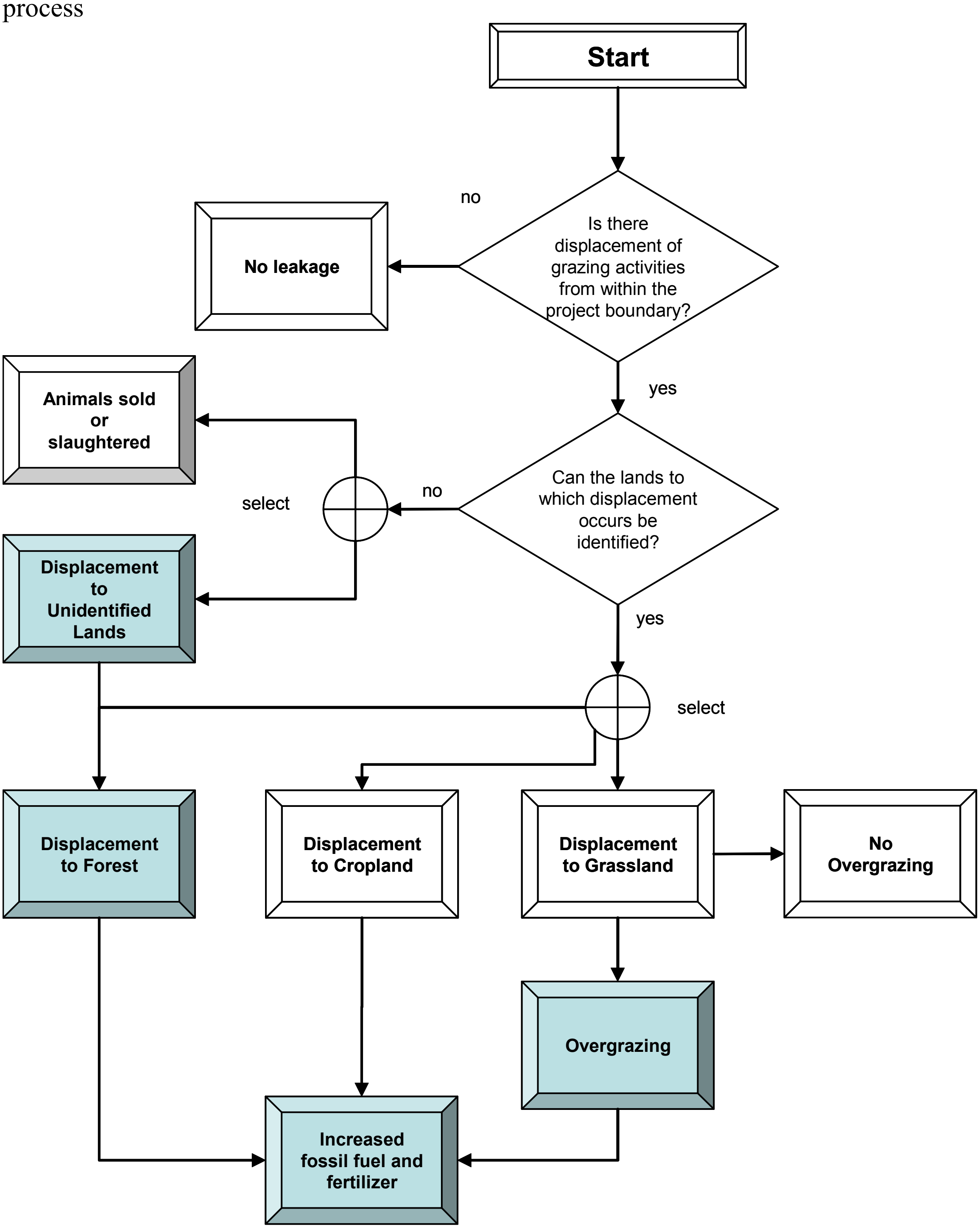
9. This tool provides procedures to determine the following parameter:

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

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

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?

11. If yes then proceed to Step 2.

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

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

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

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

where:

$DMI_{Unidentified,t}$	total dry matter intake of grazing animals displaced to unidentifed 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 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.

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

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 unidentifed 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.

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

13. 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.

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

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

Determine the number of grazing animals of type *g* displaced or the number of animals of type *g* fed by fodder that is displaced to grassland parcel *k*, $H_{g,k,t}$ in year *t*.

Calculate the area of $Area_{grassland,k}$ for animal type *g* using:

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

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* on parcel *k* existing before displacement of animals in year *t [head]*
$H_{g,k,t}$	Number of head of animal type *g* displaced or the number of animals of type *g* fed by fodder that 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 use the the DMI_g values using the equation from the annex if local data are available.

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

where:

$Area_{required,k,t}$	Total area of land required for year *t* to sustain the animals in 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.

Calculate the area of land overgrazed using:

$Area_{Overgrazed,k,t} = \sum_{g} A_{g,k,t}$ only $A_{g,k,t}$ for which $Area_{required,k,t} - A_{g,k,t} > 0$ shall be involved in the summation **(5)**

where:

$Area_{Overgrazed,k,t}$	Area overgrazed on parcel *k* caused by displacement in year *t [ha]*
$Area_{required,k,t}$	Total area of land required for year *t* to sustain the animals required in parcel *k [ha]*
$A_{g,k,t}$	Area of land in parcel *k* for animal type *g* displaced in year *t[ha]*

Calculate the GHG emissions related to overgrazing as:

$$LK_{Overgrazing,t} = \sum_{k} Area_{Overgrazed,k,t} * \left[SOC_{REF,k} * \left(1 - F_{MG,SeverelyDegraded}\right)\right] * \frac{44}{12} \qquad (6)$$

where:

$LK_{Overgrazing,t}$	Leakage from overgrazing due to displacement in year *t [t CO_2e]*
$Area_{Overgrazed,k,t}$	Area overgrazed on 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 CO2e / t C]*

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

Proceed to step 5.

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

15. 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:

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

where:

$LK_{Deforestation-CO_2,t}$	CO_2 emissions from leakage due to the displacement of animals or the displacement of fodder production in year *t* to forest lands, *[t CO2e]*
$Area_{Unidentified,t}$	Area of unidentified land required to feed animals that are displaced in year *t [ha]* – from equation 1
B_{AB}	Average above-ground woody biomass of forest land to which animals are displaced, *[t dm / ha]*
B_{Litter}	Average litter on forest land to which animals are displaced, *[t dm / ha]*
$B_{Deadwood}$	Average dead wood on forest land to which animals are displaced, *[t dm / ha]*
R_{Ave}	Average biomass-weighted root-to-shoot ratio appropriate for biomass stock of forest land to which animals are displaced, *[t dm / t dm]*
$Area_{forest,k,t}$	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 dm / ha]*
$B_{Litter,k}$	Litter on forest land parcel *k* to which animals are displaced, *[t dm / ha]*
$B_{Deadwood,k}$	Dead wood on forest land parcel *k* to which animals are displaced, *[t dm / ha]*
R_k	Root-to-shoot ratio for biomass stock of forest land parcel *k* to which animals are displaced, *[t dm / t dm]*
0.5	IPCC default carbon fraction for woody biomass; *[t C/ t dm]*
$\frac{44}{12}$	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 CH_4 component of leakage that results from the potential deforestation assuming that the biomass is burnt using:

$$LK_{Deforestation-CH_4,t} = \left\{ \begin{array}{l} Area_{Unidentified,t} * \left[B_{Ave} + B_{Litter} + B_{Deadwood} \right] \\ + \sum_k Area_{forest,k,t} * \left[B_k + B_{Litter,k} + B_{Deadwood,k} \right] \end{array} \right\} * 0.5 * CE * 0.012 * \frac{16}{12} \qquad \textbf{(8)}$$

where:

$LK_{Deforestation,CH_4}$	CH_4 emissions of leakage due to the displacement of animals to forest lands, *[t CH_4]*

$Area_{Unidentified,t}$	Area of unidentified land required to feed animals that are displaced in year *t [ha]* – from equation 1
B_{AB}	Average above-ground woody biomass of forest land to which animals are displaced, *[t dm / ha]*
B_{Litter}	Average litter on forest land to which animals are displaced, *[t dm / ha]*
$B_{Deadwood}$	Average dead wood on forest land to which animals are displaced, *[t dm / 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 dm / ha]*
$B_{Litter,k}$	Litter on forest land parcel *k* to which animals are displaced, *[t dm / ha]*
$B_{Deadwood,k}$	Dead wood on forest land parcel *k* to which animals are displaced, *[t dm / ha]*
0.5	IPCC default carbon fraction for woody biomass; *[t C/ t dm]*
CE	Average combustion efficiency for aboveground biomass (IPCC default: 0.5); dimensionless
0.012	Emission ratio - from Table 3A.1.19 of GPG LULUCF
$\frac{16}{12}$	Conversion factor from C to CH_4, *[t CH_4 / 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 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:

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

where:

$LK_{Deforestation,t}$	Total GHG emissions of leakage due to displacement in year *t* to forest lands, *[t CO_2e]*
$LK_{Deforestation,CO_2,t}$	CO_2 component of leakage due to displacement in year *t* to forest lands, *[t CO2e]*
$LK_{Deforestation,CH_4,t}$	CH_4 emissions of leakage due to displacement in year *t* to forest lands *[t CH_4]*

GWP_{CH_4}	Global warming potential of CH_4 = 21 *[t CO_2e / t CH_4]*

Proceed to Step 6:

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

16. 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.

17. 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.

18. 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:

$LK_{N2O-Displacement,t}$	Direct N_2O emission as a result of increased fertilizer use in year t as a result of all previous displacement [t CO_2e]
$F_{SN-Displacement,t}$	Mass of synthetic fertilizer nitrogen applied in year t adjusted for volatilization as NH3 and NO_X, [t N]
$F_{ON-Displacement,t}$	Mass of organic fertilizer nitrogen applied in year t adjusted for volatilization as NH3 and NO_X, [t N]
$M_{SN-Displacement,m,t}$	Mass of synthetic fertilizer type m applied in year t [t]
$M_{ON-Displacement,o,t}$	Mass of organic fertilizer type o applied in year t [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 CO2e / 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

19. 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 from overgrazing due to displacement in year *t [t CO_2e]*
$LK_{Deforestation,t}$	Total GHG emissions of leakage due to displacement in year *t* to forest lands, *[t CO_2e]*
$LK_{N_2O-Displacement,t}$	Direct N_2O emission as a result of increased fertilizer use in year *t* as a result of all previous displacement, *[t CO_2]*

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:

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

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)[3]. 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.

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[3] 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	Weight gain	Milk	Work	Pregnant	DE	CF	Maintenance	Activity	Growth	Lactation	Power	Wool	Pregnancy	REM	REG	**Gross**	NE_{ma}	**DMI**
	(kg)	(kg/day)	(kg/day)	(hrs/day)					(note 1)		(note 2)							(MJ/kg - note 5)	(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	Weight gain	Milk	Work	Pregnant	DE	CF	Maintenance	Activity	Growth	Lactation	Power	Wool	Pregnancy	REM	REG	**Gross**	NE_{ma}	**DMI**
	(kg)	(kg/day)	(kg/day)	(hrs/day)					(note 3)		(note 4)							(MJ/kg - note 5)	(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