Simplified baseline and monitoring methodology for small-scale agroforestry - afforestation and reforestation project activities under the clean development mechanism.

I. Applicability conditions, carbon pools and project emissions

1. This simplified baseline and monitoring methodology is applicable if the conditions (a)-(d) below are met.

(a) Project activities are implemented on croplands;[1]

(b) Project activities include a cropping regime that is considered an agroforestry system that is consistent with international or national definitions;

(c) The pre project living[2] biomass in trees or woody perennials[3] within the project boundary is:

(i) Not more than ten per cent of the maximum above- and below-ground biomass of trees with the project activity; or

(ii) More than ten per cent of the maximum above- and below-ground biomass of trees, and such biomass shall not be removed in the implementation of the project activity.

(d) If there is a decrease in the area cultivated with crops attributable to implementation of the project compared to the total area cultivated with crops at the start of the project then the methodology is applicable if at least one of the following conditions is met:

(i) There is no displacement of crops; or

(ii) The displacement of crops will not cause deforestation; or

(iii) The displacement is to lands surrounding the project activity that contain insignificant biomass (for example degraded land with no or only a few trees or shrubs per hectare); or

(iv) The decrease in the area cultivated with crops within the project boundary as a result of the project activity is less than 50 per cent of the total project area.[4]

2. **Carbon pools** to be considered by this methodology are above-ground and below-ground tree biomass and soil organic carbon (SOC).

[1] Cropland also includes lands which are currently under a fallow state as part of the agricultural cycle (eg. slash and burn).
[2] Throughout this methodology the term ‘living biomass’ refers to above- and below-ground biomass.
[3] Woody perennials refers to non tree woody vegetation that are present in croplands below the thresholds (of canopy cover and potential tree height) used to define forests.
[4] For this condition, leakage shall be estimated in accordance with Section IV.

3. For the purposes of the simplified methodology, the increase in emissions in the project above those that occur in the baseline is considered to be insignificant. For example, in accordance with applicability condition 1.c of this methodology,[5] the pre project living biomass is not more than ten per cent of the maximum above- and below-ground biomass of trees with the project activity, or such biomass is not removed in the implementation of the project activity. **Project emissions** are therefore considered as zero.

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

(a) The project area is eligible for the A/R CDM project activity. Eligibility of the A/R CDM project activities shall be demonstrated by applying the latest version of the "Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities" as approved by the Executive Board";

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

II. Baseline net greenhouse gas removals by sinks

5. The most plausible baseline scenario of the small-scale A/R CDM project activity is continuation of the land-use prior to the implementation of the project activity, that is croplands.

6. In accordance with applicability condition 1.c of this methodology,[6] where the pre project living biomass is not more than ten per cent of the maximum living biomass of the project activity, the baseline net GHG removals by sinks are assumed to be insignificant. Where the pre project living biomass is more than 10 per cent of the maximum living biomass of the project in trees or woody perennials, then such biomass shall not be removed in the implementation of the project activity and therefore estimation of baseline net GHG removals by sinks is not required.

7. Therefore, for purpose of the baseline calculation it is assumed that there are no changes in carbon stocks in the baseline scenario and therefore:

$$\Delta C_{BSL,t} = 0 \quad \textbf{(1)}$$

where:

$\Delta C_{BSL,t}$	The sum of the changes in carbon stocks in the living biomass of trees and soil organic carbon in the absence of the project activity for year *t*, tonnes CO_2-e yr^{-1}
t	Time index, years

[5] If the project participants intend to remove the pre project biomass for the implementation of the project activity they shall estimate if the pre project living biomass is less than 10 per cent of the average per hectare project living biomass estimated *ex ante* (t d.m ha^{-1}) at the time when the project biomass is expected to be maximum, e.g. biomass at the rotation age.

[6] If the project participants intend to remove the pre project biomass for the implementation of the project activity they shall estimate if the pre project living biomass is less than 10 per cent of the average per hectare project living biomass estimated *ex ante* (t d.m ha^{-1}) at the time when the project biomass is expected to be maximum, e.g. biomass at the rotation age.

III. Actual net greenhouse gas removals by sinks

8. Stratification of the project area may be carried out to improve the accuracy and precision of biomass estimates. Where required, stratification could be made according to the project planting plan that is possibly by, tree species (or groups of them if several tree species have similar growth habits), and age classes and agroforestry practices. Project participants may use stratified random sampling for establishing sample plots given that in agroforestry systems trees are planted in certain patterns.

9. The actual net greenhouse gas removals by sinks shall be estimated using the equations in this section. When applying these equations for *ex ante* calculations of net anthropogenic GHG removals by sinks, project participants shall provide estimates of the values of those parameters that are not available before the start of the crediting period and commencement of the monitoring activities. Project participants should retain a conservative approach in applying these estimates.

10. The **actual net greenhouse gas removals by sinks** in year *t* are equal to:

$$\Delta C_{ACTUAL,t} = \Delta C_{PJ,t} \qquad \textbf{(2)}$$

where:

$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks in year *t*, t CO_2-e yr^{-1}
$\Delta C_{PJ,t}$	Project GHG removals by sinks in year *t*, t CO_2-e yr^{-1}

11. Project GHG removals by sinks are calculated as follows:

$$\Delta C_{PJ,t} = \sum_{i=1}^{I} \Delta C_{project,i,t} .44/12 \qquad \textbf{(3)}$$

$$\Delta C_{project,i,t} = \frac{C_{trees,i,t_2} - C_{trees,i,t_1}}{T} + \Delta C_{soil,t} \qquad \textbf{(4)}$$

where:

$\Delta C_{PJ,t}$	Project GHG removals by sinks in year *t*, t CO_2-e yr^{-1}
$\Delta C_{project,i,t}$	Average GHG removals by living biomass of trees and soil for stratum *i*, for year *t,* tonnes C yr^{-1}
$C_{trees,i,t}$	Carbon stock in living biomass of trees for stratum *i*, at time *t*, tonnes C
$\Delta C_{soil,t}$	Average change in carbon stock in soil organic matter for stratum *i*, for year *t*, tonnes C yr^{-1}
T	Number of years between times t_2 and t_1

Estimation of carbon stock in living biomass of trees at the stratum level

12. The carbon stock in living biomass of trees for stratum *i* ($C_{trees,i,t}$) is estimated using the following approach:

The mean carbon stock in above-ground biomass per unit area is estimated based on field measurements in permanent sample plots. Two methods are available: the Biomass Expansion Factors (*BEF*) method and the Allometric Equations method.

BEF method

Step 1: Determine based on available data, e.g. volume tables (*ex ante*) and measurements (*ex post*), the diameter at breast height (*DBH,* at typically 1.3 m above-ground level), and also preferably height (*H*), of all the trees above some minimum *DBH* in the permanent sample plots.

Step 2: Estimate the volume of the commercial (merchantable) timber component of trees[7] based on available equations or yield tables (if locally derived equations or yield tables are not available use relevant regional, national or default data as appropriate). It is possible to combine Steps 1 and 2 if field instruments (e.g. a relascope) that measure the volume of each tree directly are applied.

Step 3: Choose appropriate values for *BEF*. See Section VII. for guidance on source of data.

Step 4: Convert the volume of the commercial timber component of trees into carbon stock in above-ground biomass via basic wood density *D*, the *BEF* and the carbon fraction using Equation 5. See Section VII. for guidance on source of data for wood density.

$$C_{AB,i,sp,j,l,t} = V_{i,sp,j,l,t}\ D_j \cdot BEF_{2,j} \cdot CF_j \qquad \textbf{(5)}$$

where:

$C_{AB,i,sp,j,l,t}$	Carbon stock in above-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i*, at time *t*, tonnes C
$V_{i,sp,j,l,t}$	Merchantable volume of tree *l* of species *j* in plot *sp* in stratum *i*, at time *t*, m^3 $tree^{-1}$
D_j	Basic wood density of species *j*, tonnes d.m. m^{-3}
$BEF_{2,j}$	Biomass expansion factor for conversion of merchantable biomass to above-ground tree biomass for species *j*, dimensionless
CF_j	Carbon fraction of dry matter for species or group of species type *j*, tonnes C (tonne d.m.)$^-$1, IPCC default value = 0.5

Step 5: Convert the carbon stock in above-ground biomass to the carbon stock in below-ground biomass via root-shoot ratio, given by:

$$C_{BB,i,sp,j,l,t} = C_{AB,i,sp,j,l,t} \cdot R_j \qquad \textbf{(6)}$$

where:

$C_{BB,i,sp,j,l,t}$	Carbon stock in below-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at time *t*, t C $tree^{-1}$
$C_{AB,i,sp,j,l,t}$	Carbon stock in above-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at time *t*, t C $tree^{-1}$
R_j	Root-shoot ratio appropriate for biomass stock, for species *j*; dimensionless

See guidance in Section VII. for selection of values of *R*.

[7] For non timber species and woody perennials such as coffee, 'merchantable timber volume' may refer to the actual volume of the stemwood for such species estimated using national inventory methods for which *BEFs* are applicable.

Step 6: Calculate carbon stock in above-ground and below-ground biomass of all trees present in plot *sp* in stratum *i* at time *t* (i.e. summation over all trees *l* by species *j* followed by summation over all species *j* present in plot *sp*)

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} \sum_{l=1}^{N_{j,i,sp,t}} (C_{AB,i,sp,j,l,t} + C_{BB,i,sp,j,l,t}) \qquad \textbf{(7)}$$

where:

$C_{tree,i,sp,t}$	Carbon stock in living biomass of trees on plot *sp* of stratum *i* at time *t*, t C
$C_{AB,i,sp,j,l,t}$	Carbon stock in above-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at time *t*; t C tree^{-1}
$C_{BB,i,sp,j,l,t}$	Carbon stock in below-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at time *t*, t C tree^{-1}
$N_{j,i,sp,t}$	Number of trees of species *j* on plot *sp* of stratum *i* at time *t*
l	*1, 2, 3, …* $N_{j,i,sp,t}$ sequence number of tree of species *j* on plot *sp* of stratum *i* at time *t*

Step 7: Calculate the mean carbon stock in tree biomass for each stratum:

$$C_{tree,i,t} = \frac{A_i}{Asp_i} \sum_{sp=1}^{P_i} C_{tree,i,sp,t} \qquad \textbf{(8)}$$

where:

$C_{tree,i,t}$	Carbon stock in living biomass of trees in stratum *i*, at time *t*; t C
$C_{tree,i,sp,t}$	Carbon stock in living biomass of trees on plot *sp* of stratum *i* at time *t*, t C
Asp_i	Total area of all sample plots in stratum *i*; ha
A_i	Area of stratum *i*; ha
sp	*1, 2, 3, …* P_i sample plots in stratum *i* in the project scenario
i	*1, 2, 3, …* M_{PS} strata in the project scenario
t	*1, 2, 3, … t* years elapsed since the start of the A/R CDM project activity

Method based on allometric equations

Step 1: As in Step 1 of *BEF* method.

Step 2: Calculate the above-ground biomass for each individual tree of a species, using allometric equations appropriate to the tree species (or groups of them if several tree species have similar growth habits) in the stratum. In the absence of species specific allometric equations use equations in accordance with guidance provided in Section VII.

Step 3: Estimate carbon stock in above-ground biomass for each individual tree *l* of species *j* in the sample plot located in stratum *i* using the selected or developed allometric equation applied to the tree dimensions resulting from Step 1, and sum the carbon stocks in the sample plot.

$$C_{AB,i,sp,j,t} = \sum_{l=1}^{N_{l,sp}} CF_j \cdot f_j(DBH,H) \qquad \textbf{(9)}$$

where:

$C_{AB,i,sp,j,t}$	Carbon stock in above-ground biomass of trees of species *j* on sample plot *sp* for stratum *i*, tonnes C
CF_j	Carbon fraction of dry matter for species or group of species type *j*, tonnes C (tonne d.m.)$^{-1}$, IPCC default value = 0.5
$f_j(DBH,H)$	An allometric equation linking above-ground biomass of living trees (d.m. tree-^{1}) to mean diameter at breast height (*DBH*) and possibly tree height (*H*) for species *j*, at time *t,* t.d.m tree^{-1} Note: For *ex ante* estimations, 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.
i	*1, 2, 3, ...* M_{PS} strata in the project scenario
j	*1, 2, 3, ...* S_{PS} tree species in the project scenario
l	*1, 2, 3, ...* $N_{j,sp}$ sequence number of individual trees of species *j* in sample plot *sp*
t	*1, 2, 3, ... t* years elapsed since the start of the A/R CDM project activity

Step 4: Convert the carbon stock in above-ground biomass to the carbon stock in below-ground biomass via root-shoot ratio, given by:

$$C_{BB,i,sp,j,t} = C_{AB,i,sp,j,t} \cdot R_j \qquad \textbf{(10)}$$

where:

$C_{BB,i,sp,j,t}$	Carbon stock in below-ground biomass of trees of species *j* in plot *sp* in stratum *i* at time *t*, t C
$C_{AB,i,sp,j,t}$	Carbon stock in above-ground biomass of trees of species *j* in plot *sp* in stratum *i* at time *t*, t C
R_j	Root-shoot ratio appropriate for biomass stock, for species *j*; dimensionless

See guidance in Section VII. for selection of values of *R*.

Step 5: Calculate total carbon stock in the living biomass of all trees present in the sample plot *sp* in stratum *i* at time *t*.

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} (C_{AB,i,sp,j,t} + C_{BB,i,sp,j,t}) \qquad \textbf{(11)}$$

where:

$C_{tree,i,sp,t}$	Carbon stock in living biomass of trees on plot *sp* of stratum *i* at time *t*, t C
$C_{AB,i,sp,j,t}$	Carbon stock in above-ground biomass of trees of species *j* in plot *sp* in stratum *i* at time *t*; t C tree^{-1}
$C_{BB,i,sp,j,t}$	Carbon stock in below-ground biomass of trees of species *j* in plot *sp* in stratum *i* at time *t*, t C tree^{-1}
i	*1, 2, 3, …* M_{PS} strata in the project scenario
j	*1, 2, 3, …* S_{PS} tree species in the project scenario
t	*1, 2, 3, … t* years elapsed since the start of the A/R CDM project activity

Step 6: Calculate the mean carbon stock in living biomass of trees for each stratum, as per Equation (8) - i.e. Step 7 of the *BEF* method.

Soil organic carbon

13. *Ex ante* and *ex post* $\Delta C_{soil,i,t}$ is estimated from the following equation:

$$\Delta C_{soil,i,t} = A_i \cdot \Delta C_{agroforestry,i} \text{ for } t \leq t_{equilibrium,i}$$
$$\Delta C_{soil,i,t} = 0 \text{ for } t > t_{equilibrium,i} \quad \textbf{(12)}$$

where:

$\Delta C_{soil,i,t}$	Average annual change in carbon stock in soil organic matter for stratum *i*, for year *t*, tonnes C yr^{-1}
A_i	Area of stratum *i*, hectare (ha)
$\Delta C_{agroforestry,i}$	Average annual increase in carbon stock in soil organic matter for agroforestry system in stratum *i,* tonnes C ha^{-1} yr^{-1}
$t_{equilibrium,i}$	Time from start of the project activity until a new equilibrium in carbon stock in soil organic matter is reached for agroforestry system in stratum *i,*years

Documented and verifiable local values of $\Delta C_{agroforestry,i}$ and $t_{equilibrium,i}$ should be used when possible, for example from published literature. The project participants may use the information such as in Appendix B as a guide to determine the influence of management practices, system characteristics and ecological conditions on soil C sequestration as a result of implementation of the project activity.

In the absence of local values, the default value of 0.5 tC ha^{-1} yr^{-1} and a $t_{equilibrium,i}$ of 20 years shall be used. Changes in carbon stock in soil organic matter are not monitored *ex post*.

14. If there is a change in agroforestry practice to pure afforestation or reforestation by increasing the number of trees or cessation of the agricultural practice at time $t = t_{change}$ then:

$$\Delta C_{soil,i,t} = 0 \text{ for } t > t_{change,i} \quad \textbf{(13)}$$

15. If the default values for $\Delta C_{agroforestry,i}$ and $t_{equilibrium,i}$ in paragraph 13 are not being used and there is a change in agroforestry practice at time $t = t_{change}$ then:

(a) If the change is to an agroforestry system that has a higher average annual change in soil organic carbon stock then $\Delta C_{soil,i,t}$ will be calculated using the new average annual change and $t_{equilibrium,i}$:

$$\Delta C_{soil,i,t} = A_i \cdot \Delta C_{agroforestry_2,i} \text{ for } t_{change,i} < t < t_{equilibrium_2,i} \quad \textbf{(14)}$$

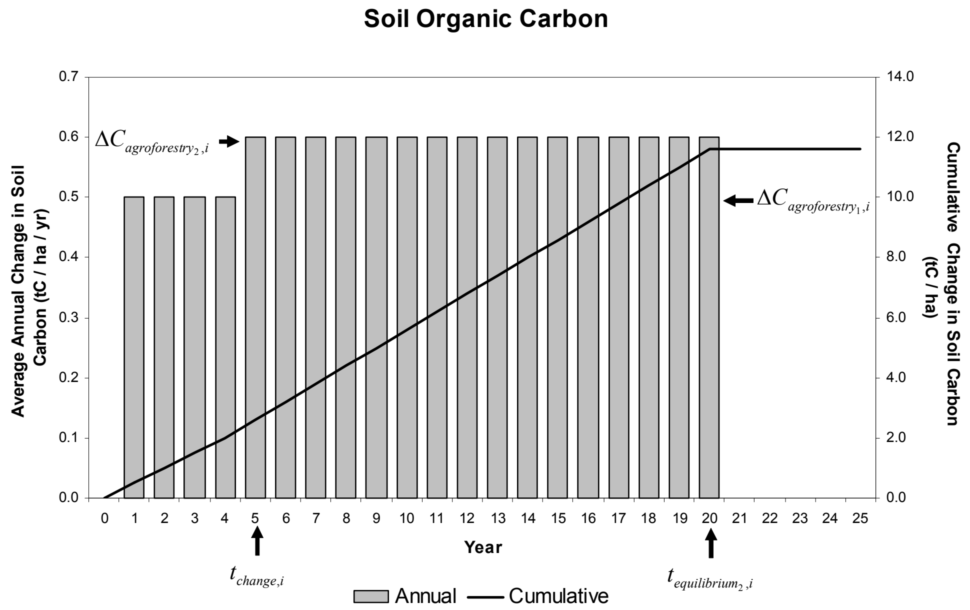

Figure 1: Schematic of annual average and cumulative stock change for case a

(b) If the change is to an agroforestry system that has a lower average annual change in soil organic carbon stock then:

$$\begin{aligned} \Delta C_{soil,i,t} &= 0 \text{ for } t_{change,i} < t < \tau \\ \Delta C_{soil,i,t} &= A_i \cdot \Delta C_{agroforestry_2,i} \text{ for } \tau \le t < t_{equilibrium_2,i} \\ \Delta C_{soil,i,t} &= 0 \text{ for } t > t_{equilibrium_2,i} \end{aligned} \quad \textbf{(15)}$$

and

$$\tau = t_{change,i} \cdot \frac{\Delta C_{agroforestry_1,i}}{\Delta C_{agroforestry_2,i}} \quad \textbf{(16)}$$

where:

$\Delta C_{soil,i,t}$	Average annual change in carbon stock in soil organic matter for stratum *i*, for year *t*, tonnes C yr^{-1}
A_i	Area of stratum *i*, hectare (ha)
$\Delta C_{agroforestry_1,i}$	Average annual increase in carbon stock in soil organic matter for the first agroforestry system in stratum *i,* tonnes C ha^{-1} yr^{-1}
$\Delta C_{agroforestry_2,i}$	Average annual increase in carbon stock in soil organic matter for the second agroforestry system in stratum *i,* tonnes C ha^{-1} yr^{-1}

τ The time at which the total accumulation of soil organic matter in the new agroforestry system equals that accumulated at $t_{change,i}$ in the original agroforestry system

$t_{change,i}$ The time at which there is a change in agroforestry system in stratum *i,* years

$t_{equilibrium_2,i}$ Time until a new equilibrium in soil organic matter is reached for the second agroforestry system in stratum *i,* years

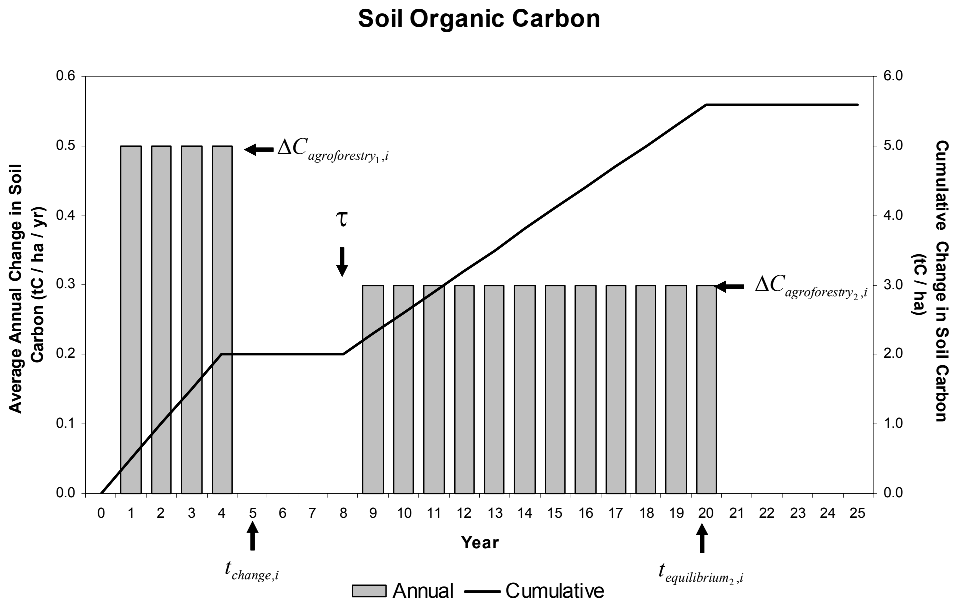

Figure 2: Schematic of annual average and cumulative stock change for case b

IV. Leakage

16. 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".

17. Where evidence has been provided that either of the applicability conditions 1 d (i) to (iii) are met, leakage can be considered zero. Such evidence can be provided by scientific literature or by experts' judgment and/or by participatory rural appraisal.[8]

[8] Participatory rural appraisal (PRA) is an approach to the analysis of local problems and the formulation of tentative solutions with local stakeholders. It makes use of a wide range of visualisation methods for group-based analysis to deal with spatial and temporal aspects of social and environmental problems. This methodology is, for example, described in:

- Chambers R (1992): Rural Appraisal: Rapid, Relaxed, and Participatory. Discussion Paper 311, Institute of Development Studies, Sussex;
- Theis J, Grady H (1991): Participatory rapid appraisal for community development. Save the Children Fund, London.

18. Where applicability condition 1 d (iv) has been shown to be applicable, project participants should assess leakage from the displacement of activities by considering area under cropland within the project boundary displaced due to the project activity.

19. If the decrease in the area cultivated with crops ($Area_{crops}$) within the project boundary as a result of project activity is not more than 10 per cent of the total project area, then:

$$LK_t = 0 \qquad \textbf{(17)}$$

where:

LK_t Leakage attributable to the project activity at time t (t CO_2-e yr^{-1})

20. If the decrease in the area cultivated with crops within the project boundary as a result of project activity is greater than 10 per cent and less than or equal to 50 per cent, then the entire leakage shall be equal to 15 per cent of the *ex ante* actual net GHG removals by sinks achieved during the first crediting period, that is the average annual leakage is equal to:

$$LK_t = \frac{0.15}{T_c}\sum_{t=1}^{T_c} \Delta C_{ACTUAL,t} \cdot \Delta t, \text{for } t \le T_c$$
$$LK_t = 0, \text{for } t > T_c \qquad \textbf{(18)}$$

where:

LK_t	Leakage attributable to the project activity at time *t,* t CO_2-e yr^{-1}
$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks in year *t*, t CO_2-e yr^{-1}
T_c	Duration of first crediting period, years
Δt	Time increment = 1 year

V. Net anthropogenic greenhouse gas removals by sinks

21. 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.

22. The net anthropogenic GHG removals by sinks for each year are calculated as:

$$C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t \qquad \textbf{(19)}$$

where:

$C_{AR-CDM,t}$	Net anthropogenic GHG removals by sinks; t CO_2-e yr^{-1}
$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks in year *t*, t 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}
LK_t	Leakage attributable to the project activity at time *t,* t CO_2-e yr^{-1}

VI. Certified Emission Reductions

23. The resulting temporary certified emission reductions (tCERs) , are calculated as follows:

$$tCER_{tv} = \sum_{t=0}^{tv} C_{AR-CDM,t} \cdot \Delta t \quad \textbf{(20)}$$

24. lCERs are calculated as follows:, calculated as follows:

$$lCER_{tv} = \sum_{t=0}^{tv} C_{AR-CDM,t} \cdot \Delta t - lCER_{tv-k} \quad \textbf{(21)}$$

where:

$tCER_{tv}$	Units of t-CERs issued at year of verification *tv*, , t CO_2-e
$C_{AR\text{-}CDM,t}$	Net anthropogenic GHG removals by sinks; t CO_2-e yr^{-1}
$lCER_{tv}$	Units of lCERs issued at year of verification *tv*, t CO_2-e
tv	Year of verification
k	Time span between two verifications (year)
Δt	Time increment = 1 year

VII. Data and parameters not monitored (default or possibly measured one time)

25. In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, project participants should retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks should be selected.

Data / parameter:	$BEF_{2,j}$,
Data unit:	Dimensionless
Used in equations:	5
Description:	Biomass expansion factor for conversion of merchantable biomass to above-ground tree biomass for tree species *j*
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Existing local and species-specific or group of species-specific; (b) National and species-specific or group of species-specific (e.g. from national GHG inventory); (c) Species-specific or group of species-specific from neighbouring countries with similar conditions. Sometimes c) might be preferable to b); (d) Globally species-specific or group of species-specific (e.g. Table 3A.1.10 of IPCC GPG-LULUCF 2003).[9]

[9] 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.

Measurement procedures (if any):	N/A
Any comment:	• 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).[10] To be conservative, the lower value in the specified range of BEF_2 values should be used and the selected *BEF* values justified; • *BEFs* are age dependent, and use of average data may result in significant errors for both young and old stands—as *BEFs* are usually large for young stands and quite small for old stands.

Data / parameter:	CF_j
Data unit:	t C t^{-1} d.m.
Used in equations:	5, 9
Description:	Carbon fraction of dry matter for species of type *j*
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Existing local and species-specific or group of species-specific; (b) National and species-specific or group of species-specific (e.g. from national GHG inventory); (c) Species-specific or group of species-specific from neighbouring countries with similar conditions. Sometimes b) might be preferable to a); (d) Globally species-specific or group of species-specific (e.g. IPCC GPG_LULUCF 2003). Alternately the default value of 0.5 t C t^{-1} d.m. may be used.
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	D_j
Data unit:	t d.m. m^{-3}
Used in equations:	5
Description:	Basic wood density for species *j*
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Existing local and species-specific or group of species-specific; (b) National and species-specific or group of species-specific (e.g. from national GHG inventory); (c) Species-specific or group of species-specific from neighbouring countries with similar conditions. Sometimes b) might be preferable to a); (d) Globally species-specific or group of species-specific (e.g. Table 3A.1.9 IPCC GPG-LULUCF 2003).

[10] 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*.

Measurement procedures (if any):	N/A
Any comment:	

Data / Parameter:	$f_j(DBH, H)$
Data unit:	t d.m. $tree^{-1}$
Used in equations:	9
Description:	Allometric equation for species *j* linking diameter at breast height (*DBH*) and possibly tree height (*H*) to above-ground biomass of living trees
Source of data:	Whenever available, use allometric equations that are species-specific or group of species-specific, provided the equations have been derived using a wide range of diameters and heights, based on datasets that comprise at least 20 trees. If species specific allometric equations are not available then use default allometric equations included in **Appendix C** to this report or default equations from IPCC literature, national inventory reports or published peer-reviewed studies —such as those provided in Tables 4.A.1 to 4.A.3 of the GPG-LULUCF (IPCC 2003).
Measurement procedures (if any):	
Any comment:	If default allometric equations are available for conditions that are similar to the project (same vegetation genus; same climate zone; similar forest type), then the equation may be used and considered conservative.

Data / parameter:	R_j
Data unit:	d.m. kg^{-1} d.m.
Used in equations:	6, 10
Description:	Root-shoot ratio appropriate for biomass stock, for species *j*
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Local values if available; (b) If local values are not available, values should be selected from Table 3A.1.8 of the GPG-LULUCF (IPCC 2003), or equivalently Table 4.4 of the AFOLU Guidelines (IPCC 2006). Alternately a default value of value of 0.3 kg d.m. $(kg\ d.m.)^{-1}$ may be used as a conservative generic root:shoot ratio for all trees.
Measurement procedures (if any):	N/A
Any comment:	Guidelines for Conservative Choice of Default Values: 1. If in the sources of data mentioned above, default data are available for conditions that are similar to the project (same vegetation genus; same climate zone; similar forest type), then mean values of default data may be used and are considered conservative; 2. Global values may be selected from Table 3A.1.8 of the GPG-LULUCF (IPCC 2003), or equivalently Table 4.4 of the AFOLU Guidelines (IPCC 2006), by choosing a climatic zone and species that most closely matches the project circumstances.

Data / Parameter:	$t_{equilibrium}$
Data unit:	yr
Used in equations:	14,15
Description:	Time until a new equilibrium in carbon stocks in soil organic matter is reached for the second agroforestry system in stratum *i,*years
Source of data:	Documented and verifiable local values of $t_{equilibrium}$ should be used when possible, for example from published literature. In the absence of such values default value of 20 years may be used.
Measurement procedures (if any):	N/A
Any comment:	Local values of this parameter should be used together with local values of $\Delta C_{agroforestry,i}$. Or else default values for both $t_{equilibrium}$ *and* $\Delta C_{agroforestry,i}$ provided in the methodology should be used.

Data / Parameter:	$\Delta C_{agroforestry,i}$
Data unit:	tonnes C yr^{-1}
Used in equations:	12, 14, 15
Description:	Average annual change in carbon stock in soil organic matter for stratum *i*, for year *t*
Source of data:	Documented and verifiable local values of $\Delta C_{agroforestry,i}$ should be used when possible, for example from published literature. In the absence of such values, the default value of 0.5 tC ha^{-1} yr^{-1} assuming a maximum accumulation period of 20 years shall be used.
Measurement procedures (if any):	N/A
Any comment:	

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

26. 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.

27. All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. All data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted according to relevant standards.

Sampling design and stratification

28. Stratification of the project area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit. Project participants should present in the AR-CDM-PDD an *ex ante* stratification of the project area or justify the lack of it. The number and boundaries of the strata defined *ex ante* may change during the crediting period (*ex post*).

29. For estimation of project GHG removals by sinks, strata shall be defined by:

(i) Stratification approach that can be shown in the PDD to estimate biomass stocks according to good forest inventory practice in the Host country ; or

(ii) Other stratification approach that can be shown in the PDD to estimate the project biomass stocks to targeted precision level of ±10 per cent of the mean at a 90 per cent confidence level.

30. The *ex post* stratification shall be updated due to the following reasons:

(i) Unexpected disturbances occurring during the crediting period (e.g. due to fire, pests or disease outbreaks), affecting differently various parts of an originally homogeneous stratum;

(ii) Forest management activities (cleaning, planting, thinning, harvesting, coppicing, re-replanting) may be implemented in a way that affects the existing stratification.

31. Established strata may be merged if reasons for their establishing have disappeared.

IX. Data and parameters monitored

32. The following parameters should be monitored during the project activity. When applying all relevant equations provided in this methodology for the *ex ante* calculation of net anthropogenic GHG removals by sinks, project participants shall provide transparent estimations for the parameters that are monitored during the crediting period. These estimates shall be based on measured or existing published data where possible and project participants should retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks should be selected.

Data / Parameter:	A_i
Data unit:	ha
Used in equations:	8, 12,14,15
Description:	Area of stratum *i*
Source of data:	Monitoring of strata and stand boundaries shall be done preferably using a Geographical Information System (GIS), which allows for integrating data from different sources (including GPS coordinates and Remote Sensing data)
Measurement procedures (if any):	
Monitoring frequency:	At least every 5 years from the start of the project activity
QA/QC procedures:	
Any comment:	

Data / Parameter:	$Asp_{,i}$
Data unit:	ha
Used in equations:	8
Description:	Total area of all sample plots in stratum *i*
Source of data:	Field measurement
Measurement procedures (if any):	

Monitoring frequency:	At least every 5 years from the start of the project activity
QA/QC procedures:	
Any comment:	GPS can be used for field survey. Sample Plot location is registered with a GPS and marked on the project map

Data / parameter:	*DBH*
Data unit:	cm
Used in following equations	Implicitly used in Eq. 9
Description:	Diameter breast height of tree
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	Typically measured 1.3 m above-ground. Measure all the trees above some minimum *DBH* in the permanent sample plots that result from the A/R project activity. The minimum *DBH* varies depending on tree species and climate; for instance, the minimum *DBH* may be as small as 2.5 cm in arid environments where trees grow slowly, whereas it could be up to 10 cm for humid environments where trees grow rapidly
Monitoring frequency:	At least every 5 years
QA/QC procedures:	
Any comment:	Note: for *ex ante* estimations, mean *DBH* and *H* values should be estimated for tree species *j* in 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.

Data / parameter:	*H*
Data unit:	m
Used in equations:	Implicitly used in Eq. 9
Description:	Height of tree
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	At least every 5 years
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Note: for *ex ante* estimations, mean *DBH* and *H* values should be estimated for tree species *j* in 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.

Data / Parameter:	*T*
Data unit:	yr
Used in equations:	4
Description:	Number of years between monitoring time t_2 and t_1 ($T = t2 – t1$)
Source of data:	
Measurement procedures (if any):	

Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	t_{change}
Data unit:	yr
Used in equations:	13,14, 15
Description:	Time at which there is a change in agroforestry system in stratum *i*, years
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	$Area_{crops}$
Data unit:	yr
Used in equations:	Implicitly in Eq. 17 and 18
Description:	Area cultivated with crops within the project boundary
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	At start of project activity and at each verification upto end of first crediting period
QA/QC procedures:	
Any comment:	

Appendix A

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 B

Management practices, system characteristics and ecological conditions to be considered for selecting default values for soil carbon sequestration in agroforestry systems[11]

Factor/Condition	Effect on soil carbon sequestration potential in general terms
Management Practices	
Tillage and soil disturbance	Inverse relation: Less soil disturbance → Higher C sequestration.
Fertilizer/Manure application	More fertilizer/manure application → Higher C sequestration.
Plant residue management	Leaving more residue in soil → Higher C sequestration.
Nature of harvest	Repeated harvest of whole woody perennials → Lower C sequestration
System Characteristics	
Tree density	More trees → Higher C sequestration.
Species attributes	Fast tree growth → Higher C sequestration; High biomass production → Higher C sequestration; Higher root:shoot ratio (i.e., more roots) → Higher C sequestration.
Ecological Conditions	
Rainfall (quantity and distribution)	Higher and evenly distributed rainfall → Higher C sequestration.
Soil properties	Higher clay+silt → More C sequestration; Sandy soil → Lower C sequestration Clayey soil → Higher C sequestration Better soil conditions that support tree growth → Higher C sequestration.

[11] Modified from the consultancy report prepared for UNFCCC by P.K. Nair (2008).

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	$AGB = 10\hat{}\{-0.535 + \log_{10}(\pi * DBH^2/4)\}$	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 biomass (Kg dry matter per tree); *DBH* = diameter at breast height (cm); H = height (m); *WD* = basic wood density (t m^{-3} or grams cm^{-3}); ln = natural logarithm; exp = “e raised to the power of”

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

History of the document

Version	Date	Nature of revision
01	EB 44, Annex # 28 November 2008	Initial adoption.