Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on settlements

I. Applicability, carbon pools and project emissions

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

(a) project activities are implemented on settlements[1]. Specifically the following lands fall under the settlement category

(i) Transportation infrastructure: Land strips along streets, country roads, highways, railways, waterways, overhead power cables, gas pipelines, provided such land is functionally or administratively associated with the transportation infrastructure and is not accounted for in another land-use category;

(ii) Human settlements: Residential and commercial lawns (rural and urban), gardens, golf courses, athletic fields, parks, provided such land is functionally or administratively associated with particular cities, villages or other settlement types and is not accounted for in another land-use category.

(b) project activities are implemented on lands where areas used for agricultural activities within the project boundary, and displaced due to the project activity, are less than 50 per cent of the total project area;

(c) 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 the methodologies are above-and below-ground tree biomass, (i.e. living biomass). It is assumed that changes in carbon stocks occur only in tree biomass[2].

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.**

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, that is settlements.

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[1] The definition of the category "settlements" as provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003), may include all developed land i.e., residential, transportation, commercial, and production (commercial, manufacturing) infrastructure of any size, unless it is already included under other land-use categories.

[2] *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC 2003), Appendix 3a.4 Settlements: Basis for Future Methodological Development, 3A.4.1.1.1 Methodological Issues (page 3.295).

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 trees are expected not to exceed 10% of *ex-ante* actual net GHG removals by sinks, to occur, the changes in carbon stocks shall be assumed to be zero;

(b) If the carbon stock in the living biomass of trees is expected to decrease in the absence of the project activity, the baseline net GHG removals by sinks shall be conservatively assumed to be zero. In the above case, the baseline carbon stocks in the carbons pools are constant and equal to the 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 of trees 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 settlements with changes in the carbon stocks 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 settlements with changes in the carbon stocks 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. The baseline is determined ex-ante and remains fixed during the crediting period. The baseline net GHG removals by sinks will be determined by the equation:

$$\Delta C_{BSL,t} = \sum_{i=1}^{I} \Delta C_{i,baseline,t} \quad (1)$$

where:

$\Delta C_{BSL,t}$	the sum of the changes in carbon stocks in the living biomass of trees in the absence of the project activity for year *t*, tonnes CO_2-e yr^{-1}
$\Delta C_{i,baseline,t}$	average annual carbon stock change in living biomass of trees for stratum *i* for year *t*, tonnes CO_2-e yr^{-1}
i	stratum i, (*I* = total number of strata)
t	year 1 to length of crediting period

9. For those strata without growing trees, $\Delta C_{i,baseline,t} = 0$. For all other cases, $\Delta C_{i,baseline,t}$ is estimated using the following *carbon gain-loss method*[3]:

$$\Delta C_{i,baseline,t} = (\Delta C_{G,i,t} - \Delta C_{L,i,t}) \quad (2)$$

where:

$\Delta C_{i,baseline,t}$ average annual carbon stock change in living biomass of trees for stratum

[3] GPG-LULUCF Equation 3.2.2, Equation 3.2.4 and Equation 3.2.5

	i, tonnes for year t, CO_2-e yr^{-1}
$\Delta C_{G,i,t}$	average annual increase in carbon due to biomass growth of living trees for stratum i for year t, tonnes CO_2-e yr^{-1}
$\Delta C_{L,i,t}$	average annual decrease in carbon due to biomass loss of living trees for stratum i for year t, tonnes CO_2-e yr^{-1}. To be conservative for the baseline scenario, $\Delta C_{L,i} = 0$ in this methodology.

$$\Delta C_{G,i,t} = A_i \cdot G_{TOTAL,i,t} \cdot C_{FRAC} \cdot 44/12 \tag{3}$$

where:

$\Delta C_{G,i,t}$	average annual increment in carbon due to total biomass growth of living trees for stratum i, tonnes CO_2-e yr^{-1} for year t
A_i	area of stratum i, hectare (ha)
$G_{TOTAL,i,t}$	average annual increment of total biomass of living trees for stratum i, for year t, tonnes of dry matter ha^{-1} yr^{-1} for year t.
C_{FRAC}	carbon fraction of dry matter, tonnes C (tonne d.m.)$^{-1}$
44/12	ratio of molecular weights of CO_2 and carbon, dimensionless

$$G_{TOTAL,i,t} = G_{AB,i,t} \cdot (1 + R) \tag{4}$$

$$G_{AB,i,t} = I_{V,i,t} \cdot D \cdot CF \cdot BEF_1 \tag{5}$$

where:

$G_{TOTAL,i,t}$	average annual increment of total biomass of living trees for stratum i, tonnes of dry matter, ha^{-1} yr^{-1} for year t
$G_{AB,i,t}$	average annual aboveground biomass increment of living trees for stratum i, for year t, tonnes d.m. ha^{-1} yr^{-1}
R	Root-shoot ratio, t.d.m/t.d.m
$I_{V,i,t}$	average annual increment in merchantable volume for stratum i, for year t, m^3 ha^{-1} yr^{-1}
D	basic wood density for tree species, tonnes d.m. m^{-3}
CF	Correction factor reflecting stand density, dimensionless
BEF_1	biomass expansion factor for conversion of merchantable volume to total aboveground biomass increment, dimensionless

10. The time points 1 and 2, for which the stock are estimated taken to determine the $\Delta C_{i,baseline}$ must be broadly representative of the typical age of the trees under the baseline scenario during the crediting period. For example, if the trees are already mature at the start of the project, it is not appropriate to select time point 1 and 2 that corresponds to the juvenile fast growth stage.

11. Documented local values for $I_{v,i,t}$ should be used. In the absence of such values, national default values should be used. If national values are also not available, $G_{w,i}$ values should be obtained from table 3.3.2 (p. 3.71) of the *IPCC good practice guidance for LULUCF* after transformation from C to d.m. For

openly stocked tree stands it is important to use an appropriate correction factor if the used values refer to fully stocked stands (e.g. CF = 1.0 for fully stocked closed crown cover, CF = 0.5 for 50% stocked stands). For local values depicting the actual stand density, CF = 1.0. BEF_1 values could be used from Table 3A.1.10 provided in the *IPCC good practice guidance for LULUCF, if no local or national specific data exist*.

12. Documented local values for *D* 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*.

13. Documented local values for *R* may be used if available. In the absence of such values, national default values for R should be used. If national values are also not available, the values should be obtained from table 3.A.1.8 of the *IPCC good practice guidance for LULUCF*.

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

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

15. 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.

16. Actual net GHG removals by sinks consider only the changes in carbon pools for the project scenario. For the *ex-ante* estimation, the following equations based on the *stock change method* may be used:

$$\Delta C_{PROJ,t} = \sum_{i=1}^{I} \Delta C_{project,i,t} \tag{6}$$

$$\Delta C_{project,i,t} = (C_{2,i} - C_{1,i}) / T \cdot 44/12 \tag{7}$$

$$C_i = C_{AB,i} + C_{BB,i} \tag{8}$$

$$C_{AB,i} = A_i \cdot V_i \cdot CF \cdot D \cdot BEF_2 \cdot C_{FRAC} \tag{9}$$

$$C_{BB,i} = C_{AB,i} \cdot R \tag{10}$$

where:

$\Delta C_{PROJ,t}$	average annual carbon stock change in living biomass of trees for the project area, tonnes CO_2-e yr^{-1}
$\Delta C_{i,project,t}$	average annual carbon stock change in living biomass of trees for stratum *i*, for year *t*, tonnes CO_2-e yr^{-1}
$C_{2,i}$	total carbon stock in living biomass of trees for stratum *i*, calculated at time 2, tonnes C
$C_{1,i}$	total carbon stock in living biomass of trees for stratum *i*, calculated at time 1,

	tonnes C
T	number of years between times 2 and 1
$C_{AB,i}$	carbon stock in aboveground biomass for stratum *i*, tonnes C
CF	Correction factor reflecting stand density, dimensionless
$C_{BB,i}$	carbon stock in belowground biomass for stratum *i*, tonnes C
A_i	area of stratum *i*, hectare (ha)
V_i	merchantable volume for stratum *i*, $m^3\ ha^{-1}$
D	basic wood density, tonnes d.m. m^{-3}
BEF_2	biomass expansion factor for conversion of merchantable volume to aboveground tree biomass, dimensionless
C_{FRAC}	carbon fraction of dry matter, tonnes C (tonne d.m.)$^{-}$1, IPCC default value = 0.5
R	Root-shoot ratio, t.d.m/t.d.m

17. Documented local values for *R* may be used if available. In the absence of such values, national default 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*.

18. V_i shall be estimated from on-site measurements of open-grown trees using the appropriate parameters (such *DBH* and height). Standard yield tables may be used especially for dense town park forests. For openly stocked tree stands, it is important to use an appropriate correction factor if the used values refer to fully stocked stands (e.g. CF = 1.0 for fully stocked closed crown cover, CF = 0.5 for 50% stocked stand). For local values depicting the actual stand density, CF = 1.0. If project specific values cannot be developed, appropriate equations taken from relevant literature on urban or roadside trees may be used, demonstrating the conservativeness of this approach.

19. Documented local values for *D* should be used. In the absence of such values, national default values shall be used. 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*.

20. Documented local values for *BEF* should be used and consistent application of *BEF* should take into account the definition of stem volume (e.g. total stem volume or thick wood stem volume requires different *BEF*s)[4]. In the absence of such values, national default values should be used. If national values are also not available, the BEF_2 values should be obtained from table 3A.1.10 of the *IPCC good practice guidance for LULUCF*[5]. Consistent application of *BEF* should be secured on the definition of stem volume (e.g. total stem volume or thick wood stem volume require different *BEF*s from the given range) [6]. To be conservative, the lower value in the specified range of BEF_2 values should be used and the selected BEF values justified.

21. Instead of forest specific BEFs, the 2006 IPCC Guidelines (chapter 8.2.1.1) recommend using allometric equations to calculate above-ground biomass directly, based on individual tree diameter at

[4] The 2006 IPCC Guidelines (chapter 8.2.1.1) recommend to give preference to allometric methods based on individual tree diameter at breast height, adjusted for open-grown trees, instead of unspecific BEFs.

[5] Although the BEF in table 3A.1.10 apply to biomass, the dimensionless factors can be equally applied for wood volume expansions. The BEF_2 values for growing stock data include bark and are given for a certain minimum diameter at breast height.

[6] The 2006 IPCC Guidelines (chapter 8.2.1.1) recommend to give preference to allometric methods based on individual tree diameter at breast height, adjusted for open-grown trees, instead of unspecific BEFs.

breast height and adjusted for open-grown trees. General allometric equations can be found in the *IPCC good practice guidance for LULUCF*, Annex 4A.2 and in **Appendix C** of this methodology. Where no other data exist, these equations can be applied to individual trees planted in lines, as living fence posts, or in more open conditions for rough but conservative[7] estimates.

22. $C_{AB,i}$ can also be estimated through the use of an allometric equation and a growth model or yield table appropriate to the tree species (or groups of them if several tree species have similar growth habits) in the stratum.

$$C_{AB,i} = A_i \cdot C_{FRAC} \cdot f\,(DBH, H) \cdot nTR_i \quad (11)$$

where:

$C_{AB,i}$	carbon stock in aboveground biomass for stratum *i*, tonnes C year^{-1}
A_i	area of stratum *i*, hectare (ha)
C_{FRAC}	carbon fraction of dry matter, tonnes C (tonne d.m.)$^{-1}$, IPCC default value = 0.5
f(DBH,H)	an allometric equation linking aboveground biomass of living trees (d.m. tree^{-1}) to mean diameter at breast height (DBH) and possibly tree height (H). Note: Mean DBH and H values should be estimated for stratum *i,* at time *t* using a growth model or yield table that gives the expected tree dimensions as a function of tree age. The allometric relationship between above-ground biomass and DBH and possibly H is a function of the species considered.
nTR_i	number of trees in stratum *i*, dimensionless ha^{-1}

23. If project participants consider that the use of fertilizers will result in significant emissions of > 10 % of the actual net greenhouse gas removals by sinks), project emissions ($GHG_{PROJ,t}$ - t CO_2-e / year) should be estimated in accordance with the procedures provided in appendix D[8].

24. The ***ex-ante* actual net GHG removal by sinks** over the first crediting period are calculated as follows:

$$\Delta C_{ACTUAL,t} = \sum_{t=0}^{tc} (\Delta C_{PROJ,t} - GHG_{PROJ,t}) * \Delta t \quad (12)$$

where:

$\Delta C_{ACTUAL,\,t}$	*ex-ante* actual net greenhouse gas removals by sinks over the first crediting period, tonnes CO_2-e
$\Delta C_{PROJ,t}$	average annual carbon stock change in living biomass of trees for the project area tonnes CO_2-e yr^{-1}
$GHG_{PROJ,\,t}$	GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity, tonnes CO_2-e yr^{-1}
tc	duration of the crediting period

[7] Such trees generally display different branching patterns and are likely to have more biomass for a given diameter than a similar diameter tree grown in a stand (Brown 1997, chapter 3.3).
[8] Use the tool: *Estimation of direct nitrous oxide emission from nitrogen fertilization* when it becomes available.

Δt = time increment = 1 year

IV. Leakage (*ex-ante*)

25. 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 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. 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.

27. In all other cases where leakage could occur because e.g. urban fields used by urban people to grow food crops are used for the tree planting project activity, project participants should assess the possibility of leakage from the displacement of activities by considering the following indicator:

(a) area used for agricultural activities within the project boundary displaced due to the project activity;

28. If the area under agricultural activities within the project boundary displaced due to the project activity is lower than 10 per cent of the total project area then:

$$L_t = 0 \qquad (13)$$

where:

L_t = leakage attributable to the project activity at time *t,* t CO_2-e year-[1]

29. If the value of the indicator is higher than 10 per cent and less than or equal to 50 per cent, then it is assumed that all leakage GHG emissions occur in the first year of the project activity and the leakage shall be equal to 15 per cent of the *ex-ante* actual net GHG removals by sinks accumulated during the first crediting period, that is:

$$L_t = \Delta C_{ACTUAL,t} * 0.15 \text{ /tc} \qquad (14)$$

where:

L_t leakage attributable to the project activity at time *t,* t CO_2-e year^{-1}

$\Delta C_{ACTUAL,t}$ *ex-ante* actual net greenhouse gas removals by sinks over the first crediting period (t CO_2-e)

tc duration of crediting period

30. If the value of above indicator calculated in paragraph 28 is higher than 50%, then this simplified methodology cannot be used.

V. Net anthropogenic greenhouse gas removals by sinks

31. The actual 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.

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

$$ER_{AR\ CDM,(t)} = \Delta C_{PROJ,t} - GHG_{PROJ,t} - \Delta C_{BSL,t} - L_t \qquad (15)$$

Where:

$ER_{AR\ CDM,(t)}$	net anthropogenic GHG removals by sinks; t CO_2-e yr^{-1}
$\Delta C_{PROJ,t}$	average annual carbon stock change in living biomass of trees for the project area tonnes CO_2-e yr^{-1}
$GHG_{PROJ,t}$	GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity, tonnes CO_2-e yr^{-1}
$\Delta C_{BSL,t}$	the sum of the changes in carbon stocks in the living biomass of trees in the absence of the project activity for year t, tonnes CO_2-e yr^{-1}
L_t	leakage attributable to the project activity at time *t,* t CO_2-e yr^{-1}

For subsequent crediting periods $L_t = 0$.

33. The resulting temporary certified emission reductions (tCERs) reflect the existing stock change at the time of verification *tv* minus leakage, calculated as follows:

$$tCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR\ CDM,(t)} * \Delta t \qquad (16)$$

lCERs reflect the *increment of the stock change* at the time of verification minus project emissions minus leakage compared to the existing stock change at the previous time of verification (t CO_2), calculated as follows:

$$lCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR\ CDM,(t)} - lCER_{(tv-k)} * \Delta t \qquad (17)$$

where:

$tCER_{(tv)}$	Units of t-CERs issued at year of verification *tv*
$ER_{AR\ CDM,(t)}$	net anthropogenic GHG removals by sinks; t CO_2-e yr^{-1}
$lCER_{(tv)}$	Units of l-CERs issued at year of verification *tv* (t CO_2)
tv	year of verification
κ	time span between two verifications (year)
Δt	= time increment = 1 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

34. 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

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

36. 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.

37. The carbon stocks changes shall be estimated through the following equations:

$$\Delta C_{ACTUAL,PROJ,t} = \Delta C_t - \mathrm{GHG_t} \qquad (18)$$

$$\Delta C_t = \sum_{\mathrm{i=1}}^{\mathrm{I}} \Delta C_{i,t} \qquad (19)$$

where:

$\Delta C_{ACTUAL,PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t, tonnes CO_2-e yr^{-1}
ΔC_t	average annual carbon stock change in living biomass of trees for the project area tonnes CO_2-e yr^{-1}
GHG_t	GHG emissions by sources within the project boundary as a result of the implementation of the A/R CDM project activity, tonnes CO_2-e yr^{-1}
$\Delta C_{i,t}$	verifiable changes in carbon stock change in carbon pools for stratum *i*, for year *t*, tonnes CO_2-e yr^{-1}

38. Since carbon stock changes in pools of soil organic matter, litter and dead wood are ignored in this small-scale methodology, the verifiable changes in carbon stock equal to the carbon stock changes in aboveground biomass and belowground biomass within the project boundary, are estimated using the following equations [9]

$$\Delta C_{i,t} = (\Delta C_{AB,i,t} + \Delta C_{BB,i,t}) \cdot 44/12 \qquad (20)$$

[9] Refers to GPG-LULUCF Equation 3.2.3

$$\Delta C_{AB,i,t} = (C_{AB,m_2,i} - C_{AB,m_1,i})/T \quad (21)$$

$$\Delta C_{BB,i,t} = (C_{BB,m_2,i} - C_{BB,m_1,i})/T \quad (22)$$

where:

$\Delta C_{i,t}$	changes in carbon stock in living biomass for stratum *i* in year *t*, tonnes CO_2-e yr^{-1}
$\Delta C_{AB,i,t}$	changes in carbon stock in aboveground biomass for stratum *i* in year *t*, tonnes C yr^{-1}
$\Delta C_{BB,i,t}$	changes in carbon stock in belowground biomass for stratum *i* in year *t*, tonnes C yr^{-1}
$C_{AB,m2,i}$	carbon stock in aboveground biomass for stratum *i*, calculated at monitoring time m_2, tonnes C
$C_{AB,\ m1,i}$	carbon stock in aboveground biomass for stratum *i*, calculated at monitoring time m_1, tonnes C
$C_{BB,m2,i}$	carbon stock in belowground biomass for stratum *i*, calculated at monitoring time m_2, tonnes C
$C_{BB,\ m1,i}$	carbon stock in belowground biomass for stratum *i*, calculated at monitoring time m_1, tonnes C
44/12	ratio of molecular weights of carbon and CO_2, dimensionless
T	number of years between monitoring time m_2 and m_1, which in this methodology is 5 years

39. For the first monitoring, the first biomass measurement could be omitted, because it is zero.

40. The total carbon stock in living biomass for each stratum at each monitoring time (m) is calculated from the area of each stratum and mean carbon stock in aboveground biomass and belowground biomass per unit area, given by:

$$C_{AB,m,i} = A_i \cdot MC_{AB,m,i} \quad (23)$$

$$C_{BB,m,i} = A_i \cdot MC_{BB,m,i} \quad (24)$$

where:

$C_{AB,m,,i}$	carbon stock in aboveground biomass for stratum *i* in year *m*, tonnes C
$C_{BB,m,,i}$	carbon stock in belowground biomass for stratum *i* in year *m* tonnes C
A_i	area of stratum *i*, hectare, ha
$MC_{AB,m,i}$	mean carbon stock in aboveground biomass per unit area for stratum *i*, tonnes C ha^{-1}
$MC_{BB,m,i}$	mean carbon stock in belowground biomass per unit area for stratum *i*, tonnes C ha^{-1}

41. The mean carbon stock in aboveground biomass and belowground biomass per unit area is estimated based on measurements on permanent plots. This can be estimated using two methods, i.e., Biomass Expansion Factors (BEF) method and Allometric Equations method. The following steps are recommended:

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

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

(c) **Step 3:** Estimate the above-ground biomass using allometric equations developed locally or nationally. Determine the carbon stocks by using default carbon fraction value of 0.5 to convert biomass to carbon. If these allometric equations are not available:

(i) Option 1: Use special allometric equations for relevant species or species groups of urban or roadside trees developed by the project proponents.

(ii) Option 2: If project specific equations cannot be developed, appropriate equations taken from relevant literature on urban or roadside trees may be used, demonstrating the conservativeness of this approach.

(iii) Option 3: General allometric equations based on individual tree diameter at breast height and sometimes tree height can be found in the IPCC good practice guidance for LULUCF, Annex 4A.2 and in **Appendix C** of this methodology. Where no other data exist, these equations can be applied to individual trees planted in lines, as living fence posts, or in more open conditions for rough but conservative[10] estimates.

(iv) Option 4: Use biomass expansion factors[11] and stem volume as follows:

$$C_{AB} = V \cdot D \cdot BEF_2 \cdot C_{FRAC} \qquad (25)$$

$$C_{BB} = C_{AB} \cdot R \qquad (26)$$

where:

C_{AB}	mean carbon stock in aboveground biomass, tonnes C ha^{-1}
C_{BB}	mean carbon stock in belowground biomass, tonnes C ha^{-1}
V	merchantable volume, m^3 ha^{-1}
D	wood density, tonnes d.m. m^{-3}
BEF_2	biomass expansion factor for conversion of merchantable volume to aboveground tree biomass, dimensionless
C_{FRAC}	carbon fraction, tonnes C (tonne d.m.)$^{-1}$, IPCC default value = 0.5
R	Root-shoot ratio, dimensionless

42. Merchantable volume (*V)* shall be estimated from on-site measurements using the appropriate parameters (such as *DBH* or *DBH* and height at the tree level). If project specific equations cannot developed, appropriate allometric equations taken from relevant literature on urban or roadside trees may be used, demonstrating the conservativeness of this approach.

[10] Such trees generally display different branching patterns and are likely to have more biomass for a given diameter than a similar diameter tree grown in a stand (Brown 1997, chapter 3.3).
[11] BEF_2 should be used in according to guidance in paragraph 20.

$$V = \sum_{n=1}^{N} g(DBH_n H_n) \qquad (27)$$

where:

V Merchantable volume, $m^3\ ha^{-1}$

$g\,(DBH_nH_n)$ an allometric equation linking merchantable volume ($m^3\ tree^{-1}$) to diameter at breast height (DBH) and possibly tree height (H)

N Total number of trees in the sample plot

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

44. Documented local values for *R* may be used if available. In the absence of such values, national default 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.*

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

$$C_{BB} = exp(-1.085 + 0.9256 * ln\ B_{AB}) * C_{FRAC} \qquad (28)$$

where:

C_{BB} carbon stocks in below-ground biomass achieved by the project activity during the monitoring interval, tonne C/ha

B_{AB} estimate of above-ground biomass achieved by the project activity, tonne d.m./ha

C_{FRAC} carbon fraction, tonnes C (tonne d.m.)$^{-1}$, IPCC default value = 0.5

Instead of equation 28 above, a more representative equation taken from the *IPCC good practice guidance for LULUCF*, Annex 4A.2 Table 4.A.4 may be used[12].

46. If project participants consider that use of fertilizers will result in significant emissions (>10 per cent of the actual net greenhouse gas removals by sinks), project emissions (GHG_t - t CO_2-e yr^{-1}), should be estimated in accordance with the procedures provided in appendix D[13].

C. Ex post estimation of leakage

47. In order to estimate leakage, project participants shall monitor the following indicator:

(a) area under cultivation within the project boundary displaced due to the project activity.

48. If the value of the indicator for the specific monitoring period is not greater than 10 per cent, then

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

where:

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[12] 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.

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

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

49. If the value of the above indicator 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

$$L_{tv} = 0.15 * \sum_{t=0}^{tv} \Delta C_{ACTUAL,PROJ,t} \quad (30)$$

For subsequent verification period

$$L_{tv} = 0.15 * \sum_{tv-k}^{tv} \Delta C_{ACTUAL,PROJ,t}$$

where:

L_{tv}	total GHG emission due to leakage at the time of verification (tonnes CO_2-e)
$\Delta C_{ACTUAL,PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t , tonnes CO_2-e year^{-1}
tv	Year of verification

50. As indicated in chapter I, paragraph 1, if the value of the above indicator is larger than 50% net anthropogenic GHG removals by sinks cannot be estimated.

51. At the end of the first crediting period the total leakage will be calculated as follows:

$$L_{CP1} = 0.15 * \sum_{t=0}^{tc} \Delta C_{ACTUAL,PROJ,t} \quad (31)$$

where:

L_{CP1} = total GHG emission due to leakage at the end of the first crediting period (tonnes CO_2-e)

$\Delta C_{ACTUAL,PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t , tonnes CO_2-e yr^{-1}
tc	end of the first crediting period

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

52. 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.

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

(a) for the first crediting period:

$$tCER_{(tv)} = \sum_{t=0}^{tv} (\Delta C_{ACTUAL,PROJ,t} - \Delta C_{BSL,t}) - L_{tv} \quad (32)$$

(b) for subsequent crediting periods:

$$tCER_{(tv)} = \sum_{t=0}^{tv}(\Delta C_{ACTUAL,PROJ,t} - \Delta C_{BSL,t}) - L_{CP1} \quad (33)$$

where:

$\Delta C_{ACTUAL,PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t , tonnes CO_2-e yr^{-1}
$\Delta C_{BSL,t}$	the sum of the changes in carbon stocks in the living biomass of trees in the absence of the project activity for year *t*, tonnes CO_2-e yr^{-1}
L_{CP1}	total GHG emission due to leakage at the end of the first crediting period (t CO_2-e)
L_{tv}	total GHG emission due to leakage at the time of verification (t CO_2-e)

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

(a) *for the first crediting period:*

$$lCER_{(tv)} = \sum_{t=0}^{tv}(\Delta C_{ACTUAL,PROJ,t} - \Delta C_{BSL,t}) - L_{tv} - lCER_{(tv-k)} \quad (34)$$

(b) *for subsequent crediting periods*

$$lCER_{(tv)} = \sum_{t=0}^{tv}(\Delta C_{ACTUAL,PROJ,t} - \Delta C_{BSL,t}) - L_{CP1} - lCER_{(tv-k)} \quad (35)$$

where:

$\Delta C_{ACTUAL\ PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t , tonnes CO_2-e $year^{-1}$
$\Delta C_{BSL,t}$	the sum of the changes in carbon stocks in the living biomass of trees in the absence of the project activity for year *t*, tonnes CO_2 yr^{-1}
L_{CP1}	total GHG emission due to leakage at the end of the first crediting period (t CO_2-e)
L_{tv}	total GHG emission due to leakage at the time of verification (t CO_2-e)
$lCER_{(tv-k)}$	units of *lCER*s issued following the previous verification
tv	year of verification
κ	time span between two verifications (years)

E. Monitoring frequency

55. A monitoring frequency for each variable is defined in Table 1.

F. Data collection

56. Tables 1 and 2 outline the data to be collected to monitor the actual net GHG removals by sinks and leakage.

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

A. 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
Areas used for agricultural activities within the project boundary displaced due to the project activity	Survey	Area in ha	Estimated	5	per cent	Electronic	

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

Parameter or abbreviation	Refers to	Units
A/R	Afforestation and reforestation	
LULUCF	Land use, land use change and orestry	
CDM	Clean development mechanism	
GPG	Good practice guidance	
CO_2	Carbon dioxide	
Kt	kilotonnes (metric)	kt
GHG	Greenhouse gas	-
$\Delta C_{BSL,t}$	the sum of the changes in carbon stocks in the living biomass of trees in the absence of the project activity for year *t*	t CO_2-e yr^{-1}
i	stratum *i* (*I* = total number of strata)	-
Ha	hectare	ha
t	Year 1 to length of crediting period	
$\Delta C_{G,i,t}$	average annual increase in carbon due to biomass growth of living trees for stratum *i*, for year *t*	t CO_2-e yr^{-1}
$\Delta C_{L,i,t}$	average annual decrease in carbon due to biomass loss of living trees for stratum *i* for year *t*	t CO_2-e yr^{-1}
A_i	area of stratum *i*	ha
$G_{TOTAL,i,t}$	average annual increment of total biomass of living trees for stratum *i*, for year *t*	t d.m. ha^{-1} yr^{-1}
$\Delta C_{i,\ baseline,\ t}$	average annual carbon stock change in living biomass of trees for stratum i for year t	t CO_2-e yr^{-1}

Parameter or abbreviation	Refers to	Units
C_{FRAC}	carbon fraction of dry matter, IPCC default value = 0.5	$t\ C\ (t\ d.m.)^{-1}$
44/12	ration of molecular weights of CO_2 and carbon, dimensionless	dimensionless
d.m.	Dry matter	t
C	Carbon	t
$G_{AB,i,t}$	average annual aboveground biomass increment of living trees for stratum *i,* for year *t*	$t\ d.m.\ ha^{-1}\ yr^{-1}$
R	Root-shoot ratio	t d.m./ t d.m.
$I_{V,i,t}$	average annual increment in merchantable volume for stratum *i* for year *t*	$m^3\ ha^{-1}\ yr^{-1}$
D	basic wood density	$t\ d.m.\ m^{-3}$ (fresh volume)
CF	Correction factor reflecting stand density, dimensionless	-
$BEF_{1,}$	biomass expansion factor for conversion of annual net increment (including bark) from merchantable volume to total aboveground biomass increment	dimensionless
$\Delta C_{PROJ,,t}$	average annual carbon stock change in living biomass of trees for the project area	$t\ CO_2\text{-}e\ yr^{-1}$
$\Delta C_{project,\ i,t}$	average project annual carbon stock change in living biomass of trees for stratum *i*, for year *t*	$t\ CO_2\text{-}e\ yr^{-1}$
$C_{2,i}$	total carbon stock in living biomass of trees for stratum *i*, calculated at time 2	t C
$C_{1,i}$	total carbon stock in living biomass of trees for stratum *i*, calculated at time 1	t C
T	number of years between times 2 and 1	-
$C_{AB,i}$	carbon stock in aboveground biomass for stratum *i*	t C
$C_{BB,i}$	carbon stock in belowground biomass for stratum *i*	t C
V_i	merchantable volume for stratum *i*	$m^3\ ha^{-1}$
$BEF_{2,}$	biomass expansion factor for conversion of biomass of merchantable volume to aboveground tree biomass, dimensionless	dimensionless
f(DBH,H)	an allometric equation linking aboveground biomass of living trees ($d.m.\ tree^{-1}$) to mean diameter at breast height (DBH) and possibly tree height (H) for stratum *i*	-
$g(DBH_nH_n)$	an allometric equation linking merchantable tree volume ($m^3\ tree^{-1}$) to mean diameter at breast height (DBH) and possibly tree height (H)	-

Parameter or abbreviation	Refers to	Units
nTR_i	number of trees in stratum *i*, dimensionless	-
$\Delta C_{ACTUAL,t}$	*ex ante* actual net greenhouse gas removals by sinks over the first crediting period	t CO_2-e
$GHG_{proj,\ t}$	GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity,	t CO_2-e yr^{-1}
L_t	leakage attributable to the project activity at time *t*	t CO_2-e yr^{-1}
tc	end of first of crediting period	years
$ER_{AR\ CDM,(t)}$	net anthropogenic GHG removals by sinks	t CO_2-e yr^{-1}
$\Delta C_{t,}$	average annual carbon stock change in living biomass of trees for the project area	t CO_2-e yr^{-1}
$\Delta C_{ACTUAL\ PROJ,t}$	actual net greenhouse gas removals by sinks achieved by the project activity at time t	t CO_2-e yr^{-1}
$\Delta C_{i,t}$	verifiable changes in carbon stock change in carbon pools for stratum *i* for year *t*	t CO_2-e yr^{-1}
C_i	total carbon stock in living biomass of trees for stratum *i*, within the project boundary at time *t* under the project scenario	t C
$tCER_{(tv)}$	units of tCERs at the year of verification *tv*	t CO_2-e
$lCER_{(tv)}$	units of *lCER*s issued at the year of verification	t CO_2-e
t_v	year of verification	-
κ	time span between two verification occasions	year
t	year 1 to end of crediting period	-
$\Delta C_{AB,i,t}$	changes in carbon stock in aboveground biomass for stratum *i* in year *t*	t C yr^{-1}
$\Delta C_{BB,i,t}$	changes in carbon stock in belowground biomass for stratum *i* in year *t*	t C yr^{-1}
$C_{AB,m2,i}$	carbon stock in aboveground biomass for stratum *I*, calculated at monitoring point m_2	t C
$C_{AB,\ m1,i}$	carbon stock in aboveground biomass for stratum *i*, calculated at monitoring point m_1	t C
$C_{BB,m2,i}$	carbon stock in belowground biomass for stratum *i*, calculated at monitoring point m_2	t C
$C_{BB,\ m1,i}$	carbon stock in belowground biomass for stratum *i*, calculated at monitoring point m_1	t C
T	number of years between monitoring time m_2 and m_1	years
$C_{AB,m,,i}$	carbon stock in aboveground biomass stratum *i* in year *m*	t C yr^{-1}

Parameter or abbreviation	Refers to	Units
$C_{BB,m,,i}$	carbon stock in belowground biomass for stratum *i* in year *m*	t C yr^{-1}
$MC_{AB,m,i}$	mean carbon stock in aboveground biomass per unit area for stratum *i*	
$MC_{BB,m,i}$	mean carbon stock in belowground biomass per unit area for stratum *i*	t C ha^{-1}
C_{AB}	mean carbon stock in aboveground biomass	t C ha^{-1}
C_{BB}	mean carbon stock in belowground biomass	t C ha^{-1}
V	merchantable volume,	m^3 ha^{-1}
D	wood density	t d.m. m^{-3}
N	Total number of trees in the sample plot	-
DBH	Diameter at breast height	m
GHG_t	increase in GHG emission as a result or the implementation of the proposed small-scale A/R CDM project activity outside the project boundary in year *t*	t CO_2-e yr^{-1}
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
tc1	end of the first crediting period	-
$lCER_{(tv-k)}$	units of *lCER*s issued following the previous verification	t CO_2-e
$PE_{N2O,t*}$	direct N_2O emission as a result of nitrogen application within the project boundary up to time *t**	t CO_2-e
$F_{SN,t}$	amount of synthetic fertilizer nitrogen applied at time *t* adjusted for volatilization as NH_3 and NOx	t N
$F_{ON,t}$	annual amount of organic fertilizer nitrogen applied at time *t* adjusted for volatilization as NH_3 and NOx	t N
$N_{SN\text{-}Fert,t}$	amount of synthetic fertilizer nitrogen applied at time *t*	t N
$N_{ON\text{-}Fert,t}$	amount of organic fertilizer nitrogen applied at time *t*	t N
EF_1	emission factor for emissions from N inputs	t N_2O-N (t N input)$^{-1}$
$Frac_{GASF}$	fraction that volatilises as NH_3 and NOx for synthetic fertilizers	dimensionless
$Frac_{GASM}$	fraction that volatilises as NH_3 and NOx for organic fertilizers	dimensionless
GWP_{N2O}	Global Warming Potential for N_2O (310 for the first commitment period)	dimensionless

Appendix A

II. 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

III. 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

IV. 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	$AGB = 4.5 + 7.7 *stem\ height$	0.90	Brown (1997)

Note: *AGB* = above-ground dry matter biomass (kg dry matter per tree); *DBH* = diameter at breast height (cm); *H* = total height (m); *WD* = basic wood density (t/m^3); ln = natural logarithm; exp = "e raised to the power of"

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.

Pillsbury et al. (1998): Tree volume equations for fifteen urban species in California. Source: http://www.ufei.calpoly.edu/files/ufeipubs/UrbanTreeEqns.pdf

Appendix D

Estimation of Project Emission

1. The project emissions from use of fertilizers will be estimated as:

Ex-ante: $GHG_{proj,t} = PE_{N2O,t^*} / t^*$

Ex-post: $GHG_t = PE_{N2O,t^*} / t^*$

where:

$GHG_{proj,\ t}$	GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity, t CO_2-e yr^{-1}
GHG_t	increase in GHG emissions as a result or the implementation of the proposed small-scale A/R CDM project activity within the project boundary in year *t* (t CO_2 e yr^{-1})
PE_{N2O,t^*}	direct N_2O emission as a result of nitrogen application within the project boundary up to time *t**; tonnes CO_2-e.

2. For determining the level of **emissions from the use of fertilizers**, limited to N_2O emissions, the proposed method refers to Equation 3.2.18 in *IPCC GPG-LULUCF 2003* for forest soils identical to the one provided in the *Revised 1996 IPCC Guidelines* for Agriculture, in *GPG 2000*, and in IPCC 2006 GHG Inventory Guidelines. The following equations shall be used:

$$PE_{N2O,t^*} = \sum_{t=1}^{t^*} [\ (F_{SN,t} + F_{ON,t}\ ) * EF_1\ ] * 44/28 * GWP_{N2O} \quad (1\text{-A})$$

$$F_{SNt} = N_{SN\text{-}Fert,t} * (1 - Frac_{GASF}) \quad (2\text{-A})$$

$$F_{ONt} = N_{ON\text{-}Fert,t} * (1 - Frac_{GASM}) \quad (3\text{-A})$$

where:

PE_{N2O,t^*}	direct N_2O emission as a result of nitrogen application within the project boundary up to time *t**; tonnes CO_2-e.
$F_{SN,t}$	amount of synthetic fertilizer nitrogen applied at time *t* adjusted for volatilization as NH_3 and NOx; tonnes N
$F_{ON,t}$	amount of organic fertilizer nitrogen applied at time *t* adjusted for volatilization as NH_3 and NOx; tonnes N
$N_{SN\text{-}Fert,t}$	amount of synthetic fertilizer nitrogen applied at time *t*; tonnes N
$N_{ON\text{-}Fert,t}$	amount of organic fertilizer nitrogen applied at time *t*; tonnes N
EF_1	emission factor for emissions from N inputs; tonnes N_2O-N (tonnes N input)$^{-1}$
$Frac_{GASF}$	fraction that volatilises as NH_3 and NOx for synthetic fertilizers; dimensionless
$Frac_{GASM}$	fraction that volatilises as NH_3 and NOx for organic fertilizers; dimensionless
GWP_{N2O}	Global Warming Potential of N_2O (310 for the 1st commitment period), dimensionless

As noted in *IPCC 2006 Guidelines*, the default emission factor (EF1) is 1% of applied N, and this value should be used when country-specific factors are unavailable. The default values for the fractions of synthetic and organic fertilizer nitrogen that are emitted as NOx and NH_3 are 0.1 and 0.2 respectively in *2006 IPCC Guidelines (chapter 11.2.2.3, Table 11.3)*. Project developers may develop specific emission factors that are more appropriate for their project. Specific good practice guidance on how to derive specific emission factors is given in Box 4.1 of *IPCC GPG 2000*.