Annex II of the "Annual report of the Executive Board of the clean development mechanism to the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol" (Addendum) - FCCC/KP/CMP/2005/4/Add.1

Revised simplified baseline and monitoring methodologies for selected small-scale afforestation and reforestation project activities under the clean development mechanism

I. Introduction

1. This annex contains simplified baseline and monitoring methodologies for selected small-scale afforestation and reforestation (A/R) clean development mechanism (CDM) project activities. Specifically it covers:

(a) A simplified baseline methodology and default factors for small-scale A/R project activities implemented on grasslands or croplands;

(b) A simplified monitoring methodology, based on appropriate statistical methods, to estimate, measure and monitor the actual net greenhouse gas (GHG) removals by sinks and leakage.

2. 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. Project activities implemented on settlements or wetlands are not included in this methodology.[1]

3. These simplified baseline and monitoring methodologies are not applicable to grasslands or croplands that have been ploughed before the plantation is established. Also, they do not apply to project activities where the displacement of households or activities, due to the implementation of the A/R CDM project activity, is estimated to be larger than 50 per cent.

4. In accordance with decision 14/CP.10, project participants may propose new simplified methodologies or amendments to these simplified monitoring methodologies for project activities for which these would not be applicable. Such proposed new methodologies would be submitted to the CDM Executive Board for consideration and approval.

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

(a) The land of the project activity is eligible, 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.**

II. General guidance

6. **Carbon pools** to be considered by these methodologies are above-ground biomass and below-ground biomass, hereinafter referred to collectively as "living biomass pool". Values chosen for

[1] Wetlands and settlements are not covered by the present methodologies for two reasons: methodologies for wetlands are still under development and, given the state of knowledge, simplification is not yet possible; conversions from settlements or wetlands to forests are unlikely for several reasons, including the social and environmental impacts that such conversions can cause.

parameters to estimate changes in carbon stocks in the baseline and monitoring methodologies, as well as the choice of approach, shall be justified and documented (including sources and references) in the clean development mechanism small-scale afforestation and reforestation project design document (CDM-SSC-AR-PDD). The choice of equations and values for parameters shall be conservative, i.e., the net anthropogenic GHG removals by sinks shall not be overestimated.

7. **Emissions of GHGs from the actual net GHG removals by sinks** do not need to be accounted for.

III. Simplified baseline methodologies for small-scale afforestation and reforestation small-scale project activities under the clean development mechanism

A. Baseline net greenhouse gas removals by sinks

8. Simplified methodologies for estimating the baseline net GHG removals by sinks are based on the baseline approach specified by paragraph 22 (a) of the modalities and procedures for afforestation and reforestation project activities under the clean development mechanism: "Existing or historical, as applicable, changes in carbon stock in the carbon pools within the project boundary."

9. According to decision 14/CP.10, annex, appendix B, paragraphs 2 and 3:

> "If project participants can provide relevant information that indicates that, in the absence of the small-scale afforestation or reforestation project activity under the CDM, no significant changes in the carbon stocks within the project boundary would have occurred, they shall assess the existing carbon stocks prior to the implementation of the project activity. The existing carbon stocks shall be considered as the baseline and shall be assumed to be constant throughout the crediting period.
>
> "If significant changes in the carbon stocks within the project boundary would be expected to occur in the absence of the small-scale afforestation or reforestation project activity, project participants shall" use the simplified baseline methodology contained in this document.

10. In order to assess if significant changes in the baseline carbon stocks within the project boundary would have occurred in absence of the project activity, project participants shall assess whether changes in carbon stocks in the baseline land-use type (grasslands or croplands), in particular the living biomass pool of woody perennials[2] and the below-ground biomass of grasslands, are expected to be significant. They shall provide documentation to prove this, for example, by including expert judgment, and proceed as follows:

(a) If significant changes in the carbon stocks, in particular the living biomass pool of woody perennials and the below-ground biomass of grasslands, are not expected to occur in the absence of the project activity, the changes in carbon stocks shall be assumed to be zero;

(b) If the carbon stock in the living biomass pool of woody perennials or 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 is constant at the level of the existing carbon stock measured at the start of the project activity;

[2] Woody perennials refers to the non-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, minimum area and tree height) used to define forests.

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

A. Estimating baseline net greenhouse gas removals by sinks

11. Baseline net GHG removals by sinks will be determined by the equation:

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

where:

$B_{(t)}$ = carbon stocks in the living biomass pools within the project boundary at time *t* in the absence of the project activity (t C)
$B_{A(t)\,i}$ = 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 activity area of stratum *i* (ha)
i = stratum *i* (*I* = total number of strata)

12. Stratification of the project activity for the purposes of estimating the baseline net GHG removals by sinks shall proceed in accordance with section 4.3.3.2 of the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* of the Intergovernmental Panel on Climate Change (IPCC) (hereinafter referred to as the IPCC good practice guidance for LULUCF). For each stratum, the following calculations shall be performed as shown below.

For above-ground biomass

13. $B_{A(t)}$ is calculated per stratum *i* as follows:

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

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 dm/ha)[3]
0.5 = carbon fraction of dry matter (t C/t dry matter)

Values for $M_{(t)}$ shall be estimated using average biomass stock and growth rates specific to the region using the following equation, taking into account the provisions of paragraph 10.

14. If living biomass carbon pools are expected to be constant according to paragraph 10.a and 10.b, the average above-ground biomass stock is estimated as the above-ground biomass stock in grass and woody perennials; biomass in crops is ignored since it is considered transient:

$$M_{(t=0)} = M_{(t)} = M_{grass} + M_{woody\,(t=0)} \qquad (3)$$

where:

[3] dm = dry matter

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

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

$$M_{(t=0)} = M_{grass} + M_{woody\ (t=0)} \quad (4)$$

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

$$M_{(t=n)} = M_{grass} + M_{woody\ (t=n-1)} + g * \Delta t \quad (5)$$

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

$$M_{(t=n)} = M_{grass} + M_{woody\_max} \quad (6)$$

where:
$M_{(t)}$ = above-ground biomass at time *t* that would have occurred in the absence of the project activity (t dm/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 dm/ha)
$M_{woody\ (t)}$ = above-ground woody biomass of woody perennials at time *t* that would have occurred in the absence of the project activity (t dm/ha)
M_{woody_max} = maximal above-ground woody perennials at time *t* that would have occurred in the absence of the project activity (t dm/ha)
g = annual biomass growth rate of woody perennials (t dm/ha/year)
Δt = time increment = 1 (year)
n = running variable that increases by $\Delta t = 1$ for each iterative step, representing the number of years elapsed since the project start (years)

15. Documented local values for *g* 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 3.3.2 of the IPCC good practice guidance for LULUCF.

16. Documented local values for 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 table 3A.1.8 of the IPCC good practice guidance for LULUCF.

For below-ground biomass

17. $B_{B(t)}$ is calculated per stratum *i* as follows:

If living biomass carbon pools are expected to be constant according to paragraph 10.a and 10.b, the average below-ground carbon stock is estimated as the below-ground carbon stock in grass and in woody biomass; biomass in crops is ignored since it is considered transient:

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

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 dm/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 dm/ha)
$M_{woody\ (t)}$ = above-ground woody biomass at time *t* that would have occurred in the absence of the project activity (t dm/ha)
R_{woody} = root to shoot ratio of woody perennials (t dm/t dm)
R_{grass} = root to shoot ratio for grassland (t dm/t dm)

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

$$B_{B(t=0)} = 0.5 * (M_{grass} * R_{grass} + M_{woody\ (t=0)} * R_{woody}) \quad (8)$$

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

$$B_{B\ (t=n)} = 0.5 * [M_{grass} * R_{grass} + (M_{woody\ (t=n-1)} + g * \Delta t) * R_{woody}] \quad (9)$$

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

$$B_{B\ (t=n)} = 0.5 * (M_{grass} * R_{grass} + M_{woody\_max} * R_{woody}) \quad (10)$$

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 dm/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 dm/ha)
$M_{woody\ (t)}$ = above-ground woody biomass of woody perennials at time *t* that would have occurred in the absence of the project activity (t dm/ha)
R_{woody} = root to shoot ratio for woody perennial *j* (t dm/t dm)
R_{grass} = root to shoot ratio for grassland (t dm/t dm)
g = annual biomass growth rate of woody perennials (t dm/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 dm)

18. 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.

B. Actual net greenhouse gas removals by sinks

19. Actual net GHG removals by sinks consider only the changes in carbon pools for the project scenario. The stocks of carbon 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:

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[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

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

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

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

where:
$N_{(t)}$ = total carbon stocks in biomass at time t under the project scenario (t C/ha)
$N_{A(t)\,i}$ = 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)
i = stratum i (I = total number of strata)

20. Stratification for the project scenario shall be undertaken in accordance with section 4.3.3.2 of the IPCC good practice guidance for LULUCF. The calculations shown below shall be performed for each stratum.

For above-ground biomass

21. $N_{A(t)}$ is calculated per stratum i as follows:

$$N_{A(t)} = T_{(t)} * 0.5 \tag{13}$$

where:
$N_{A(t)}$ = carbon stocks in above-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 dm/ha)
0.5 = carbon fraction of dry matter (t C/t dm)

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

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

22. Values for $SV_{(t)}$ 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. Documented local values for WD should be used. In the absence of such values, national default values shall be consulted. If national default values are also not available, the values should be obtained from table 3A.1.9 of the IPCC good practice guidance for LULUCF.

For below-ground biomass

23. $N_{B(t)}$ is calculated per stratum i as follows:

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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>).

$N_{B(t)} = T_{(t)} * R * 0.5$ ` (15)

where:

$N_{B(t)}$ = 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 dm/ha)
R = root to shoot ratio (dimensionless)
0.5 = carbon fraction of dry matter (t C/t dm)

24. 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.

C. Leakage

25. According to decision 14/CP.10, 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 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."

26. In regions where 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 without causing further activity shifting, leakage can be considered insignificant. Such evidence can be provided e.g. by demonstrating based on experts' judgment or scientific literature that these lands have the biophysical potential to receive the shifting pre-project activities and that the legal status of these lands or local tradition allows their use for shifting pre-project activities.

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

(a) Percentage of families/households of the community involved in or affected by the project activity displaced due to the project activity;

(b) Percentage of total production of the main agricultural produce (for example corn) within the project boundary displaced due to the project activity;

(c) The time-average number of grazing animals per hectare within the project boundary displaced due to the project activity divided by the average grazing capacity of land for the area, expressed as percentage. The default values of average grazing capacity of the land under tropical conditions will be (sources: see **appendix D**):

Dry climates: 0.5 head of cattle or 2.3 head of sheep per hectare

Wet climates: 1.0 head of cattle or 4.9 head of sheep per hectare

The project proponents may use locally derived values for average grazing capacity providing adequate documentation.

28. If the value of each of these indicators is lower than 10 per cent, then

$L_{(t)} = 0$ (16)

where:
$L_{(t)}$ = leakage attributable to the project activity within the project boundary at time *t* (t C)

29. If the value of one of these indicators is higher than 10 per cent and less than or equal to 50 per cent, then leakage shall be equal to 15 per cent of the actual net GHG removals by sinks, that is:

$$L_{(t)} = N_t * 0.15 \qquad (17)$$

where:
$L_{(t)}$ = leakage attributable to the project activity within the project boundary at time *t* (t C)
$N_{(t)}$ = carbon stocks in the living biomass pools within the project boundary at time *t* under the project scenario (t C)

30. As indicated in paragraph 3 above, if the value of any of these indicators is larger than 50 per cent, net anthropogenic removals by sinks cannot be estimated.

31. If project participants consider that the use of fertilizers would be significant leakage of N_2O (>10 per cent of the net anthropogenic GHG removals by sinks) emissions 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).

D. Ex ante estimation of net anthropogenic greenhouse gas removals by sinks

32. Net anthropogenic greenhouse gas removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage.

33. The resulting temporary certified emission reductions (tCERs) at the year of verification *tv* are calculated as follows:

$$tCER_{(tv)} = 44/12 * (N_{(tv)} - B_{(tv)} - L_{(tv)}) \qquad (18)$$

if changes in carbon stock are considered to be equal to zero, then $B_{(tv)} = B_{(t=0)}$ and

$$L_{(tv)} = 0.15 * N_{(tv)} \text{ (if required, see paragraph 29 above)} \qquad (19)$$

where:
$tCER_{(tv)}$ = tCERs emitted at year of verification *tv* (t CO_2)
$N_{(tv)}$ = carbon stocks in the living biomass pools within the project boundary at year of verification *tv* under project scenario (t C)
$B_{(tv)}$ = carbon stock in the living biomass pools within the project boundary at year of verification *tv* that would have occurred in the absence of the project activity (t C)
$L_{(tv)}$ = leakage attributable to the project activity within the project boundary at year of verification *tv* (t C)
tv = year of verification
44/12 = conversion factor from t C to t CO_2 equivalent (t CO_2/t C)

34. The resulting long-term certified emission reductions (lCERs) at the year of verification *tv* are calculated as follows:

$$lCER_{(tv)} = 44/12 * [(N_{(tv)} - N_{(tv-\kappa)}) - L_{(tv)}] \qquad (20)$$

$$L_{(tv)} = 0.15 * (N_{(tv)} - N_{(tv-\kappa)}) \text{ (if required, see paragraph 29 above)} \qquad (21)$$

$N_{(tv-\kappa)} = N_{(t=0)}$ for the first verification (22

where:

$lCER_{(tv)}$ = lCERs emitted at year of verification *tv* (t CO_2)
$N_{(tv)}$ = carbon stocks in the living biomass pools within the project boundary at year of verification *tv* under project scenario (t C)
$B_{(tv)}$ = carbon stock in the living biomass pools within the project boundary at year of verification *tv* that would have occurred in the absence of the project activity (t C)
$L_{(tv)}$ = leakage attributable to the project activity within the project boundary at year of verification *tv* (t C)
tv = year of verification
κ = time span between two verifications
44/12 = conversion factor from t C to t CO_2 equivalent (t CO_2/t C)

35. Project participants should provide in the CDM-SSC-AR-PDD a projection of the net anthropogenic GHG removals as tCERs or lCERs for all crediting periods.

IV. 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 14/CP.10, 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 III. B above.

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

37. Before performing the sampling to determine any changes in carbon stocks, project participants need to measure and monitor the area that has been planted. This can be performed through, for example, on-site visits, analysis of cadastral information, aerial photographs or satellite imagery of adequate resolution.

38. Once project participants have selected the method to monitor the area that has been planted, this method should be used to monitor the performance of the planted areas throughout the project activity. If significant underperformance is detected, changes in carbon stocks from such areas shall be assessed as a separate stratum.

39. Carbon stocks shall be estimated through stratified random sampling procedures and the following equations:

$$P_{(t)} = \sum_{i}^{I}(P_{A(t)\,i} + P_{B(t)\,i}) * A_i \qquad (23)$$

where:

$P_{(t)}$ = carbon stocks within the project boundary at time *t* achieved by the project activity (t C)
$P_{A(t)\,i}$ = 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. Stratification for sampling shall be the same as the stratification for the ex ante estimation of the actual net GHG removals by sinks (section III.C above). The calculations shown below will be performed for each stratum.

For above-ground biomass

41. $P_{A(t)}$ is calculated per stratum *i* as follows:

$$P_{A(t)} = E_{(t)} * 0.5 \tag{24}$$

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

42. $E_{(t)}$ shall be estimated through the following steps:

(a) **Step 1:** Design a statistically sound sampling procedure. Such procedures should be designed according to the standard methods described in section 4.3.3.4. of the IPCC good practice guidance LULUCF. Additional strata should be considered subsequently for areas affected by fires and pests. This procedure includes the specification of the number, type and size of permanent plots and should be described in the CDM-SSC-AR-PDD. The allowed precision target for monitoring shall be not larger than ± 10 per cent, at a 95 per cent confidence level for the mean;

(b) **Step 2:** Establish and mark permanent plots and document their location in the first monitoring report;

(c) **Step 3:** Measure the diameter at breast height (*DBH*) or *DBH* and tree height, as appropriate; this measure which should be stated in the monitoring reports;

(d) **Step 4:** Estimate the above-ground biomass (AGB) 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:

$$E_{(t)} = SV * BEF * WD \tag{25}$$

where:

$E_{(t)}$ = estimate of above-ground biomass at time *t* achieved by the project activity (t dm/ha)
SV = stem volume (m^3/ha)
WD = basic wood density (t dm/m^3)
BEF = biomass expansion factor (over bark) from stem volume to total volume (dimensionless)

43. Project participants shall use the default *BEF* proposed by the IPCC good practice guidance for LULUCF, specifically for tropical broad-leaved species, in order to obtain a conservative estimate of total biomass.

44. *SV* shall be estimated from on-site measurements using the appropriate parameters (such as *DBH* or *DBH* and height). 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).

45. Documented local values for *WD* 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.1.9 of the IPCC good practice guidance for LULUCF.

For below-ground biomass

46. $P_{B(t)}$ shall be estimated for each stratum *i* as follows:

$$P_{B(t)} = E_{(t)} * R * 0.5 \quad (26)$$

where:
$P_{B(t)}$ = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)
R = root to shoot ratio (dimensionless)
0.5 = carbon fraction of dry matter (t C/t dm)

47. 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.

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

$$P_{B(t)} = exp(-1.085 + 0.9256 * ln\, E_{(t)}) * 0.5 \quad (27)$$

where:
$P_{B(t)}$ = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)
$E_{(t)}$ = estimate of above-ground biomass at time *t* achieved by the project activity (t dm/ha)
0.5 = carbon fraction of dry matter (t C/t dm)

C. Ex post estimation of leakage

49. In order to estimate leakage, project participants shall monitor, for each monitoring period, each of the following indicators:

(a) Percentage of families/households of the community involved in or affected by the project activity displaced due to the implementation of the project activity;

(b) Percentage of total production of the main produce (for example meat or corn) within the project boundary displaced due to the project activity.

[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.

(c) The time-average number of grazing animals per hectare within the project boundary that is displaced due to the project activity divided by the average grazing capacity of land for the area, expressed as percentage.

50. If the values of these indicators for the specific monitoring period is lower than 10 per cent, then

$$L_{(t)} = 0 \quad (28)$$

where:
$L_{(t)}$ = Leakage attributable to the project activity within the project boundary at time t (t C)

51. If the value of one of these indicators is higher than 10 per cent and less than or equal to 50 per cent, then leakage shall be equal to 15 per cent of the actual net GHG removals by sinks, that is:

$$L_{(t)} = P_{(t)} * 0.15 \quad (29)$$

where:
$L_{(t)}$ = Leakage attributable to the project activity within the project boundary at time t (t C)
$P_{(t)}$ = Carbon stocks in the living biomass pools within the project boundary at time t under project scenario (t C)

52. As indicated in chapter I, paragraph 3, if the value of one of these indicators is larger than 50 per cent net anthropogenic GHG removals by sinks cannot be estimated.

53. If project participants consider that the use of fertilizers would be significant, leakage of N_2O emissions (>10 per cent of the net anthropogenic removals by sinks) should be estimated in accordance with the IPCC good practice guidance.

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

54. 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.

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

$$tCER_{(tv)} = 44/12 * (P_{(tv)} – B_{(tv)} – L_{(tv)}) \quad (30)$$

if the changes in carbon stock in the baseline are considered to be zero, then $B_{(tv)} = B_{(t=0)}$ and

$L_{(tv)} = 0.15 * P_{(tv)}$ (if required; see paragraph 51)

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

$$lCER_{(tv)} = 44/12 * [(P_{(tv)} - P_{(tv-\kappa)}) - L_{(tv)}] \quad (31)$$

$L_{(tv)} = 0.15 * (P_{(tv)} - P_{(tv-\kappa)})$ (if required; see paragraph 51) (32)

$P_{(tv-\kappa)} = P_{(t=0)} = B_{(t=0)}$ for the first verification (33)

where:
$tCER_{(tv)}$ = tCERs emitted at year of verification *tv* (t CO_2)
$lCER_{(tv)}$ = lCERs emitted at year of verification *tv* (t CO_2)

$P_{(tv)}$ = carbon stocks in the living biomass pools within the project boundary at year of verification *tv* under project scenario (t C)
$B_{(tv)}$ = carbon stock in the living biomass pools within the project boundary at year of verification *tv* that would have occurred in the absence of the project activity (t C)
$L_{(tv)}$ = leakage attributable to the project activity within the project boundary at year of verification *tv* (t C)
tv = year of verification
κ = time span between two verifications (years)
44/12 = conversion factor from t C to t CO_2 equivalent (t CO_2/t C)

E. Monitoring frequency

57. A five-year monitoring frequency of the permanent sample plots established within the project boundary is needed for an appropriate monitoring of above-ground and below-ground biomass.

E. Data collection

58. Data collection shall be organized taking into account the carbon pools measured, the sample frame used and the number of permanent plots to be monitored in accordance with the section on quality assurance/quality control (QA/QC) below. Tables 1 and 2 outline the data to be collected to monitor the actual net GHG removals by sinks and leakage.

F. Quality control and quality assurance

59. As stated in the IPCC good practice guidance LULUCF (page 4.111), monitoring requires provisions for quality assurance (QA) and quality control (QC) to be implemented via a QA/QC plan. The plan shall become part of project documentation and cover procedures as described below for:

(a) Collecting reliable field measurements;

(b) Verifying methods used to collect field data;

(c) Verifying data entry and analysis techniques;

(d) Data maintenance and archiving. This point is especially important, also for small-scale A/R CDM project activities, as timescales of project activities are much longer than those of technological improvements of electronic data archiving. Each point of importance for small-scale A/R CDM project activities is treated in the following section.

G. Procedures to ensure reliable field measurements

60. Collecting reliable data from field measurements is an important step in the quality assurance plan. Those responsible for the measurement work should be trained in all aspects of the field data collection and analysis. It is good practice to develop standard operating procedures (SOPs) for each step of the field measurements, which should be adhered to at all times. These SOPs describe in detail all steps of the field measurements and contain provisions for documentation for verification purposes so that future field personnel can check past results and repeat the measurements in a consistent fashion. To ensure the collection and maintenance of reliable field data, it is good practice to ensure that:

(a) Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible;

(b) Field teams install test plots if needed in the field and measure all pertinent components using the SOPs to estimate measurement errors;

(c) The document will list all names of the field team and the project leader will certify that the team is trained;

(d) New staff are adequately trained.

H. Procedures to verify field data collection

61. To verify that plots have been installed and the measurements taken correctly, it is good practice to remeasure independently every 10 plots and to compare the measurements. The following quality targets should be achieved for the remeasurements, compared to the original measurements:

(a) Missed or extra trees: no error within the plot

(b) Tree species or groups: no error

(c) DBH: < ± 0.5 cm or 3 % whichever is greater

(d) Height:< + 10/ and - 20%

62. At the end of the field work 10–20 per cent of the plots shall be checked independently. Field data collected at this stage will be compared with the original data. Any errors found should be corrected and recorded. Any errors discovered should be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

I. Procedures to verify data entry and analysis

63. In order to obtain reliable estimates data must be entered into the data analysis spreadsheets correctly. Errors in this process can be minimized if the entry of field data and laboratory data are cross-checked and, where necessary, internal tests are incorporated into the spreadsheets to ensure that the data are realistic. All personnel involved in measuring and analysing data should communicate to resolve any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that cannot be resolved, the plot should not be used in the analysis.

J. Data maintenance and storage

64. Due to the long-term nature of A/R project activities under the CDM, data archiving (maintenance and storage) is an important component of the work. Data archiving should take several forms and copies of all data should be provided to each project participant.

65. The following shall be stored in a dedicated and safe place, preferably offsite:

(a) Copies (electronic and/or paper) of all field data, data analyses, and models; estimates of the changes in carbon stocks and corresponding calculations and models used;

(b) Any geographical information system (GIS) products;

(c) Copies of the measuring and monitoring reports.

66. Given the time frame over which the project activity will take place and the pace of updating of software and hardware for storing data, it is recommended that the electronic copies of the data and the report be updated periodically or converted to a format that could be accessed by any future software application.

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	Permanent plots, literature	tonnes of dry matter per m^3 fresh volume	Estimated	Once	3 samples per tree from base, middle and top of the stem of three individuals	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
Percentage of families/ households of the community involved in or affected by the project activity displaced due to the implementation of the project activity	Participatory survey	Number of families or households	Estimated	5	per cent	Electronic	
Percentage of total production of the main produce (e.g. meat, corn) within the project boundary displaced due to the CDM A/R project activity.	Survey	Quantity (volume or mass)	Estimated	5	per cent	Electronic	

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

Parameter or abbreviation	Refers to	Units
$B_{(t)}$	Carbon stocks within the project boundary at time *t* that would have occurred 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* that would have occurred 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* that would have occurred in the absence of the project activity	t C/ha
A_i	Project area of stratum *i*	ha
$M_{(t)}$	Above-ground biomass at time *t* that would have occurred in the absence of the project activity	t dm/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 dm/ha

Parameter or abbreviation	Refers to	Units
$M_{woody\ (t)}m$	Above-ground woody biomass at time *t* that would have occurred in the absence of the project activity	t dm/ha Time
R_{woody}	Root to shoot ratio of woody perennials	t dm/t dm
R_{grass} R	Root to shoot ratio for grassland	t dm/t dm
g	Annual biomass growth rate of woody perennials	t dm/ha/year
i	Stratum *i* (*I* = total number of strata)	
n	Running variable that increases by Δt = 1 year for each iterative step, representing the number of years elapsed since the project start	years
$N_{(t)}$	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* from project scenario	t C/ha
$N_{B(t)\ i}$	Carbon stocks in below-ground biomass at time *t* of stratum *i* from project scenario	t C/ha
$T_{(t)}$	Above-ground biomass at time *t* for the project scenario	t dm/ha
$SV_{(t)}$	Stem volume at time *t* for the project scenario	m^3 /ha
WD	Basic wood density	t of dm/m^3 (fresh volume)
BEF	Biomass expansion factor (over bark) from stem volume to total volume	Dimensionless
L_t	Leakage for the project scenario at time *t*	t C
$P_{(t)}$	Carbon stocks within the project boundary at time *t* achieved by the project activity	t C
$P_{A(t)\ i}$	Carbon stock in above-ground biomass at time *t* of stratum *i* achieved by the project activity	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
$E_{(t)}$	Above-ground biomass at time *t* achieved by the project activity	t of dm/ha
DBH	Diameter at breast height (130 cm or 1.30 m)	cm or m
$L_{p(t)}$	Leakage resulting from the project activity at time *t*	t C
$tCER_{(tv)}$	tCERs emitted at year of verification *tv* (t CO_2)	t CO_2
$lCER_{(tv)}$	lCERs emitted at year of verification *tv* (t CO_2)	t CO_2

Parameter or abbreviation	Refers to	Units
t_0	Year of the project start	
tv	Year of verification	
κ	Time span between two verifications (years)	years
Δt	Time increment = 1 (year)	year

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	$AGB = 10^{\wedge}\{-0.535 + log_{10}(\pi * DBH^2/4)\}$	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:

$$GC = \frac{ANPP * 1000}{365 * DMI} \qquad (A.5)$$

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:

$$DMI = \frac{GE}{NE_{ma}} \qquad (A.6)$$

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)[1]. 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.

[1] 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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