UNITED NATIONS

Framework Convention on Climate Change

Distr.
GENERAL

FCCC/KP/CMP/2007/3 (Part II)
6 November 2007

ENGLISH ONLY

CONFERENCE OF THE PARTIES SERVING AS THE MEETING OF THE PARTIES TO THE KYOTO PROTOCOL
Third session
Bali, 3–14 December 2007

Item 5 of the provisional agenda
Issues relating to the clean development mechanism

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*

Part II

The annexes below have been reproduced as approved by the Executive Board of the clean development mechanism at its thirty-third, thirty-fourth and thirty-fifth meetings, and without formal editing.

CONTENTS

Annexes

* Please note that, in compliance with United Nations editorial guidelines, annex numbers have been included in each annex and the page numbers have been modified to be continuous.

Annex I

Recommendation to the CMP: Simplified baseline and monitoring methodologies for CDM SSC A/R project activities implemented on settlements

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

I. Applicability conditions, 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;**

[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).

(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.

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:

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

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]:

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

Where:

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

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

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

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

$$G_{AB,i,t} = I_{V,i,t} \cdot D \cdot CF \cdot BEF_1 \quad \textbf{(5)}$$

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

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

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:

$$\Delta C_{PROJ,t} = \sum_{i=1}^{I} \Delta C_{project,i,t} \quad \textbf{(6)}$$

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

$$C_i = C_{AB,i} + C_{BB,i} \quad \textbf{(8)}$$

$$C_{AB,i} = A_i \cdot V_i \cdot CF \cdot D \cdot BEF_2 \cdot C_{FRAC} \quad \textbf{(9)}$$

$$C_{BB,i} = C_{AB,i} \cdot R \quad \textbf{(10)}$$

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*

[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.

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 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.

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

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:

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

[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.

[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.

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

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:

$$L_t = 0 \qquad \textbf{(13)}$$

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,

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

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:

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

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:

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

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:

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

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

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]

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

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

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

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:

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

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

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

[9] Refers to GPG-LULUCF Equation 3.2.3

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:

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

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

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

[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.

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.

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

Where:

V Merchantable volume, m³ ha^{-1}

$g(DBH_nH_n)$ an allometric equation linking merchantable volume (m³ 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)

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

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:

[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.

(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

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

Where:

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

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

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:

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

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:

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

(b) for subsequent crediting periods:

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

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:

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

(b) for subsequent crediting periods

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

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-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-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 (m³ tree^{-1}) to	-

Parameter or abbreviation	**Refers to**	**Units**
	mean diameter at breast height (DBH) and possibly tree height (H)	
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

Parameter or abbreviation	Refers to	Units
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*	$t\ C\ yr^{-1}$
$C_{BB,m,,i}$	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*	$t\ CO_2\text{-}e\ yr^{-1}$
L_{tv}	total GHG emission due to leakage at the time of verification	$t\ CO_2\text{-}e$
L_{CP1}	total GHG emission due to leakage at the end of the first crediting period	$t\ CO_2\text{-}e$
tc1	end of the first crediting period	-
$lCER_{(tv-k)}$	units of *lCER*s issued following the previous verification	$t\ CO_2\text{-}e$
$PE_{N2O,t*}$	direct N_2O emission as a result of nitrogen application within the project boundary up to time *t**	$t\ CO_2\text{-}e$
$F_{SN,t}$	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	$t\ N_2O\text{-}N\ (t\ N\ input)^{-1}$
$Frac_{GASF}$	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

Parameter or abbreviation	Refers to	Units
GWP_{N2O}	Global Warming Potential for N_2O (310 for the first commitment period)	dimensionless

Appendix A

Demonstration of land eligibility

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

Appendix B

Assessment of additionality

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

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

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

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

   (c) Lack of access to credit.

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

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

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

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

   (a) Lack of access to planting materials;

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

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

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

   (b) Traditional equipment and technology;

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

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

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

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

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

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

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

   (e) Unfavourable course of ecological succession;

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

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

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

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

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

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

(e) Lack of organization of local communities.

Appendix C

Default allometric equations for estimating above-ground biomass

Annual rainfall	DBH limits	Equation	R^2	Author
Broad-leaved species, tropical dry regions				
<900 mm	3–30 cm	$AGB = 10^{\{-0.535 + log_{10}(\pi * DBH^2/4)\}}$	0.94	Martinez-Yrizar et al. (1992)
900–1500 mm	5–40 cm	$AGB = exp\{-1.996 + 2.32 * ln(DBH)\}$	0.89	Brown (1997)
Broad-leaved species, tropical humid regions				
< 1500 mm	5–40 cm	$AGB = 34.4703 – 8.0671*DBH + 0.6589*(DBH^2)$	0.67	Brown et al. (1989)
1500–4000 mm	< 60 cm	$AGB = exp\{-2.134 + 2.530 * ln(DBH)\}$	0.97	Brown (1997)
1500–4000 mm	60–148 cm	$AGB = 42.69 – 12.800*(DBH) + 1.242*(DBH)^2$	0.84	Brown et al. (1989)
1500–4000 mm	5–130 cm	$AGB = exp\{-3.1141 + 0.9719*ln(DBH^2*H)$	0.97	Brown et al. (1989)
1500–4000 mm	5–130 cm	$AGB = exp\{-2.4090 + 0.9522*ln(DBH^2*H*WD)\}$	0.99	Brown et al. (1989)
Broad-leaved species, tropical wet regions				
> 4000 mm	4–112 cm	$AGB = 21.297 – 6.953*(DBH) + 0.740*(DBH^2)$	0.92	Brown (1997)
> 4000 mm	4–112 cm	$AGB = exp\{-3.3012 + 0.9439*ln(DBH^2*H)\}$	0.90	Brown et al. (1989)
Coniferous trees				
n.d.	2–52 cm	$AGB = exp\{-1.170 + 2.119*ln(DBH)\}$	0.98	Brown (1997)
Palms				
n.d.	> 7.5 cm	$AGB = 10.0 + 6.4 * H$	0.96	Brown (1997)
n.d.	> 7.5 cm	$AGB = 4.5 + 7.7 *stem\ height$	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/m³); 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:

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

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

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

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*.

Annex II

Recommendation to the CMP: Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands

Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands

I. Applicability conditions, carbon pools and project emissions

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

(a) Project activities are implemented on wetlands[1]. The DNA of the host country shall provide a statement that project activities conform to national policies and legislation applicable to wetlands. If the host country is a Party to Ramsar or other conventions applicable to wetlands, the DNA shall additionally provide a statement that project activities conform to the provisions of the convention/s.

(b) Project activities are implemented for afforestation or reforestation through assisted natural regeneration or seeding or tree planting on degraded[2] wetlands, which may be subject to further degradation and have tree and / or non tree component that is declining or in a low carbon steady-state.

(c) Direct measures/activities undertaken by the project proponents for the establishment of forest on degraded or degrading wetlands shall not lead to any changes in hydrology of land subjected to afforestation or reforestation project activity under the control of the project participants. Some examples of direct activities that are not permitted include drainage, flooding, digging or ditch blocking. Therefore, the A/R project activities are specifically restricted to the following wetland categories:

(i) Degraded intertidal wetlands (e.g. mangroves);

(ii) Undrained peat swamps that are degraded with respect to vegetation cover[3];

(iii) Degraded flood plain areas on inorganic soils and

(iv) Seasonally flooded areas on the margin of water bodies/reservoirs.

(d) This methodology is not applicable to project activities that are implemented on wetlands where the predominant vegetation comprises of herbaceous species in its natural state.

[1] In this methodology, "wetlands" are classified as per the definition of the category "wetlands" provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003), which includes land that is covered or saturated by water for all or part of the year and that does not fall into the forest land, cropland, grassland or settlements categories. Rice cultivation areas are excluded.

[2] Degraded wetlands in this methodology refers to degradation only with respect to vegetation cover. To demonstrate that the applicability condition (b) is obeyed, prove that the A/R project lands are really degraded using appendix A

[3] Methodology is not applicable to managed peatlands as defined in section 7.1 of IPCC, 2006 Guidelines for National Greenhouse Gas Inventories

(e) Project activities are implemented on lands where in the pre-project situation, areas used for agricultural activities (other than grazing) within the project boundary are not greater than 10% of the total project area.

(f) Project activities are implemented on lands where displacement of grazing animals does not result in leakage (see Section IV). If the possibility of leakage from displacement of grazing animals is not excluded using approach provided in para 19 below, the methodology is not applicable.

(g) Project activities are implemented on lands where <10% of the total surface project area is disturbed as result of soil preparation for planting. However, in project areas with organic soils, site preparation activities such as ploughing and drainage before or after the trees are planted are not allowed.

2. **Carbon pools** to be considered by these methodologies are above- and below-ground biomass (i.e. living biomass) of trees.

3. **Project emissions** attributable to A/R activities implemented on wetlands are assumed to be negligible hence, they are accounted for as zero in this methodology. According to IPCC GPG for LULUCF, GHGs emitted from wetlands may consist of CO_2, CH_4 and N_2O but the applicability conditions of the methodology ensure that hydrology of the project area is not changed as a result of the direct measures/activities undertaken by the project proponents for the establishment of the A/R project activity, therefore the chemical properties of the wetland soils influencing the GHG emissions will not change (Haldon et al., 2004[4]) hence, the above assumption is valid.

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

(a) The land of the project activity is eligible, using the approach for the demonstration of land eligibility contained in appendix B;

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

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 degraded or degrading wetlands, where, the changes in carbon stocks in the living biomass pools of trees and non tree vegetation under the baseline scenario are expected to be in steady state or declining. Therefore changes in the carbon stocks in the living biomass pool of trees and non tree vegetation shall be assumed to be zero in the absence of the project activity.

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

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

7. 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.

[4] Holden, J, Chapman, P.J. and Labadz, J.C. 2004. Artificial drainage of peatlands: Hydrological and hydrochemical process and wetland restoration. Progress in Physical Geography 28: 95–123.

8. Actual net GHG removals by sinks consider the changes in above and below ground carbon pools for trees in the project scenario.

9. Changes in above and below ground carbon pools for trees should be calculated as follows

$$\Delta C_{PROJ,t} = \frac{C_t - C_{t-1}}{T} \quad \textbf{(1)}$$

where:

$\Delta C_{PROJ,t}$ = Removal component of actual net GHG removals by sinks at time t; t CO_2-e yr^{-1}
C_t = Carbon stocks in the above and below ground carbon pools for trees at time t ; t CO_2-e
T Time difference between t and $t-1$; years

10. Degraded or degrading wetlands may have significant number of trees at the time of start of the project activity. The carbon stocks in the above and below ground carbon pools for trees within the project boundary at the starting date of the project activity[5] ($C_{t=0}$) and for all other years at time t (C_t) shall be calculated as follows:

$$C_t = \sum_{i=1}^{I}((C_{AB,i,t} + C_{BB,i,t}) * A_i * 44/12) \quad \textbf{(2)}$$

where:

C_t = Carbon stocks in the above and below ground carbon pools for trees at time t ; t CO_2-e

$C_{AB,\,i,\,t}$ = Carbon stocks in above-ground biomass of trees for stratum i, at time t; t C ha^{-1}

$C_{BB\,i,\,t}$ = Carbon stocks in below-ground biomass of trees for stratum i, at time t; t C ha^{-1}

A_i = Area of stratum i; ha

i = Index for stratum (I = total number of strata in project area)

For above-ground biomass

11. $C_{AB,i,t}$ is calculated per stratum i as follows:

$$C_{AB,i,t} = B_{AB,i,t} * 0.5 \quad \textbf{(3)}$$

where:

$C_{AB,i,t}$ = Carbon stocks in above-ground biomass of trees for stratum i, at time t; t C ha^{-1}

$B_{AB,i,t}$ = Above-ground biomass of trees in stratum i at time t; t dm ha^{-1}

0.5 = Carbon fraction of dry matter; t C $(t\ dm)^{-1}$

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

There are 2 options for estimating aboveground biomass at time *t.* Option 1 shall be used for estimating above ground biomass ($B_{AB,\ i,t=0}$) and carbon stocks ($C_{t=0}$) in trees at start of the project activity.

Option 1:

$$B_{AB,i,t} = \sum_{j=1}^{Sps} B_{AB,i,j,t} \quad (4)$$

$$B_{AB,i,j,t} = SV_{i,j,t} * BEF_{2,j} * D_j \quad (5)$$

where:

$B_{AB,i,t}$	=	Above-ground biomass of trees in stratum *i* at time *t*; t dm ha^{-1}
$B_{AB,i,j,t}$		Above-ground biomass of trees of species *j* in stratum *i* at time *t*; t dm ha^{-1}
$SV_{i,j,t}$	=	Stem volume of species *j* in stratum *i* at time *t;* m^3 ha^{-1}
$BEF_{2,j}$	=	Biomass expansion factor of species or group of species *j* for conversion from stem volume to total volume; dimensionless
D_j	=	Basic wood density of species or group of species *j;* t d.m. m^{-3}
i	=	Index for stratum
j	=	Index for species (*Sps* = total number of species in stratum)

12. Documented existing local species-specific data from peer-reviewed studies or official reports (such as standard yield tables) for $SV_{i,j,t}$ or $SV_{i,j,t=0}$ should be used[6] . At time t = 0, $SV_{i,j,t=0}$ for tree species or groups of species present at the time of start of the project activity shall be used. In the absence of such values, regional/national species-specific data for $SV_{i,j,t}$ or $SV_{i,j,t=0}$ shall be obtained (e.g., from regional/national forest inventory, standard yield tables such as standard yield tables). If regional/national values are also not available, species-specific data from neighbouring countries with similar ecological conditions affecting growth of trees may be used. In absence of any of the above, global species-specific data (e.g., from the GPG-LULUCF) may be used.

13. Documented local values for $BEF_{2,j}$ 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 literature or data shall be obtained from a region that has similar ecological conditions affecting growth of tree species. If no information is available in the literature the project proponents should conduct sampling to generate such value using common standardized method. Sampling can be done in other locations where such ecosystem exists.

14. Documented local values for *Dj* 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 Reyes et al. 1992; Wood Density database http://www.worldagroforestrycentre.org/Sea/Products/AFDbases/WD/Index.htm or from table 3A.1.9 of the IPCC good practice guidance for LULUCF. If no information is available from any of the above sources, the project proponents should conduct sampling to generate such value using common standardized method.

Option 2:

[6] Mean annual increments from documented sources may be used in the absence of annual increments.

Alternatively local, national, or regional sources on aboveground biomass accumulation through time for the species planted in the project area may exist and that are fit to standard biomass growth equations (biomass in t ha^{-1} versus time). These can be used directly for $B_{AB,i,t}$:

$$B_{AB,i,t} = \sum_{j=1}^{Sps} B_{AB,i,j,t} \quad \textbf{(6)}$$

$$B_{AB,i,j,t=n} = B_{AB,i,j(t=n-1)} + g * \Delta t \quad \textbf{(7)}$$

where:

$B_{AB,i,t}$	=	Above-ground biomass of trees in stratum i at time t; t dm ha^{-1}
$B_{AB,i,j,t=n}$	=	Above-ground biomass of trees of species j in stratum i at time $t=n$; t dm ha^{-1}
g	=	Annual increment in biomass; t d.m. ha^{-1} yr^{-1}
Δt	=	Time increment; years
n	=	Running variable that increases by Δt for each iterative step
j	=	Index for species (Sps = total number of species in stratum)

For below-ground biomass

15. $C_{BB\ i,\ t}$ is calculated per stratum i as follows

$$C_{BB,i,t} = \sum_{j=1}^{Sps} C_{BB,i,j,t} \quad \textbf{(8)}$$

$$C_{BB,ij,t} = B_{AB,i,j,t} * R_j * 0.5 \quad \textbf{(9)}$$

where:

$C_{BB\ i,\ t}$	=	Carbon stocks in below-ground biomass of trees for stratum i, at time t; t C ha^{-1}
$C_{BB,i,j,t}$	=	Carbon stocks in below-ground biomass of trees of species j in stratum i, at time t; t C ha^{-1}
$B_{AB,i,j,t}$		Above-ground biomass of trees of species j in stratum i at time t; t dm ha^{-1}
R_j	=	Root to shoot ratio for species or group of species j; dimensionless
0.5	=	Carbon fraction of dry matter; t C (t dm)$^{-1}$

16. Documented local or national values for R_j should be used. If national values are not available, a default value of 0.1 should be used.

17. **Project emissions** are assumed to be negligible hence, they are accounted for as zero in this methodology (refer to para 3). The *ex-ante* actual net greenhouse gas removals by sinks in year t are therefore equal to:

$$\Delta C_{ACTUAL,t} = \Delta C_{PROJ,t} \quad \textbf{(10)}$$

where:

$\Delta C_{ACTUAL,t}$ = annual actual net greenhouse gas removals by sinks at time *t*; t CO_2-e yr^{-1}

$\Delta C_{PROJ,t}$ = removal component of actual net GHG removals by sinks at time *t*; t CO_2-e yr^{-1}

IV. Leakage

18. 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."

19. Leakage (L_t) can be considered zero if evidence can be provided that:

(a) There is no displacement, or the displacement of pre-project grazing or agricultural activities or fuel wood collection will not cause deforestation attributable to the project activity, or

(b) Displacement of grazing animals or agricultural activities or fuel wood collection occurs to other degraded non wetlands which contain no significant biomass (i.e. degraded land) and if evidence can be provided that these lands are likely to receive the shifted activities, or

(c) Displacement of grazing animals occurs to other areas such as grasslands (non wetlands) and that the total number of animals so displaced is less than 15% of the average grazing capacity of such area.

Such evidence in (a), (b) can be provided by scientific literature or by experts' judgment and in (c) through sound estimation[7].

20. If the possibility of leakage from displacement of grazing animals is not excluded using approach provided in para 19 above, the methodology is not applicable.

21. In cases, where the possibility of leakage from displacement of agricultural activities other than from grazing is not excluded as provided in para 19 above, project participants should assess the possibility of leakage by considering the area used for agricultural activities within the project boundary displaced due to the project activity.

22. 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 for the ex-ante calculation it is assumed that entire leakage shall be equal to 20 per cent of the ex-ante actual net GHG removals by sinks accumulated during the first crediting period, that is the average annual leakage is equal to:

$$L_{t\_A} = \Delta C_{ACTUAL,t} * 0.20 \quad \textbf{(11)}$$

where:

L_{t_A} = Annual leakage due to displacement of agricultural activity attributable to the project activity at time *t;* t CO_2-e yr^{-1}

[7] See appendix E

$\Delta C_{ACTUAL,t}$ = Annual actual net greenhouse gas removals by sinks at time t; t CO_2-e yr^{-1}

23. If the area under agricultural activities within the project boundary displaced due to the project activity is greater than 10 per cent of the total project area then this methodology is not applicable.

24. In cases where the possibility of leakage displacement due to fuel wood collection is not excluded as in para 19 above, leakage shall be equal to 5 per cent of the ex-ante actual net GHG removals by sinks accumulated during the first crediting period. The 5% value is estimated based on potential fuel wood collection possible from a degraded wetland ecosystem that represents the maximal biomass of fuel wood that is likely to be displaced elsewhere. The average annual leakage is equal to:

$$L_{t\_FW} = \Delta C_{ACTUAL,t} * 0.05 \quad \textbf{(12)}$$

where:

L_{t_FW} = Annual leakage due to displacement of fuel wood collection attributable to the project activity at time t; t CO_2-e yr^{-1}

$\Delta C_{ACTUAL,t}$ = Annual actual net greenhouse gas removals by sinks at time t; t CO_2-e yr^{-1}

25. Total leakage is calculated as the sum of leakage due to displacement of agricultural activities and displacement of fuel wood collection is estimated as:

$$L_t = L_{t\_A} + L_{t\_FW} \quad \textbf{(13)}$$

where:

L_t Total leakage attributable to the project activity at time t; t CO_2-e yr^{-1}

L_{t_A} = Annual leakage due to displacement of agricultural activity attributable to the project activity at time t; t CO_2-e yr^{-1}

L_{t_FW} = Annual leakage due to displacement of fuel wood collection attributable to the project activity at time t; t CO_2-e yr^{-1}

V. Net anthropogenic greenhouse gas removals by sinks

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

$$ER_{AR\ CDM,\ t} = \Delta C_{ACTUAL,\ t} - L_t \quad \textbf{(14)}$$

where:

$ER_{AR\ CDM,t}$ = Annual net anthropogenic GHG removals by sinks at time t ; t CO_2-e yr^{-1}

$\Delta C_{ACTUAL,\ t}$ = Actual net greenhouse gas removals by sinks at time t; t CO_2-e yr^{-1}

L_t = Total leakage attributable to the project activity at time t; t CO_2-e yr^{-1}

For subsequent crediting periods L_t=0.

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

$$tCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR-CDM,t} \tag{15}$$

where:

$tCER_{tv}$	=	Temporary certified emission reductions (tCERs) at the time of assumed verification t_v; t CO_2-e
$ER_{AR\ CDM,t}$	=	Annual net anthropogenic GHG removals by sinks at time t ; t CO_2-e yr^{-1}
t_v	=	Assumed year of verification (year)

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

$$lCER_{(tv)} = \sum_{t=0}^{tv} ER_{AR\ CDM,t} - lCER_{(t-k)} \tag{16}$$

where:

$lCER_{tv}$	=	Long-term certified emission reductions (lCERs) at the time of verification tv
$ER_{AR\ CDM,\ t}$	=	Annual net anthropogenic GHG removals by sinks in year t; t CO_2-e yr^{-1}
k	=	Time span between two verifications (year)
t_v	=	Year of assumed verification (year)

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

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

29. The baseline net GHG removals by sinks is estimated at zero in this methodology. Therefore monitoring of the baseline is not required.

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

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

31. 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 for the species or groups of species 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.

32. The carbon stocks in above-ground biomass of trees within the project boundary at the starting date of the project activity ($C_{t=0}$) and for all other years at time t (C_t) shall be shall be estimated through the following equations:

$$C_t = \sum_{i=1}^{I}(C_{AB,i,t} + C_{BB,i,t}) * A_i * 44/12 \quad \textbf{(17)}$$

where:

C_t = Carbon stocks in the above and below ground carbon pools for trees at time t; t CO_2-e

$C_{AB,\ i,\ t}$ = Carbon stocks in above-ground biomass of trees for stratum i, at time t; t C ha^{-1}

$C_{BB\ i,\ t}$ = Carbon stocks in below-ground biomass of trees for stratum i, at time t; t C ha^{-1}

A_i = Area of stratum i; ha

For above-ground biomass

33. For above-ground biomass $C_{AB,i,t}$ is calculated per stratum i as follows:

$$C_{AB,i,t} = B_{AB,i,t} * 0.5 \quad \textbf{(18)}$$

where:

$C_{AB,i,t}$ = Carbon stocks in above-ground biomass of trees for stratum i, at time t; t C ha^{-1}

$B_{AB,i,t}$ = Above-ground biomass of trees in stratum i at the time t; t dm ha^{-1}

0.5 = Carbon fraction of dry matter; t C $(t\ dm)^{-1}$

34. Estimate of above-ground biomass of trees at the start of the project activity $B_{AB,i,t=0}$ and at time t achieved by the project activity $B_{AB,i,t}$ shall be estimated through the following steps:

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

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

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

(i) Option 1: Use allometric equations included in **appendix D** 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:

$$B_{AB,i,j,t} = SV_{i,j,t} * BEF_{2,j} * D_j \quad \textbf{(19)}$$

where:

$B_{AB,i,j,t}$ = Above-ground biomass of trees of species j in stratum i at time t; t dm ha^{-1}

$SV_{i,j,t}$ = Stem volume of species j in stratum i at time t; m^3 ha^{-1}

D_j = Basic wood density for species or groups of species j ; t d.m. m^{-3})

$BEF_{2,j}$	=	Biomass expansion factor (over bark) from stem to total aboveground biomass for species or group of species j ; dimensionless

35. Stem volume $SV_{i,j,t}$ shall be estimated from the on-site measurements of diameter at breast height and tree height performed in step 2 above. Consistent application of $BEF_{2,j}$ should be secured on the definition of stem volume (e.g. total stem volume or thick wood stem volume requires different *BEF*s).

36. Documented local values for D_j 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 Reyes et al. 1992; Wood Density database http://www.worldagroforestrycentre.org/Sea/Products/AFDbases/WD/Index.htm or from table 3A.1.9 of the IPCC good practice guidance for LULUCF. If no information is available from any of the above sources, the project proponents should conduct sampling to generate such value using common standardized method.

37. The same values for $BEF_{2,j}$ and D_j should be used in the *ex-post* and in the *ex-ante* calculations.

38. The above-ground biomass of trees in the stratum shall be estimated as follows:

$$B_{AB,i,t} = \sum_{j=1}^{Sps} B_{AB,i,j,t} \quad \textbf{(20)}$$

where:

$B_{AB,i,t}$	=	Above-ground biomass of trees in stratum *i* at time *t*; t dm ha^{-1}
$B_{AB,i,j,t}$	=	Above-ground biomass of trees of species *j* in stratum *i* at time *t*; t dm ha^{-1}
j	=	Index for species (*Sps* = total number of species in stratum)

Below-ground biomass

39. Carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval $C_{BB\ i,\ t}$ shall be estimated for each stratum *i* as follows:

$$C_{BB,i,t} = \sum_{j=1}^{Sps} C_{BB,i,j,t} \quad \textbf{(21)}$$

$$C_{BB,i,j,t} = B_{AB,i,j,t} * R_j * 0.5 \quad \textbf{(22)}$$

where:

$C_{BB\ i,\ t}$	=	Carbon stocks in below-ground biomass of trees for stratum *i*, at time *t*; t C ha^{-1}
$C_{BB\ i,j,\ t}$	=	Carbon stocks in below-ground biomass of trees of species *j* for stratum *i*, at time *t*; t C ha^{-1}
$B_{AB,i,j,t}$	=	Above-ground biomass of trees of species *j* in stratum *i* at time *t*; t dm ha^{-1}
R_j	=	Root to shoot ratio for species or groups of species *j*; dimensionless
0.5	=	Carbon fraction of dry matter; t C $(t\ dm)^{-1}$

40. Documented local or national values for R_j should be used. If national values are not available, the default value of 0.1 should be used.

C. Ex post estimation of leakage

41. As indicated in paragraph 19, if it is demonstrated that there is no leakage due to displacement of grazing activities or agricultural activities or fuel wood collection then:

$$L_{tv} = 0 \quad \textbf{(23)}$$

where:

L_{tv} = Total leakage at the time of verification; t CO_2-e

42. In order to estimate leakage due to displacement of agricultural activities, during the first crediting period project participants shall monitor the area used for agricultural activities within the project boundary displaced due to the project activity.

43. If the project participants cannot demonstrate that the displacement of agricultural activities and fuel wood collection does not result in leakage (as provided in para 19) then leakage shall be determined at the time of verification using the following equations:

For the first verification period of the first crediting period:

(a) Leakage due to displacement of agricultural activity (L_{tv_A}) equals to:

$$L_{tv\_A} = 0.20 * (C_{tv} - C_{t=0}) \quad \textbf{(24)}$$

(b) Leakage due to displacement of fuel wood collection (L_{tv_FW}) equals to:

$$L_{tv\_FW} = 0.05 * (C_{tv} - C_{t=0}) \quad \textbf{(25)}$$

(c) Total Leakage (L_{tv}) equals to:

$$L_{tv} = L_{tv\_A} + L_{tv\_FW} \quad \textbf{(26)}$$

For subsequent verification periods of the first crediting period:

(a) Leakage due to displacement of agricultural activity (L_{tv_A}) equals to:

$$L_{tv\_A} = 0.20 * (C_{tv} - C_{tv-k}) \quad \textbf{(27)}$$

(b) Leakage due to displacement of fuel wood collection (L_{tv_FW}) equals to:

$$L_{tv\_FW} = 0.05 * (C_{tv} - C_{tv-k}) \quad \textbf{(28)}$$

(c) *Total leakage (L_{tv}) equals to:*

$$L_{tv} = L_{tv\_A} + L_{tv\_FW} \quad \textbf{(29)}$$

where:

L_{tv_A} = Leakage due to displacement of agricultural activities at time of verification; t CO_2-e

L_{tv_FW} = Leakage due to displacement of fuel wood collection at time of verification; t CO_2-e

L_{tv} = Total leakage at the time of verification; t CO_2-e

C_{tv} = Carbon stocks in the above and below ground carbon pools for trees at time of verification; t CO_2-e

$C_{(t=0)}$ = Carbon stocks in the above and below ground carbon pools for trees at time t= 0 (calculated as in paragraph 32); t CO_2-e

tv = Time of verification

κ = Time span between two verifications; year

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

$$L_{CP1} = 0.20 * (C_{tc} - C_{t=0}) + 0.05 * (C_{tc} - C_{t=0}) \quad \textbf{(30)}$$

where:

L_{CP1} = Total leakage at the end of the first crediting period; t CO_2-e

C_{tc} = Carbon stocks in the above and below ground carbon pools for trees at the end of crediting period; t CO_2-e

$C_{t=0}$ = Carbon stocks in the above and below ground carbon pools for trees at time $t=0$; t CO_2-e

tc = Duration of the crediting period

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

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

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

For the first crediting period:

$$tCER_{(tv)} = C_{tv} - L_{tv} \quad \textbf{(31)}$$

For subsequent crediting periods:

$$tCER_{(tv)} = C_{tv} - L_{CP1} \quad \textbf{(32)}$$

where:

C_{tv} = Carbon stocks in the above and below ground carbon pools for trees at time of verification ; t CO_2-e

L_{tv} = Total leakage at the time of verification; t CO_2-e

L_{CP1} = Total leakage at the end of the first crediting period; t CO_2-e

tv = Year of verification

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

For the first crediting period:

$$lCER_{(tv)} = C_{tv} - L_{tv} - lCER_{(tv-k)} \quad \textbf{(33)}$$

For subsequent crediting periods:

$$lCER_{(tv)} = C_{tv} - L_{CP1} - lCER_{(tv-k)} \quad \textbf{(34)}$$

where:

C_{tv}	=	Carbon stocks in the above and below ground carbon pools for trees at time of verification ; t CO_2-e
L_{tv}	=	Total leakage at the time of verification; t CO_2-e
L_{CP1}	=	Total leakage at the end of the first crediting period; t CO_2-e
$lCER_{(tv-k)}$	=	Units of *lCER*s issued following the previous verification
tv	=	Time of verification
κ	=	Time span between two verifications (year)

E. Monitoring frequency

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

Table 1. Data to be collected or used 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)	Propor-tion	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

Data variable	Source	Data unit	Measured, calculated or estimated	Frequency (years)	Propor-tion	Archiving	Comment
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		Electronic, paper	
Total CO_2-e	Project activity	Tons	Calculated	5	All project data	Electronic	Based on data collected from all plots and carbon pools

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

Data variable	Source	Data unit	Measured, calculated or estimated	Frequency (years)	Proportion	Archiving	Comment
Area used for agricultural activities within the project boundary displaced due to the project activity	Survey	Hectares or other area units	Measured or estimated	One time after project is established but before the first verification	30%	Electronic	

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

Parameter or abbreviation	Refers to	Units
$\Delta C_{PROJ,t}$	Removal component of actual net GHG removals by sinks at time *t*	t CO_2-e yr^{-1}
C_t	Carbon stocks in the above and below ground carbon pools for trees at time *t*	t C
T	Time difference between *t* and *t-1*	years
$C_{t=0}$	Carbon stocks in the above and below ground carbon pools for trees at time of start of the project activity	t C
$C_{AB,\ i,\ t}$	Carbon stocks in above-ground biomass of trees for stratum *i* at time *t*	t C ha^{-1}
$C_{BB\ i,\ t}$	Carbon stocks in below-ground biomass of trees for stratum *i*, at time *t*	t C ha^{-1}
A_i	Area of stratum *i*	ha
i	Index for stratum (I=total number of strata in project area)	
$B_{AB,i,t}$	Above-ground biomass of trees in stratum *i* at time *t*	t dm ha^{-1}
$B_{AB,i,j,t}$	Above-ground biomass of trees of species *j* in stratum *i* at time *t*	t dm ha^{-1}
$B_{AB,j,t=0}$	Above-ground biomass of trees of species *j* at time *t*=0	t dm ha^{-1}
$SV_{i,j,t}$	Stem volume of species *j* in stratum *i* at time *t*	m^3 ha^{-1}
$SV_{j,t=0}$	Stem volume of species *j* at time *t*=0	m^3 ha^{-1}
$BEF_{2,j}$	Biomass expansion factor (over bark) from stem to total aboveground biomass for species or group of species *j*	dimensionless
D_j	Basic wood density for species or group of species *j*	t d.m. m^{-3}

Parameter or abbreviation	Refers to	Units
j	Index for species (Sps= total number of species in stratum)	
g	Annual increment in biomass	t d.m. ha^{-1} $year^{-1}$
Δt	Time increment = 1 (year)	
n	Running variable that increases by Δt for each iterative step	
$C_{BB,i,j,t}$	Carbon stocks in below-ground biomass of trees of species j in stratum i, at time t	t C ha^{-1}
$B_{BB,j,t=0}$	Below-ground biomass of trees of species j at time t=0	t dm ha^{-1}
R_j	Root to shoot ratio for species or groups of species j;	dimensionless
$\Delta C_{ACTUAL,t}$	Annual actual net greenhouse gas removals by sinks at time t	t CO_2-e yr^{-1}
L_{t_A}	Annual leakage due to displacement of agricultural activity attributable to the project activity at time t;	t CO_2-e yr^{-1}
L_{t_FW}	Annual leakage due to displacement of fuel wood collection attributable to the project activity at time t;	t CO_2-e yr^{-1}
L_t	Annual leakage attributable to the project activity at time t	t CO_2-e yr^{-1}
$ER_{AR\ CDM,t}$	Annual net anthropogenic GHG removals by sinks at time t	t CO_2-e yr^{-1}
$tCER_{tv}$	Temporary certified emission reductions (tCERs) at the time of assumed verification t_v	t CO_2-e
t_v	Assumed year time of verification	
$lCER_{tv}$	Long-term certified emission reductions (lCERs) at the time of verification tv	t CO_2-e
κ	Time span between two verifications	year
tc	Duration of the crediting period	years
L_{tv}	Total leakage at the time of verification	t CO_2-e
L_{tv_A}	Leakage due to displacement of agricultural activities at time of verification	t CO_2-e
L_{tv_FW}	Leakage due to displacement of fuel wood collection at time of verification	t CO_2-e
C_{tv}	Carbon stocks in the above and below ground carbon pools for trees at time of verification	t CO_2-e
C_{tc}	Carbon stocks in the above and below ground carbon pools for trees at the end of crediting period	t CO_2-e
L_{CP1}	Total leakage at the end of the first crediting period	t CO_2-e
tv	Time of verification	

Appendix A

Procedure for demonstration of wetlands that are degraded and degrading with respect to vegetation cover

Analyze the historical and existing land use/cover changes in the context of climate and socio-economic conditions for the project area and/or surrounding similar wetlands, and identify key factors that influence vegetation degradation over time. In this procedure project participants may use multiple sources of data including archived information, maps, or remote sensing data of land use/cover to demonstrate the changing status of vegetation occurring over a reasonable period of time since 31 December 1989 as selected by the project participants and before the start of the proposed A/R project activity. Supplementary field investigation, landowner and public interviews, as well as collection of data from other sources may also be used, to demonstrate that the project area is degraded with respect to vegetation cover and is likely to continue to degrade in absence of the project activity.

A degraded or degrading state is confirmed if there is evidence that one or more of the following conditions are commonly present within the proposed project boundary and are likely to continue to occur in absence of the project activity:

1. Vegetation degradation:
    - For degraded condition show that, for example: The cover and/or health of vegetation as determined by visual assessment or similar indicator-based approach has decreased by at least 25% below that of similar undisturbed wetlands with similar ecological conditions.
    - For degrading condition show that, for example: The cover and/or health of vegetation as determined by visual assessment or similar indicator-based approach has decreased by at least 25% occurring over a reasonable period of time since 31 December 1989 as selected by the project participants and before the start of the proposed A/R project activity.
2. Anthropogenic influences leading to degradation, for example:
    - There is a documented history of on-going loss of vegetation cover due to anthropogenic influences; or
    - Evidence can be provided that anthropogenic actions, which are likely to continue in the absence of the small scale A/R project activity, can be documented as the cause of on-going loss of vegetation cover on similar lands elsewhere.
3. Provision of any other evidence that transparently demonstrates project lands are degraded or degrading.

Appendix B

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 C

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 D

Default allometric equations for estimating above-ground biomass

Annual rainfall	DBH limits	Equation	R^2	Author
Broad-leaved species, tropical dry regions				
<1500 mm		Use the biomass expansion approach with volume estimates (see Option 2 in section IV)		
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				
Taxodium distichum		$AGB = -1.398 + 2.731 \log(DBH)$	0.99	Brown (1978)
Palms				
n.d.	> 7.5 cm	$AGB = 10.0 + 6.4 * H$	0.96	Brown (1997)
n.d.	> 7.5 cm	$AGB = 4.5 + 7.7 * WD*H$	0.90	Brown (1997)
Mangrove (General equations)				
Mangrove	5-42 cm	$\ln(ABG) = -1.265 + 2.009 \ln(DBH) + 1.7 \ln(WD)$, or $\ln(ABG) = -1.786 + 2.471 \ln(DBH) + \ln(WD)$	0.99	Chave et al. (2005)
Mangrove (Specific equations: Location at 25^o N in South Florida)				
Avicennia germinans (L.): black mangrove	0.7-21.5 cm	$\log_{10} AGB = 1.934 \log_{10}(DBH) - 0.395$	0.95	Smith and Whelan (2006)
Languncularia racemosa (L.): white mangrove	0.5-18.0 cm	$\log_{10} AGB = 1.930 \log_{10}(DBH) - 0.441$	0.98	Smith and Whelan (2006)
Rhizophora mangle (L.): red mangrove	0.5-20.0 cm	$\log_{10} AGB = 1.731 \log_{10}(DBH) - 0.112$	0.94	Smith and Whelan

Annual rainfall	DBH limits	Equation	R^2	Author
				(2006)
Mangrove (Location in Mexico)				
Avicennia germinans (L.): black mangrove	1-10 cm	Log_{10} AGB = 2.507 log_{10} (DBH) – 1.561		Day et al (1987)
Languncularia racemosa (L.): white mangrove	1-10 cm	Log_{10} AGB = 2.192 log_{10} (DBH) – 0.592		Day et al (1987)
Rhizophora mangle (L.): red mangrove	1-10 cm	Log_{10} AGB = 2.302 log_{10} (DBH) – 1.580		Day et al (1987)
Mangrove (Location in Indo-West Pacific; Tropical wet region)				
Rhizophora apiculata	5-31 cm	Log_{10} AGB = 2.516 log_{10} (DBH) – 0.767		Putz and Chan (1986)
Rhizophora spp	3-25 cm	Log_{10} AGB = 2.685 log_{10} (DBH) – 0.979		Clough and Scott (1989)

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

References:

Brown, S. 1978. A comparison of cypress ecosystems in the landscape of Florida. Ph.D. dissertation, Department of Environmental Engineering Sciences, University of Florida, Gainesville, 571 pp.

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.

Chave, J., Andalo, C., Brown, S., Cairn, M.A. Chambers, J.Q., Eamus, D., Folster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.P., Nelson, B.W., Ogawa, H., Puig, H., Riera, B, and Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87-99.

Clough, B.F., and Scott, K. 1989. Allometric relationships for estimating biomass in multi-stemmed mangrove tress. Aust. J. Bot. 45:1023-1031

Day, J.W., Conner, W.H., Ley-Lou F., Day, R.H. and Navarro A.M. 1987. The productivity and composition of mangrove forests, Langúna de Terminos, Mexico. Aquat. Bot 27:267-284

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.

Putz, F.E., and Chan, H.T. 1986. Tree growth, dynamics, and productivity in a mature mangrove forest in Malaysia. Forest Ecology Management 17:211-230.

Smith, T.J. and Whelan, K.R.T. 2006. Development of allometric relations for three species in South Florida for use in the Greater Everglades ecosystem restoration. Wetlands Ecology and Management 14:409-419.

Appendix E

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:

$$GC = \frac{ANPP * 1000}{365 * DMI} \quad \textbf{(1)}$$

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:

$$DMI = \frac{GE}{NE_{ma}} \quad \textbf{(2)}$$

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)[8]. 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.

[8] 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 GRASSLAND (AS DRY MATTER) AND ABOVEGROUND NET PRIMARY PRODUCTION, CLASSIFIED BY IPCC CLIMATE ZONES.

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

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

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

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

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

Cattle - Africa

	Weight (kg)	Weight Gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Pregnant	DE	Coefficient for NE_m equation	Mix (of grazing)
Mature Females	200	0.00	0.30	0	33%	55%	0.365	8%
Mature Males	275	0.00	0.00	0	0%	55%	0.370	33%
Young	75	0.10	0.00	0	0%	60%	0.361	59%
Weighted Average	**152**	**0.06**	**0.02**	**0**	**3%**	**58%**	**0.364**	**100%**

Cattle - Asia

	Weight (kg)	Weight Gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Pregnant	DE	Coefficient for NE_m equation	Mix (of grazing)
Mature Females	300	0.00	1.10	0	50%	60%	0.354	18%
Mature Males	400	0.00	0.00	0	0%	60%	0.370	16%
Young	200	0.20	0.00	0	0%	60%	0.345	65%
Weighted Average	**251**	**0.13**	**0.20**	**0**	**9%**	**60%**	**0.350**	**100%**

Cattle - India

	Weight (kg)	Weight Gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Pregnant	DE	Coefficient for NE_m equation	Mix (of grazing)
Mature Females	125	0.00	0.60	0.0	33%	50%	0.365	40%
Mature Males	200	0.00	0.00	2.7	0%	50%	0.370	10%
Young	80	0.10	0.00	0.0	0%	50%	0.332	50%
Weighted Average	**110**	**0.05**	**0.24**	**0.3**	**13%**	**50%**	**0.349**	**100%**

Cattle - Latin America

	Weight (kg)	Weight Gain (kg/day)	Milk (kg/day)	Work (hrs/day)	Pregnant	DE	Coefficient for NE_m equation	Mix (of grazing)
Mature Females	400	0.00	1.10	0	67%	60%	0.343	37%
Mature Males	450	0.00	0.00	0	0%	60%	0.370	6%
Young	230	0.30	0.00	0	0%	60%	0.329	57%
Weighted Average	**306**	**0.17**	**0.41**	**0**	**25%**	**60%**	**0.337**	**100%**

Sheep

	Weight (kg)	Weight Gain (kg/day)	Milk (kg/day)	Wool (kg/year)	Pregnant	DE	Coefficient for NE_m equation	Mix (of grazing)
Mature Females	45	0.00	0.70	4	50%	60%	0.217	40%
Mature Males	45	0.00	0.00	4	0%	60%	0.217	10%
Young	5	0.11	0.00	2	0%	60%	0.236	50%
Weighted Average	**25**	**0.05**	**0.28**	**3**	**20%**	**60%**	**0.227**	**100%**

Table 3: Daily energy requirement and dry matter intake calculation

Cattle																		
Region	**Average Characteristics**							**Energy (MJ/head/day)**									**Consumption**	
	Weight	Weight gain	Milk	Work	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

Annex III

Recommendation to the CMP: SSC I.E. Switch from Non-Renewable Biomass for Thermal Applications by the User

Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories

TYPE I - RENEWABLE ENERGY PROJECTS

Note: Categories I.A, I.B and I.C involve renewable energy technologies that supply electricity, mechanical and thermal energy, respectively, to the user directly. Renewable energy technologies that supply electricity to a grid fall into category I.D.

Project participants shall take into account the general guidance to the methodologies, information on additionality, abbreviations and general guidance on leakage provided at: http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html.

I.E. Switch from Non-Renewable Biomass for Thermal Applications by the User

Technology/measure

1. This category comprises small appliances involving the switch from non-renewable biomass to renewable sources of energy. These technologies include biogas stoves, use of solar cookers and measures that involve the switch to renewable biomass.

2. If any similar registered small-scale CDM project activities exist in the same region as the proposed project activity then it must be ensured that the proposed project activity is not saving the non-renewable biomass accounted for by the other registered project activities.

3. Project participants are able to show that non-renewable biomass has been used since 31 December 1989, using survey methods.

Boundary

4. The project boundary is the physical, geographical area of the use of biomass or the renewable energy.

Baseline

5. It is assumed that in the absence of the project activity, the baseline scenario would be the use of fossil fuels for meeting similar thermal energy needs.

6. Emission reductions would be calculated as:

$$ER_y = B_y \cdot f_{NRB,y} . NCV_{biomass} \cdot EF_{projected\_fossilfuel}$$

where:

ER_y Emission reductions during the year y in tCO_2e

B_y	Quantity of biomass that is substituted or displaced in tonnes
$f_{NRB,y}$	Fraction of biomass used in the absence of the project activity in year y that can be established as non renewable biomass using survey methods
$NCV_{biomass}$	Net calorific value of the non-renewable biomass that is substituted (IPCC default for wood fuel, 0.015 TJ/tonne)
$EF_{projected\_fossilfuel}$	Emission factor for the projected fossil fuel consumption in the baseline. The fossil fuel likely to be used by similar consumers is taken: 71.5 tCO_2/TJ for Kerosene, 63.0 tCO_2/TJ for Liquefied Petroleum Gas (LPG) or the IPCC default value of other relevant fossil fuel.

B_y is determined by using one of the two following options.

(a) Calculated as the product of the number of appliances multiplied by the estimate of average annual consumption of biomass per appliance (tonnes/year). This can be derived from historical data or estimated using survey methods, OR

(b) Calculated from the thermal energy generated in the project activity as:

$$\mathrm{B_y} = HG_{p,y} / (\mathrm{NCV_{biomass}} \cdot \eta_{\mathrm{old}})$$

where:

$HG_{p,y}$	Quantity of thermal energy generated by the new renewable energy technology in the project in year y (TJ)
η_{old}	Efficiency of the system being replaced, use 0.10 (i.e. 10%) as default value or local data if available

Differentiation between Non-renewable and Renewable biomass

7. Project participants must determine the share of renewable and non-renewable biomass in the total biomass consumption using nationally approved methods (e.g. surveys or government data if available) and determine $f_{NRB,y}$. The following principles shall be taken into account:

Renewable biomass:

Biomass is “renewable”[1] if any one of the following five conditions is satisfied:

[1] This definition is based on Annex 18, EB 23

I. The biomass is originating from land areas that are forests[2] where:

(a) The land area remains a forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure, in particular, that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry and nature conservation regulations are complied with.

II. The biomass is woody biomass and originates from croplands and/or grasslands where:

(a) The land area remains cropland and/or grasslands or is reverted to forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure in particular that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

III. The biomass is non-woody biomass and originates from croplands and/or grasslands where:

(a) The land area remains cropland and/or grasslands or is reverted to forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure in particular that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

IV. The biomass is a biomass residue and the use of that biomass residue in the project activity does not involve a decrease of carbon pools, in particular dead wood, litter or soil organic carbon, on the land areas where the biomass residues are originating from.

V. The biomass is the non-fossil fraction of an industrial or municipal waste.

Non-renewable biomass:

To complement the survey results, national or local statistics, or other sources of information such as remote sensing data can be used to establish the portion of the biomass used that can be considered as non renewable($f_{NRB,y}$). Inference derived from historical data may also be used if available for this purpose. Maps can be used to illustrate the biomass supply area, where necessary. The following indicators may be useful for conducting surveys in the local areas:

---

[2] The forest definitions as established by the country in accordance with the decisions 11/CP.7 and 19/CP.9 should apply.

- Increasing trend of time spent or distance travelled by users for gathering fuel wood;
- Increasing trend in fuel wood price indicating scarcity;
- Trends in the type of biomass collected by users, suggesting scarcity of woody biomass.

A single indicator may not provide sufficient evidence that biomass in the region is non-renewable and therefore more than one indicator may be used. Project participants shall also provide evidence that the trends seen are not on account of enforcement of local/national regulations.

Leakage

8. If the project activity includes substitution of non-renewable biomass by renewable biomass, leakage in the production of renewable biomass must be considered using the general guidance on leakage in biomass project activities (attachment C of appendix B).

9. Leakage relating to the non-renewable biomass shall be assessed from ex-post surveys of users and areas from where biomass is sourced. The following potential sources of leakage were identified:

a) Use/diversion of non-renewable biomass saved under the project activity by non-project households/users who previously used renewable energy sources. If this leakage assessment quantifies an increase in the use of non-renewable biomass used by the non-project households/users attributable to the project activity then B_y is adjusted to account for the quantified leakage.

b) Use of non-renewable biomass saved under the project activity to justify the baseline of other CDM project activities can also be potential source of leakage. If this leakage assessment quantifies a portion of non-renewable biomass saved under the project activity that is used as the baseline of other CDM project activity then B_y is adjusted to account for the quantified leakage.

c) Increase in the use of non-renewable biomass outside the project boundary to create non-renewable biomass baselines can also be potential source of leakage. If this leakage assessment quantifies an increase in use of non-renewable biomass outside the project boundary then B_y is adjusted to account for the quantified leakage.

10. If the equipment is transferred from another activity or if the existing equipment is transferred to another activity, leakage is to be considered.

Monitoring

11. Monitoring shall consist of an annual check of all appliances or a representative sample thereof to ensure that they are still operating or are replaced by an equivalent in service appliance.

12. In order to assess the leakages specified under 9 monitoring shall include data on the amount of biomass saved under the project activity that is used by non-project households/users (who previously used renewable energy sources). Other data on non-renewable biomass use required for leakage assessment shall also be collected.

13. Monitoring should confirm the displacement or substitution of the non-renewable biomass at each location. In the case of appliances switching to renewable biomass the quantity of renewable biomass used shall be monitored.

14. In case option (b) in paragraph 6 is chosen for baseline calculations, monitoring shall include the amount of thermal energy generated by the new renewable energy technology in the project in year y, where applicable.

Annex IV

Recommendation to the CMP: SSC II.G. Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass

Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories

TYPE II - ENERGY EFFICIENCY IMPROVEMENT PROJECTS

Project participants shall take into account the general guidance to the methodologies, information on additionality, abbreviations and general guidance on leakage provided at: http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html.

II.G. Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass

Technology/measure

1. This category comprises small appliances involving the efficiency improvements in the thermal applications of non-renewable biomass. These technologies and measures include high efficiency cook stoves and ovens using biomass. Project activities, which also involve the switch to renewable biomass, shall apply category I.E.

2. If any similar registered small-scale CDM project activities exist in the same region as the proposed project activity then it must be ensured that the proposed project activity is not saving the non-renewable biomass accounted for by the other registered project activities.

3. Project participants are able to show that non-renewable biomass has been used since 31 December 1989, using survey methods.

Boundary

4. The project boundary is the physical, geographical area of the use of non-renewable biomass.

Baseline

5. It is assumed that in the absence of the project activity, the baseline scenario would be the use of fossil fuels for meeting similar thermal energy needs.

6. Emission reductions would be calculated as:

$$ER_y = B_{y,savings} \cdot f_{NRB,y} . NCV_{biomass} \cdot EF_{projected\_fossilfuel}$$

where:

ER_y	Emission reductions during the year y in tCO_2e
$B_{y,savings}$	Quantity of biomass that is saved in tonnes
$f_{NRB,y}$	Fraction of biomass saved by the project activity in year y that can be established as non renewable biomass using survey methods
$NCV_{biomass}$	Net calorific value of the non-renewable biomass that is substituted (IPCC default for wood fuel, 0.015 TJ/tonne)

$EF_{projected\_fossilfuel}$	Emission factor for the substitution of non-renewable biomass by similar consumers. The substitution fuel likely to be used by similar consumers is taken: 71.5 tCO_2/TJ for Kerosene, 63.0 tCO_2/TJ for Liquefied Petroleum Gas (LPG) or the IPCC default value of other relevant fuel

$$B_{y,savings} = B_y \cdot (1 - \frac{\eta_{old}}{\eta_{new}})$$

where:

B_y	Quantity of biomass used in the absence of the project activity in tonnes
η_{old}	Efficiency of the system being replaced, use 0.10 (i.e. 10%) as default value or local data if available (fraction)
η_{new}	Efficiency of the system being deployed as part of the project activity (fraction)

B_y is determined by using one of the two following options.

a) Calculated as the product of the number of appliances multiplied by the estimate of average annual consumption of biomass per appliance (tonnes/year). This can be derived from historical data or a survey of local usage, OR

b) Calculated from the thermal energy generated in the project activity as:

$$B_y = \frac{HG_{p,y}}{NCV_{biomass} \cdot \eta_{old}}$$

where:

$HG_{p,y}$ Amount of thermal energy generated by the new technology in the project in year y (TJ)

Differentiation between Non-renewable and Renewable biomass

7. Project participants must determine the share of renewable and non-renewable biomass in the total biomass consumption using nationally approved methods (e.g. surveys or government data if available) and determine $f_{NRB,y}$. The following principles shall be taken into account:

Renewable biomass[1]:

Biomass is "renewable" if any one of the following five conditions is satisfied:

I. The biomass is originating from land areas that are forests[2] where:

[1] This definition is based on Annex 18, EB 23

[2] The forest definitions as established by the country in accordance with the decisions 11/CP.7 and 19/CP.9 should apply.

(a) The land area remains a forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure, in particular, that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry and nature conservation regulations are complied with.

II. The biomass is woody biomass and originates from croplands and/or grasslands where:

(a) The land area remains cropland and/or grasslands or is reverted to forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure in particular that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

III. The biomass is non-woody biomass and originates from croplands and/or grasslands where:

(a) The land area remains cropland and/or grasslands or is reverted to forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure in particular that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

IV. The biomass is a biomass residue and the use of that biomass residue in the project activity does not involve a decrease of carbon pools, in particular dead wood, litter or soil organic carbon, on the land areas where the biomass residues are originating from.

V. The biomass is the non-fossil fraction of an industrial or municipal waste.

Non-renewable biomass:

To complement the survey results, national or local statistics, or other sources of information such as remote sensing data can be used to establish the portion of the biomass used that can be considered as non renewable($f_{NRB,y}$). Inference derived from historical data may also be used if available for this purpose. Maps can be used to illustrate the biomass supply area, where necessary. The following indicators may be useful for conducting surveys in the local areas:

- Increasing trend of time spent or distance travelled by users for gathering fuel wood;
- Increasing trends in fuel wood price indicating scarcity;
- Trends in the type of biomass collected by users, suggesting scarcity of woody biomass.

A single indicator may not provide sufficient evidence that biomass in the region is non-renewable and therefore more than one indicator may be used. Project participants shall also provide evidence that the trends seen are not on account of enforcement of local/national regulations.

Leakage

8. Leakage relating to the non-renewable biomass shall be assessed from ex post surveys of users and areas from where biomass is sourced. The following potential sources of leakage were identified:

a) Use/diversion of non-renewable biomass saved under the project activity by non-project households/users who previously used renewable energy sources. If this leakage assessment quantifies an increase in the use of non-renewable biomass used by the non-project households/users attributable to the project activity then B_y is adjusted to account for the quantified leakage.

b) Use of non-renewable biomass saved under the project activity to justify the baseline of other CDM project activities can also be potential source of leakage. If this leakage assessment quantifies a portion of non-renewable biomass saved under the project activity that is used as the baseline of other CDM project activity then B_y is adjusted to account for the quantified leakage.

c) Increase in the use of non-renewable biomass outside the project boundary to create non-renewable biomass baselines can also be potential source of leakage. If this leakage assessment quantifies an increase in use of non-renewable biomass outside the project boundary then B_y is adjusted to account for the quantified leakage.

9. If the equipment is transferred from another activity or if the existing equipment is transferred to another activity, leakage is to be considered.

Monitoring

10. Monitoring shall consist of an annual check of efficiency of all appliances or a representative sample thereof to ensure that they are still operating at the specified efficiency (η_{new}) or replaced by an equivalent in service appliance. Where replacements are made, monitoring shall also ensure that the efficiency of the new appliances is similar to the appliances being replaced.

11. In order to assess the leakages specified above monitoring shall include data on the amount of biomass saved under the project activity that is used by non-project households/users (who previously used renewable energy sources). Other data on non-renewable biomass use required for leakage assessment shall also be collected.

12. Monitoring shall ensure that the replaced low efficiency appliances are disposed off and not used within the boundary or within the region.

13. In case option (b) in paragraph 6 is chosen for baseline calculations, monitoring shall include the amount of thermal energy generated by the new renewable energy technology in the project in year y, where applicable.

- - - - -