Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on grasslands or croplands AR-AMS0001

I. Applicability conditions, carbon pools and project emissions

1. The simplified baseline and monitoring methodologies are applicable if the conditions (a) - (d) mentioned below are met.

(a) Project activities are implemented on grasslands or croplands;

(b) Project activities are implemented on lands where the area of the cropland within the project boundary displaced due to the project activity is less than 50 per cent of the total project area;

(c) Project activities are implemented on lands where the number of displaced grazing animals is less than 50 per cent of the average grazing capacity[1] of the project area;

(d) Project activities are implemented on lands where ≤ 10% of the total surface project area is disturbed as result of soil preparation for planting.

2. **Carbon pools** to be considered by these methodologies are above- and below-ground tree and woody perennials[2] biomass and below-ground biomass of grasslands (i.e. living biomass).

3. **Project emissions** to be taken into account (ex-ante and ex-post) are limited to emissions from the use of fertilizers.

4. Before using simplified methodologies, project participants shall demonstrate whether:

(a) The project area is eligible for the A/R CDM project activity, using procedures for the demonstration of land eligibility contained in **appendix A;**

(b) The project activity is additional, using the procedures for the assessment of additionality contained in **appendix B.**

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[1] See appendix D.

[2] Woody perennials refers to other than tree vegetation (for example coffee, tea, rubber or oil palm) and shrubs that are present in croplands and grasslands below the thresholds (of canopy cover, and potential tree height) used to define forests

II. Baseline net greenhouse gas removals by sinks

5. The most likely baseline scenario of the small-scale A/R CDM project activity is considered to be the land-use prior to the implementation of the project activity, either grasslands or croplands.

6. The project participants shall provide documentation from literature and/or expert judgment, to justify which of the following cases occurs:

(a) If changes in the carbon stocks in the living biomass of woody perennials and the below-ground biomass of grasslands are expected not to exceed 10% of *ex-ante* actual net GHG removals by sinks, then the changes in carbon stocks shall be assumed to be zero in the absence of the project activity;

(b) If the carbon stock in the living biomass pool of woody perennials and in below-ground biomass of grasslands is expected to decrease in the absence of the project activity, the baseline net GHG removals by sinks shall be assumed to be zero. In the above case, the baseline carbon stocks in the carbons pools are constant and equal to existing carbon stocks measured at the start of the project activity;

(c) Otherwise, baseline net GHG removals by sinks shall be equal to the changes in carbon stocks in the living biomass pool of woody perennials and in below-ground biomass of grasslands that are expected to occur in the absence of the project activity.

7. The project area should be stratified for purpose of the baseline calculation into:

(a) Area of cropland with changes in the carbon stocks in the living biomass pool of woody perennials and in below-ground biomass of grasslands expected not to exceed 10% of *ex-ante* actual net GHG removals by sinks multiplied by share of the area in the entire project area;

(b) Area of grassland with changes in the carbon stocks in the living biomass pool of woody perennials and in below-ground biomass of grasslands expected not to exceed 10% of *ex-ante* actual net GHG removals by sinks multiplied by share of the area in the entire project area;

(c) Area of cropland with changes in the carbon stocks in the living biomass pool of woody perennials and in below-ground biomass of grasslands expected to exceed 10% of *ex-ante* actual net GHG removals by sinks multiplied by share of the area in the entire project area;

(d) Area of grassland with changes in the carbon stocks in the living biomass pool of woody perennials and in below-ground biomass of grasslands expected to exceed 10% of *ex-ante* actual net GHG removals by sinks multiplied by share of the area in the entire project area.

8. Baseline carbon stocks will be determined by the equation:

$$B_{(t)} = \sum_{i=1}^{I} (B_{A(t)i} + B_{B(t)i}) * A_i \qquad \textbf{(1)}$$

Where:

$B_{(t)}$ = carbon stocks in the living biomass within the project boundary at time *t* in the absence of the project activity (t C)

$B_{A(t)\,i}$ = carbon stocks in above-ground biomass at time *t* of stratum *i* in the absence of the project activity (t C/ha)

$B_{B(t)\,i}$ = carbon stocks in below-ground biomass at time *t* of stratum *i* in the absence of the project activity (t C/ha)

A_i = project area of stratum *i* (ha)

i = stratum *i* (*I* = total number of strata)

Above-ground biomass

9. For above-ground biomass $B_{A(t)}$ is calculated per stratum *i* as follows:

$$B_{A(t)} = M_{(t)} * 0.5 \quad \textbf{(2)}$$

Where:

$B_{A(t)}$ = carbon stocks in above-ground biomass at time *t* in the absence of the project activity (t C/ha)

$M_{(t)}$ = above-ground biomass at time *t* that would have occurred in the absence of the project activity (t d.m./ha)[3]

0.5 = carbon fraction of dry matter (t C/t d.m.)

$M_{(t)}$ shall be estimated using average biomass stock and growth rates specific to the region. In the absence of such values, national default values should be used. If national values are also not available, the values should be obtained from table 3.3.2 of the IPCC good practice guidance for LULUCF.

10. If living biomass carbon pools are expected to increase according to paragraph 6.c, the average biomass stock is estimated as the above-ground biomass stock in age-dependent above-ground biomass stock in woody perennials:

$$M_{(t=0)} = M_{woody\,(t=0)} \quad \textbf{(3)}$$

if: $M_{woody\,(t=n-1)} + g * \Delta t < M_{woody\_max}$ then

$$M_{(t=n)} = M_{woody\,(t=n-1)} + g * \Delta t \quad \textbf{(4)}$$

if: $M_{woody\,(t=n-1)} + g * \Delta t \geq M_{woody\_max}$ then

$$M_{(t=n)} = M_{woody\_max} \quad \textbf{(5)}$$

Where:

$M_{(t)}$ = above-ground biomass at time *t* that would have occurred in the absence of the project activity (t d.m./ha)

$M_{woody\,(t)}$ = above-ground biomass of woody perennials at time *t* that would have occurred in the absence of the project activity (t d.m./ha)

M_{woody_max} = maximal above-ground biomass of woody perennials that would have occurred in the absence of the project activity (t d.m./ha)

g = annual increment in biomass of woody perennials (t d.m./ha/year)

Δt = time increment = 1 (year)

n = running variable that increases by $\Delta t = 1$ for each iterative step, representing the

[3] d.m. = dry matter

number of years elapsed since the project start (years)

11. Documented local values for g and M_{woody_max} should be used. In the absence of such values, national default values should be used. If national values are also not available, the values should be obtained from the IPCC good practice guidance for LULUCF: for g from table 3.3.2 and for M_{woody_max} from table 3A.1.8.

Below-ground biomass

12. For below-ground biomass $B_{B(t)}$ is calculated per stratum i as follows:

If living biomass carbon pools are expected to be constant according to paragraph 6.a and 6.c, the average below-ground carbon stock is estimated as the below-ground carbon stock in grass and in biomass of woody perennials:

$$B_{B(t=0)} = B_{B(t)} = 0.5 * (M_{grass} * R_{grass} + M_{woody\ (t=0)} * R_{woody}) \quad \textbf{(6)}$$

Where:

$B_{B(t)}$ = carbon stocks in below-ground biomass at time t that would have occurred in the absence of the project activity (t C/ha)

M_{grass} = above-ground biomass in grass on grassland at time t that would have occurred in the absence of the project activity (t d.m./ha)

$M_{woody\ (t=0)}$ = above-ground biomass of woody perennials at $t=0$ that would have occurred in the absence of the project activity (t d.m./ha)

R_{woody} = root to shoot ratio of woody perennials (t d.m./t d.m.)

R_{grass} = root to shoot ratio for grassland (t d.m./t d.m.)

If living biomass carbon pools are expected to increase according to paragraph 6.c, the average below-ground carbon stock is estimated as follows:

$$B_{B(t=0)} = 0.5 * (M_{grass} * R_{grass} + M_{woody\ (t=0)} * R_{woody}) \quad \textbf{(7)}$$

if: $M_{woody\ (t=n-1)} + g * \Delta t < M_{woody\_max}$ then

$$B_{B\ (t=n)} = 0.5 * [M_{grass} * R_{grass} + (M_{woody\ (t=n-1)} + g * \Delta t) * R_{woody}] \quad \textbf{(8)}$$

if: $M_{woody\ (t=n-1)} + g * \Delta t \geq M_{woody\_max}$ then

$$B_{B\ (t=n)} = 0.5 * (M_{grass} * R_{grass} + M_{woody\_max} * R_{woody}) \quad \textbf{(9)}$$

Where:

$B_{B(t)}$ = carbon stocks in below-ground biomass at time t that would have occurred in the absence of the project activity (t C/ha)

M_{grass} = above-ground biomass in grass on grassland at time t that would have occurred in the absence of the project activity (t d.m./ha)

$M_{woody\ (t)}$ = above-ground biomass of woody perennials at time t that would have occurred in the absence of the project activity (t d.m./ha)

R_{woody} = root to shoot ratio for woody perennial j (t d.m./t d.m.)

R_{grass} = root to shoot ratio for grassland (t d.m./t d.m.)

g = annual increment in biomass of woody perennials (t d.m./ha/year)

Δt = time increment = 1 (year)
n = running variable that increases by Δt = 1 year for each iterative step, representing the number of years elapsed since the project start (years)
0.5 = carbon fraction of dry matter (t C/t d.m.)

13. Documented local values for R_{grass} and R_{woody} should be used. In the absence of such values, national default values should be used. If national values are also not available, the values should be obtained from table 3.4.3 of the IPCC good practice guidance for LULUCF.

14. The baseline net GHG removals by sinks can be calculated by:

$$\Delta C_{BSL,t} = (B_{(t)} - B_{(t-1)})*(44/12) \quad \textbf{(10)}$$

Where:
$\Delta C_{BSL,t}$ = baseline net GHG removals by sinks (t CO_2-e)
$B_{(t)}$ = carbon stocks in the living biomass pools within the project boundary at time *t* in the absence of the project activity (t C)

III. Actual net greenhouse gas removals by sinks (ex-ante)

15. Stratification of the project area should be carried out to improve the accuracy and precision of biomass estimates.

16. For the *ex-ante* calculation of the project biomass, the project area should be stratified according to the project planting plan that is, at least by tree species (or groups of them if several tree species have similar growth habits), and age classes.

17. The carbon stocks for the project scenario at the starting date of the project activity[4] (*t*=0) shall be the same as the baseline stocks of carbon at the starting date of the project (*t*=0). Therefore:

$$N_{(t=0)} = B_{(t=0)} \quad \textbf{(11)}$$

For all other years, the carbon stocks within the project boundary ($N_{(t)}$) at time *t* shall be calculated as follows:

$$N_{(t)} = \sum_{i=1}^{I}(N_{A(t)\,i} + N_{B(t)\,i}) * A_i \quad \textbf{(12)}$$

Where:
$N_{(t)}$ = total carbon stocks in biomass at time *t* under the project scenario (t C)
$N_{A(t)\,i}$ = carbon stocks in above-ground biomass at time *t* of stratum *i* under the project scenario (t C/ha)
$N_{B(t)\,i}$ = carbon stocks in below-ground biomass at time *t* of stratum *i* under the project scenario (t C/ha)
A_i = project activity area of stratum *i* (ha)

[4] The starting date of the project activity should be the time when the land is prepared for the initiation of the afforestation or reforestation project activity under the CDM. In accordance with paragraph 23 of the modalities and procedures for afforestation and reforestation project activities under the CDM, the crediting period shall begin at the start of the afforestation and reforestation project activity under the CDM (see UNFCCC web site at <http://unfccc.int/resource/docs/cop9/06a02.pdf#page=21>).

i = stratum i (I = total number of strata)

Above-ground biomass

18. For above-ground biomass $N_{A(t)\,i}$ is calculated per stratum i as follows:

$$N_{A(t)\,i} = T_{(t)i} * 0.5 \quad (13)$$

Where:
$N_{A(t)\,i}$ = carbon stocks in above-ground biomass at time t under the project scenario (t C/ha)
$T_{(t)i}$ = above-ground biomass at time t under the project scenario (t d.m./ha)
0.5 = carbon fraction of dry matter (t C/t d.m.)

19. If biomass tables or equations are available then these shall be used to estimate $T_{(t)i}$ per stratum i. If volume table or equations are used then

$$T_{(t)i} = SV_{(t)i} * BEF * WD \quad (14)$$

Where:
$T_{(t)i}$ = above-ground biomass at time t under the project scenario (t d.m./ha)
$SV_{(t)i}$ = stem volume at time t for the project scenario (m^3/ha)
BEF = biomass expansion factor (over bark) from stem to total above-ground biomass (dimensionless)
WD = basic wood density (t d.m./m^3)

20. Values for $SV_{(t)i}$ shall be obtained from national sources (such as standard yield tables). Documented local values for *BEF* should be used. In the absence of such values, national default values should be used. If national values are also not available, the values should be obtained from table 3A.1.10 of the IPCC good practice guidance for LULUCF. If national default values are not available, the values should be obtained from table 3A.1.9 of the *IPCC good practice guidance* for LULUCF.

Below-ground biomass

21. For below-ground biomass, $N_{B(t)}$ is calculated per stratum i as follows:

$$N_{B(t)\,i} = T_{(t)} * R * 0.5 \quad (15)$$

Where:
$N_{B(t)\,i}$ = carbon stocks in below-ground biomass at time t under the project scenario (t C/ha)
$T_{(t)}$ = above-ground biomass at time t under the project scenario (t d.m./ha)
R = root to shoot ratio (t d.m./ t d.m.)
0.5 = carbon fraction of dry matter (t C/t d.m.)

22. Documented national values for R should be used. If national values are not available, appropriate values should be obtained from table 3A.1.8 of the IPCC good practice guidance for LULUCF.

23. If root to shoot ratios for the species concerned are not available, project proponents shall use the allometric equation developed by Cairns et al. (1997)

$$N_{B(t)} = \exp(-1.085 + 0.9256 * \ln T_{(t)}) * 0.5 \quad (16)$$

Where:

$N_{B(t)}$ = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)

$T_{(t)}$ = estimate of above-ground biomass at time *t* achieved by the project activity (t d.m./ha)

0.5 = carbon fraction of dry matter (t C/t d.m.)

or a more general equation taken from the IPCC good practice guidance for LULUCF, Table 4.A.4[5].

24. The removal component of actual net GHG removals by sinks can be calculated by:

$$\Delta C_{PROJ,t} = (N_t - N_{t-1})*(44/12)/\Delta t \quad \textbf{(17)}$$

Where:

$\Delta C_{PROJ,t}$ = removal component of actual net GHG removals by sinks per annum (t CO_2-e / year)

$N_{(t)}$ = total carbon stocks in biomass at time *t* under the project scenario (t C)

Δt = time increment = 1 (year)

25. If project participants consider that the use of fertilizers would result in significant emissions of N_2O (>10 per cent of the actual net greenhouse gas removals by sinks) project emissions ($GHG_{PROJ,(t)}$ - t CO_2e / year) should be estimated in accordance with the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as IPCC good practice guidance).[6]

26. The *ex-ante* actual net greenhouse gas removals by sinks in year t are equal to:

$$\Delta C_{ACTUAL,t} = \Delta C_{PROJ,t} - GHG_{PROJ,t} \quad \textbf{(18)}$$

Where:

$\Delta C_{ACTUAL,t}$ = *ex-ante* actual net greenhouse gas removals by sinks in year t (t CO_2-e / year)

$\Delta C_{PROJ,t}$ = project GHG removals by sinks (t CO_2-e / year)

$GHG_{PROJ,t}$ = project emissions (t CO_2-e / year)

IV. Leakage (ex-ante)

27. According to decision 6/CMP.1, annex, appendix B, paragraph 9: "If project participants demonstrate that the small-scale afforestation or reforestation project activity under the CDM does not result in the displacement of activities or people, or does not trigger activities outside the project boundary, that would be attributable to the small-scale afforestation or reforestation project activity under

[5] Cairns, M.A., S. Brown, E.H. Helmer, G.A. Baumgardner (1997). Root biomass allocation in the world's upland forests. *Oecologia* (1):1–11.

[6] Use the tool: *Estimation of direct nitrous oxide emission from nitrogen fertilization* when it becomes available.

the CDM, such that an increase in greenhouse gas emissions by sources occurs, a leakage estimation is not required. In all other cases leakage estimation is required.”

28. If evidence can be provided that there is no displacement, or the displacement of pre-project activities will not cause deforestation attributable to the project activity, or the lands surrounding the project activity contain no significant biomass (i.e. degraded land with no or only a few trees or shrubs per hectare) and if evidence can be provided that these lands are likely to receive the shifted activities, leakage can be considered zero. Such evidence can be provided by scientific literature or by experts' judgment.

29. In all other cases, project participants should assess the possibility of leakage from the displacement of activities by considering the following indicators:

(a) Area under cropland[7] within the project boundary displaced due to the project activity;

(b) Number of domesticated grazing animals within the project boundary displaced due to the project activity;

(c) For domesticated roaming animals, the time-average number of grazing animals per hectare within the project boundary displaced due to the project activity.

30. If the area of the cropland within the project boundary displaced due to the project activity is lower than 10 per cent of the total project area, and the number of domesticated grazing animals displaced is less than 10% of the average grazing capacity (see appendix D for calculations) of the project area, and the time-average number of domesticated roaming animals displaced is less than 10% of the average grazing capacity per hectare (see appendix D for calculations) of the project area, then:

$$L_t = 0 \qquad \textbf{(19)}$$

Where:
L_t = leakage attributable to the project activity at time *t* (t CO_2-e / year)

31. If the value of one of these indicators is higher than 10 per cent and less than or equal to 50 per cent, then the entire leakage shall be equal to 15 per cent of the *ex-ante* actual net GHG removals by sinks achieved during the first crediting period, that is the average annual leakage is equal to:

$$L_t = \Delta C_{ACTUAL,t} * 0.15 \qquad \textbf{(20)}$$

Where:
L_t = average annual leakage attributable to the project activity at time *t* (t CO_2-e / year)
$\Delta C_{ACTUAL,t}$ = *ex-ante* actual net greenhouse gas removals by sinks in year t (t CO_2-e / year)

32. If the value of any of these indicators calculated in paragraph 28 is higher than 50 per cent, then this simplified methodology cannot be used.

[7] Cropland also includes lands which are currently under a fallow state as part of the agricultural cycle (eg. slash and burn).

V. Net anthropogenic greenhouse gas removals by sinks

33. The net anthropogenic GHG removals by sinks for each year during the first crediting period are calculated as,

$$ER_{AR\ CDM,\ t} = \Delta C_{PROJ,\ t} - \Delta C_{BSL,\ t} - GHG_{PROJ,\ t} - L_t \quad \textbf{(21)}$$

Where:

$ER_{AR\ CDM,\ t}$	=	net anthropogenic GHG removals by sinks (t CO_2-e / year)
$\Delta C_{PROJ,\ t}$	=	project GHG removals by sinks at time *t* (t CO_2-e / year)
$\Delta\ C_{BSL,t}$	=	baseline net GHG removals by sinks (t CO_2-e / year)
$GHG_{PROJ,\ t}$	=	project emissions (t CO_2-e / year)
L_t	=	leakage attributable to the project activity at time *t* (t CO_2-e / year)

For subsequent crediting periods L_t=0.

34. The resulting temporary certified emission reductions (tCERs) at the year of assumed verification t_v are calculated as follows:

$$tCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR-CDM,t} * \Delta t \quad \textbf{(22)}$$

Where:

$tCER_{(t)}$	=	temporary certified emission reductions (tCERs) at the year of assumed verification t_v
$ER_{AR\ CDM,\ t}$	=	net anthropogenic GHG removals by sinks (t CO_2-e / year)
t_v	=	assumed year of verification (year)
Δt	=	time increment = 1 (year)

35. The resulting long-term certified emission reductions (lCERs) at the year of assumed verification t_v are calculated as follows:

$$lCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR\ CDM,t} * \Delta t - lCER_{(t-k)} \quad \textbf{(23)}$$

Where:

$lCER_{(tv)}$	=	long-term certified emission reductions (lCERs) at the year of verification *tv*
$ER_{AR\ CDM,\ t}$	=	net anthropogenic GHG removals by sinks; (t CO_2-e / year)
k	=	time span between two verifications (year)
t_v	=	year of assumed verification (year)

VI. Simplified monitoring methodology for small-scale afforestation and reforestation projects under the clean development mechanism

A. Ex post estimation of the baseline net greenhouse gas removals by sinks

36. In accordance with decision 6/CMP.1, appendix B, paragraph 6, no monitoring of the baseline is requested. Baseline net GHG removals by sinks for the monitoring methodology will be the same as using the simplified baseline methodology in section II above.

B. Ex post estimation of the actual net greenhouse gas removals by sinks

37. Stratification of the project area should be carried out to improve the accuracy and precision of biomass estimates.

38. For *ex post* estimation of project GHG removals by sinks, strata shall be defined by:

(i) relevant guidance on stratification for A/R project activities under the clean development mechanism as approved by the Executive Board (if available); or

(ii) stratification approach that can be shown in the PDD to estimate biomass stocks according to good forest inventory practice in the host country in accordance with DNA indications; or

(iii) other stratification approach that can be shown in the PDD to estimate the project biomass stocks to targeted precision level of ±10% of the mean at a 95% confidence level.

39. Carbon stocks (expressed in t CO_2-e) shall be estimated through the following equations:

$$P_{(t)} = \sum_{i=1}^{I} (P_{A(t)\,i} + P_{B(t)\,i}) * A_i * (44/12) \qquad \textbf{(24)}$$

Where:

$P_{(t)}$ = carbon stocks within the project boundary at time *t* achieved by the project activity (t CO_2-e)
$P_{A(t)\,i}$ = carbon stocks in above-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval (t C/ha)
$P_{B(t)\,i}$ = carbon stocks in below-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval (t C/ha)
A_i = project activity area of stratum *i* (ha)
i = stratum *i* (*I* = total number of strata)

40. The calculations shown in paragraphs 41 - 47 shall be performed for each stratum.

Above-ground biomass

41. For above-ground biomass $P_{A(t)\,i}$ is calculated per stratum *i* as follows:

$$P_{A(t)\,i} = E_{(t)\,i} * 0.5 \qquad \textbf{(25)}$$

Where:

$P_{A(t)\,i}$ = carbon stocks in above-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)
$E_{(t)\,i}$ = estimate of above-ground biomass at time *t* achieved by the project activity (t d.m./ha)
0.5 = carbon fraction of dry matter (t C/t d.m.)

42. Estimate of above-ground biomass at time *t* achieved by the project activity $E_{(t)}$ shall be estimated through the following steps:

(a) **Step 1:** Establish permanent plots and document their location in the first monitoring report;

(b) **Step 2:** Measure the diameter at breast height (*DBH*) or *DBH* and tree height, as appropriate this measure and document it in the monitoring reports;

(c) **Step 3:** Estimate the above-ground biomass using allometric equations developed locally or nationally. If these allometric equations are not available:

(i) Option 1: Use allometric equations included in **appendix C** to this report or in annex 4A.2 of the IPCC good practice guidance for LULUCF;

(ii) Option 2: Use biomass expansion factors and stem volume as follows:

$$E_{(t)\,i} = SV_{(t)\,i} * BEF * WD \qquad \textbf{(26)}$$

Where:

$E_{(t)\,i}$	=	estimate of above-ground biomass of stratum i at time t achieved by the project activity (t d.m./ha)
$SV_{(t)\,i}$	=	stem volume (m^3/ha)
WD	=	basic wood density (t d.m./m^3)
BEF	=	biomass expansion factor (over bark) from stem to total aboveground biomass (dimensionless)

43. Stem volume $SV_{(t)i}$ shall be estimated from on-site measurements. Consistent application of *BEF* should be secured on the definition of stem volume (e.g. total stem volume or thick wood stem volume requires different *BEF*s). National default values for wood density should be used. If national values are also not available, the values should be obtained from table 3A.1.9 of the IPCC good practice guidance for LULUCF.

44. The same values for *BEF* and *WD* should be used in the *ex-post* and in the *ex-ante* calculations.

Below-ground biomass

45. Carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval $P_{B(t)}$ shall be estimated for each stratum *i* as follows:

$$P_{B(t)\,i} = E_{(t)\,i} * R * 0.5 \qquad \textbf{(27)}$$

Where:

$P_{B(t)\,i}$ = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)

E (t) i = estimate of above-ground biomass of stratum i at time t achieved by the project activity (t d.m./ha)

R = root to shoot ratio (dimensionless)

0.5 = carbon fraction of dry matter (t C/t d.m.)

46. Documented national values for *R* should be used. If national values are not available, the values should be obtained from table 3A.1.8 of the IPCC good practice guidance for LULUCF.

If root to shoot ratios for the species concerned are not available, project proponents shall use the allometric equation developed by Cairns et al. (1997)

$$P_{B(t)\,i} = exp(-1.085 + 0.9256 * ln\, E_{(t)\,i}) * 0.5 \qquad \textbf{(28)}$$

Where:

$P_{B(t)\,i}$ = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)

$E_{(t)\,i}$ = estimate of above-ground biomass at time *t* achieved by the project activity (t d.m./ha)

0.5 = carbon fraction of dry matter (t C/t d.m.)

or a more representative equation taken from the IPCC good practice guidance for LULUCF, Table 4.A.4:

47. If project participants consider that the use of fertilizers would result in significant emissions of N_2O (>10 per cent of the actual net greenhouse gas removals by sinks) project emissions ($GHG_{PROJ,\,(t)}$ - t CO_2e / year) should be estimated in accordance with the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as IPCC good practice guidance).[8]

C. *Ex-post* estimation of leakage

48. In order to estimate leakage, project participants shall monitor each of the following indicators during the first crediting period:

(a) Area under cropland[9] within the project boundary displaced due to the project activity;

(b) Number of domesticated grazing animals within the project boundary displaced due to the project activity;

(c) For domesticated roaming animals, the time-average number of domesticated grazing animals per hectare within the project boundary displaced due to the project activity.

49. If the values of these indicators for the specific monitoring period are not greater than 10 per cent, then

$$L_{tv} = 0 \qquad \textbf{(29)}$$

Where:

L_{tv} = total GHG emission due to leakage at the time of verification (t CO_2-e)

[8] Use the tool: *Estimation of direct nitrous oxide emission from nitrogen fertilization* when it becomes available.

[9] Cropland also includes lands which are currently under a fallow state as part of the agricultural cycle (eg. slash and burn).

If the value of any of these indicators is higher than 10 per cent and less than or equal to 50 per cent during the first crediting period, then leakage shall be determined at the time of verification using the following equations:

for the first verification period:

$$L_{tv} = 0.15 * (P_{(tv)} - B_{(t=0)} - \sum_{t=0}^{tv} GHG_{PROJ,(t)}) \quad \textbf{(30)}$$

for subsequent verification periods:

$$L_{tv} = 0.15 * (P_{(tv)} - P_{(tv-k)} - \sum_{tv-k}^{tv} GHG_{PROJ,(t)}) \quad \textbf{(31)}$$

Where:

L_{tv}	=	GHG emission due to leakage at the time of verification (t CO_2-e)
$P_{(t)}$	=	carbon stocks within the project boundary achieved by the project activity at time *t* (t CO_2-e)
$GHG_{PROJ,\,(t)}$	=	project emissions from use of fertilizers (t CO_2-e / year)
$B_{(t=0)}$	=	carbon stocks in biomass at time 0 that would have occurred in the absence of the project activity (t C/ha)
tv	=	year of verification (year)
κ	=	time span between two verifications (year)

As indicated in chapter IV, paragraph 31, if the value of one of these indicators is larger than 50 per cent net anthropogenic GHG removals by sinks cannot be estimated using this methodology.

At the end of the first crediting period the total leakage equals to:

$$L_{CP1} = 0.15 * (P_{(tc)} - B_{(t=0)} - \sum_{t=0}^{tc} GHG_{PROJ,(t)}) \quad \textbf{(32)}$$

Where:

L_{CP1}	=	total GHG emission due to leakage at the end of the first crediting period (t CO_2-e)
$GHG_{PROJ,\,(t)}$	=	project emissions from use of fertilizers (t CO_2-e / year)
$B_{(t=0)}$	=	carbon stocks in biomass at time 0 that would have occurred in the absence of the project activity (t C/ha)
tc	=	duration of the crediting period

D. *Ex-post* estimation of the net anthropogenic GHG removals by sinks

50. Net anthropogenic greenhouse gas removals by sinks is the actual net greenhouse gas removals by sinks minus the baseline net greenhouse gas removals by sinks minus leakage as appropriate.

51. The resulting tCERs at the year of verification *tv* are calculated as follows

for the first crediting period:

$$tCER_{(tv)} = P_{(t)} - \sum_{t=0}^{tv} (GHG_{PROJ,(t)} - \Delta C_{BSL,t}) - L_{tv} \quad \textbf{(33)}$$

for subsequent crediting periods:

$$tCER_{(tv)} = P_{(t)} - \sum_{t=0}^{tv} (GHG_{PROJ,(t)} - \Delta C_{BSL,t}) - L_{CP1} \quad \textbf{(34)}$$

Where:

$P_{(t)}$	=	carbon stocks within the project boundary achieved by the project activity at time *t* (t CO_2-e)
$GHG_{PROJ,(t)}$	=	project emissions from use of fertilizers (t CO_2-e/ year)
$\Delta C_{BSL,t}$	=	baseline net GHG removals by sinks (t CO_2-e/ year)
L_{tv}	=	total GHG emission due to leakage at the time of verification (t CO_2-e)
L_{CP1}	=	total GHG emission due to leakage at the end of the first crediting period (t CO_2-e)
tv	=	year of verification

52. The resulting lCERs at the year of verification *tv* are calculated as follows:

for the first crediting period:

$$lCER_{(tv)} = P_{(t)} - \sum_{t=0}^{tv} (GHG_{PROJ,(t)} - \Delta C_{BSL,t}) - L_{tv} - lCER_{(tv-k)} \quad \textbf{(35)}$$

for subsequent crediting periods:

$$lCER_{(tv)} = P_{(t)} - \sum_{t=0}^{tv} (GHG_{PROJ,(t)} - \Delta C_{BSL,t}) - L_{CP1} - lCER_{(tv-k)} \quad \textbf{(36)}$$

Where:

$P_{(t)}$	=	carbon stocks within the project boundary achieved by the project activity at time *t* (t CO_2-e)
$GHG_{PROJ,(t)}$	=	project emissions from use of fertilizers (t CO_2-e/ year)

$\Delta C_{BSL,t}$	=	baseline net GHG removals by sinks (t CO_2-e/ year)
L_{tv}	=	total GHG emission due to leakage at the time of verification (t CO_2-e)
L_{CP1}	=	total GHG emission due to leakage at the end of the first crediting period (t CO_2-e)
$lCER_{(tv-k)}$	=	units of *lCER*s issued following the previous verification
tv	=	year of verification (year)
κ	=	time span between two verifications (year)

E. Monitoring frequency

53. Monitoring frequency for each variable is defined in the Tables 1 and 2.

Table 1. Data to be collected or used in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary from the proposed afforestation and reforestation project activity under the clean development mechanism, and how these data will be archived.

Data variable	Source	Data unit	Measured, calculated or estimated	Frequency (years)	Proportion	Archiving	Comment
Location of the areas where the project activity has been implemented	Field survey or cadastral information or aerial photographs or satellite imagery	latitude and longitude	Measured	5	100 per cent	Electronic, paper, photos	GPS can be used for field survey
A_i - Size of the areas where the project activity has been implemented for each type of strata	Field survey or cadastral information or aerial photographs or satellite imagery or GPS	ha	Measured	5	100 per cent	Electronic, paper, photos	GPS can be used for field survey
Location of the permanent sample plots	Project maps and project design	latitude and longitude	Defined	5	100 per cent	Electronic, paper	Plot location is registered with a GPS and marked on the map
Diameter of tree at breast height (1.30 m)	Permanent plot	cm	Measured	5	Each tree in the sample plot	Electronic, paper	Measure diameter at breast height (*DBH*) for each tree that falls within the sample plot and applies to size limits
Height of tree	Permanent plot	m	Measured	5	Each tree in the sample plot	Electronic, paper	Measure height (*H*) for each tree that falls within the sample plot and applies to size limits
Basic wood density	Literature	tonnes of dry matter per m^3 fresh volume	Estimated	Once		Electronic, paper	
Total CO_2	Project activity	Mg	Calculated	5	All project data	Electronic	Based on data collected from all plots and carbon pools

Table 2. Data to be collected or used in order to monitor leakage and how these data will be archived.

Data variable	Source	Data unit	Measured, calculated or estimated	Frequency (years)	Proportion	Archiving	Comment
Area under cropland within the project boundary displaced due to the project activity	Survey	Hectares or other area units	Measured or estimated	One time after project is established but before the first verification	30%	Electronic	
Number of domesticated grazing animals within the project boundary displaced due to the project activity	Survey	Number of heads	Estimated	One time after project is established but before the first verification	30%	Electronic	
Time-average number of grazing domesticated roaming animals per hectare within the project boundary displaced due to the project activity	Survey	Number of heads	Estimated	One time after project is established but before the first verification	30%	Electronic	

Table 3. Abbreviations and parameters (in order of appearance).

Parameter or abbreviation	Refers to	Units
$B_{(t)}$	carbon stocks in the living biomass within the project boundary at time t in the absence of the project activity	t C
$B_{A(t)\ i}$	carbon stocks in above-ground biomass at time t of stratum i in the absence of the project activity	t C/ha
$B_{B\ (t)\ i}$	carbon stocks in below-ground biomass at time t of stratum i in the absence of the project activity	t C/ha
A_i	project area of stratum *i*	ha
i	stratum index	
I	total number of strata	
$M_{(t)}$	above-ground biomass at time *t* that would have occurred in the absence of the project activity	t d.m./ha
0.5	carbon fraction of dry matter	tC / t d.m.
$M_{woody\ (t)}$	above-ground biomass of woody perennials at time t that would have occurred in the absence of the project activity	t d.m./ha
M_{woody_max}	maximal above-ground biomass of woody perennials that would have occurred in the absence of the project activity	t d.m./ha
g	annual increment in biomass of woody perennials	t d.m./ha/year
Δt	time increment = 1 (year)	year
n	running variable that increases by Δt = 1 year for each iterative step, representing the number of years elapsed since the project start	years
R_{woody}	root to shoot ratio of woody perennials	t d.m./t d.m.
M_{grass}	Above-ground biomass in grass on grassland at time *t* that would have occurred in the absence of the project activity	t d.m./ha
R_{grass}	root to shoot ratio for grassland	t d.m./t d.m.
$\Delta\ C_{BSL,t}$	baseline net GHG removals by sinks at time t	t CO_2-e
$N_{(t)}$	total carbon stocks within the project boundary at time *t* under project scenario	t C
$N_{A(t)\ i}$	carbon stocks in above-ground biomass at time *t* of stratum *i* under project scenario	t C/ha
$N_{B(t)\ i}$	carbon stocks in below-ground biomass at time *t* of stratum *i* under project scenario	t C/ha

Parameter or abbreviation	Refers to	Units
$T_{(t)i}$	above-ground biomass at time *t* for the project scenario	t d.m./ha
R	root to shoot ratio	t d.m./t d.m.
$SV_{(t)\ i}$	stem volume at time *t* for the project scenario	m^3/ha
WD	basic wood density	t d.m./m^3 (fresh volume)
BEF	biomass expansion factor (over bark) from stem to total biomass	dimensionless
DBH	diameter at breast height (130 cm or 1.30 m)	cm or m
$\Delta\ C_{PROJ,t}$	removal component of actual net GHG removals by sinks per annum	t CO_2-e/ year
$\Delta\ C_{ACTUAL,t}$	*ex-ante* actual net greenhouse gas removals by sinks over the first crediting period	t CO_2-e/ year
t_C	duration of the crediting period	year
$GHG_{PROJ,\ t}$	project GHG emissions by non-sink sources at time *t*	t CO_2-e/ year
L_t	leakage attributable to the project activity at time *t*	t CO_2-e/ year
L_{tv}	total GHG emission due to leakage at the time of verification	t CO_2-e
L_{CP1}	total GHG emission due to leakage at the end of the first crediting period	t CO_2-e
$ER_{AR\ CDM,\ t}$	net anthropogenic GHG removals by sinks	t CO_2-e / year
$tCER_{(tv)}$	tCERs emitted at year of verification *tv*	t CO_2-e
$lCER_{(tv)}$	lCERs emitted at year of verification *tv*	t CO_2-e
tv	year of verification	
k	time span between two verifications (years)	years
$P_{(t)}$	carbon stocks within the project boundary at time *t* achieved by the project activity	t CO_2-e
$P_{A(t)\ i}$	carbon stocks in above-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval	t C/ha
$P_{B(t)\ i}$	carbon stocks in below-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval	t C/ha
$E_{(t)\ i}$	estimate of above-ground biomass at time *t* achieved by the project activity	t d.m./ha
$B_{(t=0)}$	carbon stocks in biomass at time 0 that would have occurred in the absence of the project activity	t C/ha
L_{CP1}	total GHG emission due to leakage at the end of the first crediting period	t CO_2-e

Appendix A

Demonstration of land eligibility

1. Eligibility of the A/R CDM project activities under Article 12 of the Kyoto Protocol shall be demonstrated based on definitions provided in paragraph 1 of the annex to the Decision 16/CMP.1 ("Land use, land-use change and forestry"), as requested by Decision 5/CMP.1 ("Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol"), until new procedures to demonstrate the eligibility of lands for afforestation and reforestation project activities under the clean development mechanism are recommended by the EB.

Appendix B

Assessment of additionality

1. Project participants shall provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

2. **Investment barriers, other than economic/financial barriers**, inter alia:

   (a) Debt funding not available for this type of project activity;

   (b) No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented;

   (c) Lack of access to credit.

3. **Institutional barriers**, inter alia:

   (a) Risk relating to changes in government policies or laws;

   (b) Lack of enforcement of legislation relating to forest or land-use.

4. **Technological barriers**, inter alia:

   (a) Lack of access to planting materials;

   (b) Lack of infrastructure for implementation of the technology.

5. **Barriers relating to local tradition**, inter alia:

   (a) Traditional knowledge or lack thereof, of laws and customs, market conditions, practices;

   (b) Traditional equipment and technology;

6. **Barriers due to prevailing practice**, inter alia:

   (a) The project activity is the "first of its kind". No project activity of this type is currently operational in the host country or region.

7. **Barriers due to local ecological conditions**, inter alia:

   (a) Degraded soil (e.g. water/wind erosion, salination);

   (b) Catastrophic natural and/or human-induced events (e.g. land slides, fire);

   (c) Unfavourable meteorological conditions (e.g. early/late frost, drought);

   (d) Pervasive opportunistic species preventing regeneration of trees (e.g. grasses, weeds);

   (e) Unfavourable course of ecological succession;

   (f) Biotic pressure in terms of grazing, fodder collection, etc.

8. **Barriers due to social conditions**, inter alia:

(a) Demographic pressure on the land (e.g. increased demand on land due to population growth);

(b) Social conflict among interest groups in the region where the project activity takes place;

(c) Widespread illegal practices (e.g. illegal grazing, non-timber product extraction and tree felling);

(d) Lack of skilled and/or properly trained labour force;

(e) Lack of organization of local communities.

Appendix C

Default allometric equations for estimating above-ground biomass

Annual rainfall	DBH limits	Equation	R^2	Author
Broad-leaved species, tropical dry regions				
<900 mm	3–30 cm	$AGB = 10^{-0.535 + \log_{10}(\pi * DBH^2/4)}$	0.94	Martinez-Yrizar et al. (1992)
900–1500 mm	5–40 cm	$AGB = \exp\{-1.996 + 2.32 * \ln(DBH)\}$	0.89	Brown (1997)
Broad-leaved species, tropical humid regions				
< 1500 mm	5–40 cm	$AGB = 34.4703 – 8.0671*DBH + 0.6589*(DBH^2)$	0.67	Brown et al. (1989)
1500–4000 mm	< 60 cm	$AGB = \exp\{-2.134 + 2.530 * \ln(DBH)\}$	0.97	Brown (1997)
1500–4000 mm	60–148 cm	$AGB = 42.69 – 12.800*(DBH) + 1.242*(DBH)^2$	0.84	Brown et al. (1989)
1500–4000 mm	5–130 cm	$AGB = \exp\{-3.1141 + 0.9719*\ln(DBH^2*H)$	0.97	Brown et al. (1989)
1500–4000 mm	5–130 cm	$AGB = \exp\{-2.4090 + 0.9522*\ln(DBH^2*H*WD)\}$	0.99	Brown et al. (1989)
Broad-leaved species, tropical wet regions				
> 4000 mm	4–112 cm	$AGB = 21.297 – 6.953*(DBH) + 0.740*(DBH^2)$	0.92	Brown (1997)
> 4000 mm	4–112 cm	$AGB = \exp\{-3.3012 + 0.9439*\ln(DBH^2*H)\}$	0.90	Brown et al. (1989)
Coniferous trees				
n.d.	2–52 cm	$AGB = \exp\{-1.170 + 2.119*\ln(DBH)\}$	0.98	Brown (1997)
Palms				
n.d.	> 7.5 cm	$AGB = 10.0 + 6.4 * H$	0.96	Brown (1997)
n.d.	> 7.5 cm	$AGB = 4.5 + 7.7 * WDH$	0.90	Brown (1997)

Note: *AGB* = above-ground biomass; *DBH* = diameter at breast height; *H* = height; *WD* = basic wood density

References:

Brown, S. 1997. *Estimating biomass and biomass change of tropical forests. A primer*. FAO Forestry Paper 134. Food and Agriculture Organization of the United Nations, Rome, Italy.
Brown, S., A.J.R. Gillespie, and A.E. Lugo. 1989. Biomass estimation methods for tropical forests with applications to forest inventory data. *Forest Science* 35: 881–902.
Martínez-Y., A.J., J. Sarukhan, A. Perez-J., E. Rincón, J.M. Maas, A. Solis-M, and L. Cervantes. 1992. Above-ground phytomass of a tropical deciduous forest on the coast of Jalisco, Mexico. *Journal of Tropical Ecology* 8: 87–96.

Appendix D

Calculating average grazing capacity

A. Concept

1. Sustainable grazing capacity is calculated by assuming that the grazing animals should not consume more biomass than is annually produced by the site

B. Methodology

2. The sustainable grazing capacity is calculated using the following equation:

$$GC = \frac{ANPP * 1000}{365 * DMI} \qquad (37)$$

where:
GC = grazing capacity (head/ha)
ANPP = above-ground net primary productivity in tonnes dry biomass (t d.m.)/ha/yr)
DMI = daily dry matter intake per grazing animal (kg d.m./head/day)

3. 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.

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

$$DMI = \frac{GE}{NE_{ma}} \qquad (38)$$

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.)

5. 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)[10]. 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.

[10] 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 avaerages 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	Preg-nant	DE	CF	Mainte-nance	Activity	Growth	Lactation	Power	Wool	Preg-nancy	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	Preg-nant	DE	CF	Mainte-nance	Activity	Growth	Lactation	Power	Wool	Preg-nancy	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

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