Approved afforestation and reforestation baseline and monitoring methodology AR-AM0007

"Afforestation and Reforestation of Land Currently Under Agricultural or Pastoral Use"

(Version 05)

I.   SOURCE, DEFINITIONS AND APPLICABILITY

1.   Sources

This methodology is based on the draft CDM-AR-PDD "Chocó-Manabí Corridor Reforestation and Conservation Carbon Project" whose baseline study, monitoring and verification plan and project design document were prepared by EcoSecurities Consult, Britain; Joanneum Research, Austria; Conservation International, USA and EcoDecision. For more information regarding the proposal and its consideration by the Executive Board please refer to case ARNM0021-rev: "Chocó-Manabí Corridor Reforestation and Conservation Carbon Project" at: <http://cdm.unfccc.int/goto/ARpropmeth>.

This methodology also refers to the latest approved versions of the following tools:

- Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities;
- Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities;
- Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected in A/R CDM project activities;
- Calculation of the number of sample plots for measurements within A/R CDM project activities;
- Tool for testing significance of GHG emissions in A/R CDM project activities.

All the above-mentioned tools are available at: <http://cdm.unfccc.int/Reference/tools>.

2.   Selected Baseline Approach from Paragraph 22 of the CDM A/R Modalities and Procedures

"Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary"

3.   Definitions

This methodology does not use any methodology specific definitions.

4.   Applicability

This methodology is applicable to the following project activities:

- Afforestation or reforestation activities undertaken on agricultural or pastoral lands.

The conditions under which the methodology is applicable are:

- The establishment of the project occurs after a period of decreasing intensity of agricultural and pastoral activities and it may be expected that the trend would be continued in the absence of the project activity. In particular:

    (a)   If the pre-project activity is agriculture then:

        (i)   Total production of crops collected from the planned project area has decreased by at least 30% during five years preceding the validation year; or

        (ii)   Area cultivated within the planned project boundary has decreased by at least 30% during five years preceding the validation year.

    (b)   If the pre-project activity is pastoral activity then:

        (i)   The annual average number of animals present in the planned project area when expressed using the common livestock unit used in the host country has decreased by at least 30% during five years preceding the validation year.

- Soil organic carbon pool may be conservatively neglected in the proposed A/R CDM project activity;

- Flooding irrigation is not applied in the project activity;

- The pre-project crown cover of trees within the project boundary is less than 20% of the threshold for crown cover reported to the EB by the host Party.

The latest version of the "Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected in A/R CDM project activities" shall be applied to demonstrate that the soil organic carbon pool may be conservatively neglected in A/R CDM project activities.

II.   BASELINE METHODOLOGY PROCEDURE

1.   Project boundary and eligibility of land

The "project boundary" geographically delineates the afforestation or reforestation project activity under the control of the project participants (PPs). The A/R CDM project activity may contain more than one discrete area of land. Each discrete area of land shall have a unique geographical identification.

It shall be demonstrated that each discrete area of land to be included in the boundary is eligible for an A/R CDM project activity. PPs shall apply the latest version of the tool "Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities" as approved by the Executive Board.

The latest version of "Guidance on the application of the definition of project boundary to A/R CDM project activities" (available at: <http://cdm.unfccc.int/Reference/Guidclarif>) may be applied in identification of areas of land planned for an A/R CDM project activity.

The carbon pools included in or excluded from the project boundary are shown in Table 1.

Table 1: Selection and justification of carbon pools

Carbon Pools	Selected	Justification / Explanation
Above-ground	Yes	Major carbon pool subjected to the project activity. PPs may explicitly select carbon stock of above-ground biomass of non-tree woody vegetation planted as a part of the A/R CDM project activity to be included in the above-ground biomass carbon pool.
Below-ground	Yes	Major carbon pool subjected to the project activity. PPs may explicitly select carbon stock of below-ground biomass of non-tree woody vegetation planted as a part of the A/R CDM project activity to be included in the below-ground biomass carbon pool.
Dead wood	Yes alternatively No	Carbon pool subjected to the project activity. Alternatively, this pool may be conservatively excluded under the applicability conditions.
Litter	Yes alternatively No	Carbon pool subjected to the project activity. Alternatively, this pool may be conservatively excluded under the applicability conditions.
Soil organic carbon (SOC)	No alternatively Yes (only for default approach)	If No - conservative approach under applicability condition. If Yes - the default approach is selected and additional applicability conditions apply (see: Chapter 5.1.5.1 *Default Changes in Soil Organic Carbon Pool*)

The emissions sources included in or excluded from the project boundary are shown in Table 2. Any one of these sources can be neglected, i.e., accounted as zero, if the application of the most recent version of the "Tool for testing significance of GHG emissions in A/R CDM project activities" leads to the conclusion that the emission source is insignificant.

Table 2: Gases considered from emissions by sources other than resulting from changes in stocks in carbon pools

Source	Gas	Included/ excluded	Justification / Explanation
Burning of woody biomass (i.e., excluding herbaceous biomass)	CO_2	Included	Carbon stock decreases due to burning are accounted as a change in carbon stock
	CH_4	Included	Non-CO_2 gas emitted from woody biomass burning
	N_2O	Excluded	Potential emissions are negligibly small

2. Identification of the baseline scenario and demonstration of additionality

PPs shall use the most recent version of the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities".

3. Stratification

If the project activity area is not homogeneous, stratification should be carried out to improve the accuracy and the precision of biomass estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy of the estimates of net GHG removal by sinks.

For estimation of baseline net GHG removals by sinks, or estimation of actual net GHG removals by sinks, strata should be defined on the basis of parameters that are key entry variables in any method (e.g., growth models or yield curves/tables) used to estimate changes in biomass stocks:

- **For baseline net GHG removals by sinks.** It will usually be sufficient to stratify according to area of major vegetation types because baseline removals for degraded (or degrading) land are expected to be small in comparison to project removals;

- **For actual net GHG removals by sinks.** The *ex ante* estimations shall be based on the project planting/management plan. The *ex post* stratification shall be based on the actual implementation of the project planting/management plan. The *ex post* stratification may be affected by natural or anthropogenic impacts if they are able to add variability to growth pattern in the project area, e.g., local fires (see Section III.2).

Further subdivision of the project strata to represent spatial variation in the distribution of the baseline or the project biomass stocks/removals is not usually warranted. However, factors impacting growth (e.g., soil type) might be useful for *ex post* stratification if their variability in the project area is large.

For *ex ante* and *ex post* stratification, PPs may optionally make use of remote sensing data acquired close to the time the project commences and/or close to the time of occurrence of natural or anthropogenic impacts if such impacts add variability to growth pattern in the project area.

4. Baseline Net GHG Removals by Sinks

Under the applicability conditions of this methodology:

- Changes in carbon stock of above-ground and below-ground biomass of non-tree vegetation may be conservatively assumed to be zero for all strata in the baseline scenario;

- It is expected that the baseline dead wood and litter carbon pools will not show a permanent net increase. It is therefore conservative to assume that the sum of the changes in the carbon stocks of dead wood and litter carbon pools is zero for all strata in the baseline scenario;

- Changes in carbon stock in soil organic carbon (SOC) may be conservatively assumed to be zero for all strata in the baseline scenario.

If the pre-project crown cover of trees within the project boundary is less than 20% of the threshold for crown cover reported to the EB by the host Party then the baseline net GHG removals by sinks may be accounted for as zero. Otherwise, the baseline net GHG removals by sinks will be determined as:

$$\Delta C_{BSL} = \Delta C_{BSL,tree} \tag{1}$$

where:

ΔC_{BSL} Baseline net greenhouse gas removals by sinks; t CO_2-e

$\Delta C_{BSL,tree}$ Sum of the carbon stock changes in above-ground and below-ground biomass of trees in the baseline; t CO_2-e

4.1 Carbon stock changes in above-ground and below-ground tree biomass

The estimation of carbon stock changes in above-ground and below-ground tree biomass in the baseline ($\Delta C_{BSL,tree}$) will be performed as per the equations below. These equations provide for the calculations to be performed for each stratum. If there is more than one stratum in the baseline scenario, the outcome will be summed over all the strata to obtain the value for the whole project.

$$\Delta C_{BSL,tree,i} = \sum_{t=1}^{t^*} \Delta C_{BSL,AG/BG,i,t} * \frac{44}{12} * 1 \, year \tag{2}$$

where:

$\Delta C_{BSL,tree,i}$ Sum of the baseline annual carbon stock changes in above-ground and below-ground tree biomass for stratum i; t CO_2-e

$\Delta C_{BSL,AG/BG,i,t}$ Baseline annual net carbon stock change in above-ground and below-ground biomass for stratum i, year t; t C yr^{-1}

i 1, 2, 3, ... M_B strata in the baseline scenario

t 1, 2, 3, ... t^* years elapsed since the start of the A/R CDM project activity

44/12   Ratio of molecular weight of CO_2 to carbon; t CO_2-e t C^{-1}

$\Delta C_{BSL,AG/BG,i,t}$ is estimated using one of the following methods that can be selected on the basis of the availability of data.

Method 1 (Carbon gain-loss method)[1]

$$\Delta C_{BSL,AG/BG,i,t} = \Delta C_{G,i,t} - \Delta C_{L,i,t} \tag{3}$$

where:

$\Delta C_{BSL,AG/BG,i,t}$ Baseline annual carbon stock net change in above-ground and below-ground biomass for stratum i, year t; t C yr^{-1}

$\Delta C_{G,i,t}$ Annual increase in above-ground and below-ground carbon due to biomass growth of living trees in stratum i, for year t; t C yr^{-1}
Note: This is the "potential growth" which is greater than the "observed growth".

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[1] *IPCC GPG-LULUCF 2003*, Equation 3.2.2, Equation 3.2.4 and Equation 3.2.5.

$\Delta C_{L,i,t}$	Annual decrease in above-ground and below-ground carbon stock of living trees due to biomass loss for stratum i, year t; t C yr^{-1} Note: Conservative assumption that $\Delta C_{L,i,t} = 0$ is allowed for the baseline scenario.[2]
i	$1, 2, 3, \dots M_B$ strata in the baseline scenario
t	$1, 2, 3, \dots t^*$ years elapsed since the start of the A/R CDM project activity

$$\Delta C_{G,i,t} = A_{BSL,i} * \sum_{j=1}^{J} G_{tree,j,i,t} * CF_j \qquad \qquad (4)$$

where:

$\Delta C_{G,i,t}$	Annual increase in carbon due to biomass growth of living trees in stratum i, for year t; t C yr^{-1}
$A_{BSL,i}$	Area of baseline stratum i; ha
$G_{tree,j,i,t}$	Annual increment of total above-ground and below-ground dry biomass of living trees of species j, in stratum i, for year t; t d.m. ha^{-1} yr^{-1}
CF_j	Carbon fraction of dry matter for species j; t C t^{-1} d.m.
i	$1, 2, 3, \dots M_B$ strata in the baseline scenario
j	$1, 2, 3, \dots J$ tree species in the baseline scenario
t	$1, 2, 3, \dots t^*$ years elapsed since the start of the A/R CDM project activity

and

$$G_{tree,j,i,t} = G_{w,j,i,t} * (1 + R_{1j}) \qquad \qquad (5)$$

$$G_{w,j,i,t} = I_{V,j,i,t} * D_j * BEF_{1,j} \qquad \qquad (6)$$

where:

$G_{tree,j,i,t}$	Annual increment of total dry biomass of living trees of species j, in stratum i, for year t; t d.m. ha^{-1} yr^{-1}
$G_{w,j,i,t}$	Average annual above-ground dry biomass increment of living trees of species j, in stratum i, for year t; t d.m. ha^{-1} yr^{-1}
R_{1j}	Root-shoot ratio appropriate for biomass increment for species j; t d.m. t^{-1} d.m

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[2] This assumption implies that all baseline woody biomass is assumed to remain living and growing during the entire crediting period. This is conservative because the proportion of living biomass that will die or will be harvested is not deduced from the estimation of baseline net GHG removals by sinks and because the growth of the baseline biomass will cease (i.e., the biomass will reach saturation) at some point in time.

$I_{V,j,i,t}$	Current annual increment in volume of species j, in stratum i, for year t; m^3 ha^{-1} yr^{-1}
	Note: $I_{V,j,i,t}$ can be estimated as a constant annual average value over a period including the year t (Periodical Annual Increment).
	Note: t is likely to be different than age of individual trees in the year t.
D_j	Basic wood density for species j; t d.m. m^{-3}
$BEF_{1,j}$	Biomass expansion factor for conversion of annual net increment (including bark) in stem biomass to total above-ground tree biomass increment for species j; t d.m. (t d.m.)$^{-1}$
i	1, 2, 3, ... M_B strata in the baseline scenario
j	1, 2, 3, ... J tree species in the baseline scenario
t	1, 2, 3, ... t^* years elapsed since the start of the A/R CDM project activity

If biomass increment tables are available and applicable to the species used in the project activity, these can directly be used in Eq. (5). Note that available data on average annual increment in the volume of species j in stratum i for year t ($I_{V,j,i,t}$) may be expressed as a <u>net</u> average annual increment (i.e., the term $\Delta C_{L,i,t}$ is already implicitly allowed for and shall be set to zero in Eq. (3) in order to avoid double counting).

Alternatively, if the average annual increment in volume of species j in stratum i, for year t ($I_{V,j,i,t}$) is expressed as the <u>gross</u> average annual increment, then $\Delta C_{L,i,t}$ may be conservatively assumed as zero. Otherwise $\Delta C_{L,i,t}$ must be estimated on the basis of transparent and verifiable information on the rate at which pre-project activities (or mortality) are reducing carbon stocks in existing live trees (e.g., due to harvesting for local timber consumption, or for fuelwood).

Method 2 (stock change method)[3]

$$\Delta C_{BSL,AG/BG,i,t} = \sum_{j=1}^{J} \frac{C_{j,i,t_2} - C_{j,i,t_1}}{T} \tag{7}$$

$$C_{j,i,t} = C_{AB\_tree,j,i,t} + C_{BB\_tree,j,i,t} \tag{8}$$

$$C_{AB\_tree,j,i,t} = A_{BSL,i} * V_{tree,j,i,t} * D_j * BEF_{2,j} * CF_j \tag{9}$$

$$C_{BB\_tree,j,i,t} = C_{AB\_tree,j,i,t} * R_j \tag{10}$$

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[3] GPG-LULUCF Equation 3.2.3.

where:

$\Delta C_{BSL,AG/BG,i,t}$	Annual carbon stock change in above-ground and below-ground tree biomass for stratum i, year t; t C yr^{-1}
$C_{j,i,t}$	Total carbon stock in living biomass of trees of species j, in stratum i, calculated at year t; t C
T	Number of years between times t_2 and t_1; yr
$C_{AB\_tree,j,i,t}$	Carbon stock in above-ground tree biomass of species j, in stratum i, at year t; t C
$C_{BB\_tree,j,i,t}$	Carbon stock in below-ground tree biomass of species j, in stratum i, at year t; t C
$A_{BSL,i}$	Area of baseline stratum i; ha
$V_{tree,j,i,t}$	Pre-project tree stem volume for species j, stratum i, at year t; m^3 ha^{-1}
D_j	Basic wood density for species j; t d.m. m^{-3}
$BEF_{2,j}$	Biomass expansion factor for conversion of stem biomass to above-ground tree biomass for tree species j; t d.m t^{-1} d.m
CF_j	Carbon fraction of dry matter for species j; t C t^{-1} d.m.
R_j	Root-shoot ratio appropriate for biomass stock, for species j; t C t^{-1} C
i	$1, 2, 3, ... M_B$ strata in the baseline scenario
j	$1, 2, 3, ... J$ tree species in the baseline scenario
t	$1, 2, 3, ... t^*$ years elapsed since the start of the A/R CDM project activity

An alternative way of estimating $C_{AB\_tree,j,i,t}$ is to use allometric equations:

$$C_{AB\_tree,j,i,t} = A_{BSL,i} * nTR_{j,i,t} * CF_j * f_j(DBH, H) \tag{11}$$

where:

$C_{AB\_tree,j,i,t}$	Carbon stock in above-ground tree biomass of species j, in stratum i, at year t; t C
$A_{BSL,i}$	Area of baseline stratum i; ha
$nTR_{j,i,t}$	Pre-project tree stand density of species j, in stratum i, at year t; trees ha^{-1}
CF_j	Carbon fraction of dry matter for species j; t C t^{-1} d.m.

$f_j(DBH, H)$ Allometric equation for species j linking diameter at breast height (DBH) and possibly tree height (H) to above-ground biomass of living trees; t d.m. ~~tree~~$^{-1}$ (<u>Note</u>: If using an average DBH in an allometric equation, the average must be calculated as the square root of the sum of the squares of the individual tree diameters making up the sample divided by their number - i.e., so called "quadratic mean" or "root mean square").

i 1, 2, 3, ... M_B strata in the baseline scenario

j 1, 2, 3, ... J tree species in the baseline scenario

t 1, 2, 3, ... t^* years elapsed since the start of the A/R CDM project activity

Note that volume tables from which $V_{tree,j,i,t}$ are obtained may or may not include allowance for losses due to harvesting or mortality. Such losses may be conservatively neglected when estimating baseline removals in pre-project trees. Otherwise $\Delta C_{L,i,t}$ must be estimated on the basis of credible and transparent information on the rate at which pre-project activities (and mortality, if applicable) are reducing carbon stocks in existing live trees (e.g., due to harvesting for local timber consumption, or for fuelwood).

4.2 Steady state under the baseline conditions

The baseline net GHG removals by sinks, if greater than zero, shall be estimated as per approach provided in Section 4.1 until steady state is reached under the baseline conditions. Under steady state:

$$\Delta C_{BSL} = 0$$

PPs may, on a project specific basis, assess when a steady state is reached during the crediting period. This shall be estimated on the basis of transparent and verifiable information originating as appropriate from available literature, data from comparable areas, from field measurements in the planned project area, or from other sources relevant to the baseline circumstances. If no data is available, a default period of 20 years since commencement of the CDM project activity will be applied.

5. Actual net GHG removals by sinks

Under the applicability conditions of this methodology:

- Changes in carbon stock of above-ground and below-ground biomass of non-tree vegetation may be conservatively assumed to be zero for all strata in the project scenario. Optionally, PPs may include changes in carbon stock of above-ground and below-ground biomass of planted non-tree woody vegetation if selected in Table 1.

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

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \qquad\qquad\qquad\qquad\qquad \textbf{(12)}$$

where:

ΔC_{ACTUAL} — Actual net greenhouse gas removals by sinks; t CO_2-e

ΔC_P — Sum of the changes in above-ground and below-ground tree biomass, dead wood, litter and soil organic carbon stocks in the project scenario; t CO_2-e

GHG_E — Increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary; t CO_2-e

<u>Note</u>: In this methodology Eq. (12) is used to estimate actual net greenhouse gas removals by sinks for the period of time elapsed between project start ($t = 1$) and the year $t = t^*$, t^* being the year for which actual net greenhouse gas removals by sinks are estimated. The "stock change" method should be used to determine annual, or periodical values.

5.1 Estimation of changes in the carbon stocks

The verifiable changes in the carbon stock in tree above-ground biomass and below-ground biomass, litter and soil organic carbon within the project boundary are estimated using the following approach:[4]

$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_t * \frac{44}{12} * 1\, year \tag{13}$$

where:

ΔC_P — Sum of the changes in carbon pools in above-ground and below-ground tree biomass, dead wood, litter and soil organic carbon in the project scenario; t CO_2-e

ΔC_t — Annual change in carbon stock in all selected carbon pools for year t; t C yr^{-1}

t — $1, 2, 3, ... t^*$ years elapsed since the start of the A/R project activity; yr

$44/12$ — Ratio of molecular weights of CO_2 and carbon; t CO_2-e (t C)$^{-1}$

ΔC_t shall be estimated using the following equation:

$$\Delta C_t = \sum_{i=1}^{M_{PS}} (\Delta C_{AG,i,t} + \Delta C_{BG,i,t} + \Delta C_{DW,i,t} + \Delta C_{LI,i,t} + \Delta C_{SOC,i,t}) \tag{14}$$

where:

ΔC_t — Annual change in carbon stock in all carbon pools for year t; t C yr^{-1}

$\Delta C_{AG,i,t}$ — Annual carbon stock change in above-ground biomass of trees for stratum i, (possibly average over a monitoring period); t C yr^{-1}

$\Delta C_{BG,i,t}$ — Annual carbon stock change in below-ground biomass of trees for stratum i, (possibly average over a monitoring period); t C yr^{-1}

$\Delta C_{DW,i,t}$ — Annual change in the dead wood carbon pool in stratum i, (possibly averaged over a monitoring period); t C yr^{-1}

$\Delta C_{LI,i,t}$ — Annual change in the litter carbon pool in stratum i, (possibly averaged over a monitoring period); t C yr^{-1}

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[4] IPCC GPG-LULUCF 2003, Equation 3.2.3.

$\Delta C_{SOC,i,t}$ Annual carbon stock change in the soil organic carbon pool-for stratum i, year t; t C yr^{-1}

i $1, 2, 3, \ldots M_{PS}$ strata in the project scenario

t $1, 2, 3, \ldots t^*$ years elapsed since the start of the A/R CDM project activity

Changes in the carbon pools that are conservatively excluded from accounting shall be set equal to zero.

5.1.1 Tree Biomass

The mean carbon stock in above-ground and below-ground biomass per unit area is estimated on the basis of 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 on the basis of 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 stem volume of trees $V_{l,j,i,sp,t}$ on the basis of 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 *BEF* and root-shoot ratio (*R*) - see Section II.8 for guidance on source of data. If relevant information is available the *BEF* and the *R* should be corrected for age.

Step 4: Convert the stem volume of trees into carbon stock in above-ground biomass via basic wood density, the *BEF* and the carbon fraction:

$$C_{AB\_tree,l,j,i,sp,t} = V_{l,j,i,sp,t} * D_j * BEF_{2,j} * CF_j \tag{15}$$

where:

$C_{AB\_tree,l,j,i,sp,t}$ Carbon stock in above-ground biomass of tree l, of species $j,$ in plot $sp,$ in stratum i at year t; t C

$V_{l,j,i,sp,t}$ Stem volume of tree $l,$ of species $j,$ in plot $sp,$ in stratum $i,$ at year t; m^3

D_j Basic wood density of species j; t d.m. m^{-3}

$BEF_{2,j}$ Biomass expansion factor for conversion of stem biomass to above-ground tree biomass for species j; dimensionless

CF_j Carbon fraction of biomass for tree species j; t C t^{-1} d.m. (IPCC default value = 0.5 t C t^{-1} d.m.)

l Sequence number of trees on plot sp

i $1, 2, 3, \ldots M_{PS}$ strata in the project scenario

j $1, 2, 3, \ldots S_{PS}$ tree species in the project scenario

t $1, 2, 3, \ldots t^*$ years elapsed since the start of the A/R CDM project activity

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

$$C_{BB\_tree,l,j,i,sp,t} = C_{AB\_tree,l,j,i,sp,t} * R_j \qquad \textbf{(16)}$$

where:

$C_{BB\_tree,l,j,i,sp,t}$ Carbon stock in below-ground biomass of tree *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

$C_{AB\_tree,l,j,i,sp,t}$ Carbon stock in above-ground biomass of tree *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

R_j Root-shoot ratio appropriate for biomass stock, for species *j*; dimensionless

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

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} \sum_{l=1}^{N_{j,i,sp,t}} (C_{AB\_tree,l,j,i,sp,t} + C_{BB\_tree,l,j,i,sp,t}) \qquad \textbf{(17)}$$

where:

$C_{tree,i,sp,t}$ Carbon stock in trees on plot *sp*, of stratum *i*, at year *t*; t C

$C_{AB\_tree,l,j,i,sp,t}$ Carbon stock in above-ground biomass of tree *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

$C_{BB\_tree,l,j,i,sp,t}$ Carbon stock in below-ground biomass of tree *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

$N_{j,i,sp,t}$ Number of trees of species *j*, on plot *sp*, of stratum *i*, at year *t*

l   Sequence number of trees on plot *sp*

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

$$C_{tree,i,t} = \frac{A_i}{A_{sp_i}} \sum_{sp=1}^{P_i} C_{tree,i,sp,t} \qquad \textbf{(18)}$$

where:

$C_{tree,i,t}$ Carbon stock in trees in stratum *i*, at year *t*; t C

$C_{tree,i,sp,t}$ Carbon stock in trees on plot *sp* of stratum *i,* at year *t*; t C

A_{sp_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

Allometric method

Step 1: Proceed as in Step 1 of the *BEF* Method.

Step 2: Select or develop an appropriate allometric equation (if possible species-specific, or if not from a similar species) - see Section II.8 for additional guidance.

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 determined in Step 1, and sum the carbon stocks in the sample plot:

$$C_{AB\_tree,j,i,sp,t} = \sum_{l=1}^{N_{j,sp}} f_j(DBH,H) * CF_j \qquad (19)$$

where:

$C_{AB\_tree,j,i,sp,t}$	Carbon stock in above-ground biomass of trees of species j, on sample plot sp, of stratum i, at year t; t C
CF_j	Carbon fraction of dry matter for species or type j; t C t^{-1} d.m.
$f_j(DBH,H)$	Allometric equation for species j linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of a living tree; t d.m.
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:

$$C_{BB\_tree,j,i,sp,t} = C_{AB\_tree,j,i,sp,t} * R_j \qquad (20)$$

where:

$C_{BB\_tree,j,i,sp,t}$ Carbon stock in below-ground biomass of trees of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

$C_{AB\_tree,j,i,sp,t}$ Carbon stock in above-ground biomass of trees of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

R_j Root-shoot ratio appropriate for biomass stock, for species *j*; dimensionless

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

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} (C_{AB\_tree,j,i,sp,t} + C_{BB\_tree,j,i,sp,t}) \tag{21}$$

where:

$C_{tree,i,sp,t}$ Carbon stock in trees on plot *sp*, of stratum *i*, at year *t*; t C

$C_{AB\_tree,j,i,sp,t}$ Carbon stock in above-ground biomass of trees of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

$C_{BB\_tree,j,i,sp,t}$ Carbon stock in below-ground biomass of trees of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C

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 tree biomass for each stratum, as per Eq. (18) - i.e., Step 7 of the *BEF* method.

For both the *BEF* and the allometric methods calculate:

$$\Delta C_{AG,i,t} + \Delta C_{BG,i,t} = \frac{C_{tree,i,t_2} - C_{tree,i,t_1}}{T} \tag{22}$$

where:

$\Delta C_{AG,i,t}$ Annual carbon stock change in above-ground biomass of trees for stratum *i*; t C yr^{-1}

$\Delta C_{BG,i,t}$ Annual carbon stock change in below-ground biomass of trees for stratum *i*; t C yr^{-1}

$C_{tree,i,t}$ Carbon stock in trees in stratum *i*, at year *t*; t C

T   Number of years between monitoring time t_2 and t_1 ($T = t_2 - t_1$); yr

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

5.1.2 Planted non-tree woody vegetation biomass (if selected in Table 1)

The mean carbon stock in above-ground and below-ground biomass per unit area is estimated on the basis of field measurements in permanent sample plots.

Step 1: Determine on the basis of available data (*ex ante*) and measurements (*ex post*), the characteristic numerical data on planted non-tree woody vegetation, e.g., diameter at grid, breast or other height as appropriate (*Dh*), height (*H*), crown cover (*CC*), number of stems (*NS*) or any other numerical data known to be related to above-ground volume or biomass of planted non-tree woody vegetation in the permanent sample plots. The set of characteristic numerical data used by PPs is dependent on the species and the method and need not to follow the above list. The PPs shall however, provide in the PDD a description of the relationship (equation, yield tables, etc.) between measurements taken in the sample plots and the above-ground volume/biomass of planted non-tree woody vegetation, including relevant references.

Step 2: Estimate the above-ground volume/biomass of planted non-tree woody vegetation on the basis of the above-mentioned equations or yield tables. It is possible to combine Steps 1 and 2 if a method that directly estimates the volume/biomass of planted non-tree woody vegetation is applied. Foreign data may be used if appropriate.

Step 3a: If the above-ground volume of planted non-tree woody vegetation was estimated in Step 2 above, convert the volume into carbon stock in above-ground biomass via basic wood density and the carbon fraction:

$$C_{AB\_non-tree,l,j,i,sp,t} = f_{Vj}(Dh,H,...)_{non-tree,l,i,sp,t} * D_j * CF \qquad (23)$$

Step 3b: If the above-ground biomass of planted non-tree woody vegetation was estimated in Step 2 above, convert the volume into carbon stock in above-ground biomass via the carbon fraction:

$$C_{AB\_non-tree,l,j,i,sp,t} = f_j(Dh,H,...)_{non-tree,l,i,sp,t} * CF \qquad (24)$$

where (for Eq. (23) and Eq. (24)):

$C_{AB\_non-tree,l,j,i,sp,t}$	Carbon stock in above-ground biomass of planted non-tree woody vegetation *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t C non-tree^{-1}
$f_{Vj}(Dh,H,...)_{non-tree,l,i,sp,t}$	Volume of planted non-tree woody individual *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; m^3
$f_j(Dh,H,...)_{non-tree,l,i,sp,t}$	Biomass of planted non-tree woody individual *l*, of species *j*, in plot *sp*, in stratum *i*, at year *t*; t d.m.
D_j	Basic wood density of planted non-tree woody vegetation of species *j*; t d.m. m^{-3}
CF	Carbon fraction of biomass for planted non-tree woody vegetation; t C t^{-1} d.m. (IPCC default value = 0.49 t C t^{-1} d.m.)
l	Sequence number of planted non-tree woody vegetation individuals on plot *sp*
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 4: Convert the carbon stock in above-ground biomass to the carbon stock in below-ground biomass via root-shoot ratio, given by:

$$C_{BB\_non-tree,l,j,i,sp,t} = C_{AB\_non-tree,l,j,i,sp,t} * R_j \qquad (25)$$

where:

$C_{BB\_non-tree,l,j,i,sp,t}$	Carbon stock in below-ground biomass of planted non-tree woody vegetation l, of species j, in plot sp, in stratum i, at year t; t C
$C_{AB\_non-tree,l,j,i,sp,t}$	Carbon stock in above-ground biomass of planted non-tree woody vegetation l, of species j, in plot sp, in stratum i, at year t; t C
R_j	Root-shoot ratio appropriate for biomass stock of planted non-tree woody vegetation, for species j; dimensionless

Step 5: Calculate carbon stock in above-ground and below-ground biomass of all trees present in plot sp in stratum i at year t (i.e., summation over all trees l by species j followed by summation over all species j present in plot sp).

$$C_{non-tree,i,sp,t} = \sum_{j=1}^{S_{PS}} \sum_{l=1}^{N_{j,i,sp,t}} (C_{AB\_non-tree,l,j,i,sp,t} + C_{BB\_non-tree,l,j,i,sp,t}) \qquad (26)$$

where:

$C_{non-tree,i,sp,t}$	Carbon stock in planted non-tree woody vegetation on plot sp, of stratum i, at year t; t C
$C_{AB\_non-tree,l,j,i,sp,t}$	Carbon stock in above-ground biomass of planted non-tree woody vegetation l, of species j, in plot sp, in stratum i, at year t; t C
$C_{BB\_non-tree,l,j,i,sp,t}$	Carbon stock in below-ground biomass of planted non-tree woody vegetation l, of species j, in plot sp, in stratum i, at year t; t C
$N_{j,i,sp,t}$	Number of planted non-tree woody vegetation of species j, on plot sp, of stratum i, at year t
l	Sequence number of planted non-tree woody vegetation individuals on plot sp
i	1, 2, 3, ... M_{PS} strata in the project scenario
j	1, 2, 3, ... S_{PS} planted non-tree woody vegetation 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 tree biomass for each stratum:

$$C_{non-tree,i,t} = \frac{A_i}{A_{sp_i}} \sum_{sp=1}^{P_i} C_{non-tree,i,sp,t} \qquad (27)$$

where:

$C_{non-tree,i,t}$	Carbon stock in planted non-tree woody vegetation in stratum *i*, at year *t*; t C
$C_{non-tree,i,sp,t}$	Carbon stock in planted non-tree woody vegetation on plot *sp*, of stratum *i*, at year *t*; t C
A_{sp_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

Step 7: Calculate:

$$\Delta C_{non-tree,i,t} = \frac{C_{non-tree,i,t_2} - C_{non-tree,i,t_1}}{T} \tag{28}$$

where:

$\Delta C_{non-tree,i,t}$	Annual carbon stock change in above-ground and below-ground biomass of planted non-tree woody vegetation for stratum *i*, year *t* (average over a monitoring period); t C yr^{-1}
$C_{non-tree,i,t}$	Carbon stock in planted non-tree woody vegetation in stratum *i*, at year *t*; t C
T	Number of years between monitoring time t_2 and t_1 ($T = t_2 - t_1$); yr
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

5.1.3 Dead wood (if selected in Table 1)

For *ex ante* estimates, the changes in carbon stocks of dead wood shall be conservatively neglected.

Dead wood included in the methodology comprises two components only—*standing dead wood* and *lying dead wood* (that is, below-ground dead wood is conservatively neglected). Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components.

For the *ex post* situation, the change is estimated as follows:

$$\Delta C_{DW,i,t} = \frac{C_{DW,i,t_2} - C_{DW,i,t_1}}{T} \tag{29}$$

where:

$\Delta C_{DW,i,t}$	Annual carbon stock change in the dead wood in stratum *i*, (averaged over a monitoring period); t C yr^{-1}
$C_{DW,i,t}$	Carbon stock of dead wood in stratum *i*, at year *t*; t C

T	Number of years between monitoring time t_2 and t_1 ($T = t_2 - t_1$); yr
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

The methods to be followed in the measurement of the standing dead wood and the lying dead wood biomass are outlined below.

$$C_{DW,i,t} = (B_{SDW,i,t} + B_{LDW,i,t}) * CF_{DW} \tag{30}$$

where:

$C_{DW,i,t}$	Carbon stock of dead wood biomass in stratum i, at year t; t C
$B_{SDW,i,t}$	Biomass of standing dead wood in stratum i, at year t; t d.m.
$B_{LDW,i,t}$	Biomass of lying dead wood in stratum i, at year t; t d.m.
CF_{DW}	Carbon fraction of dry matter in dead wood; t C t^{-1} d.m.
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

5.1.3.1 Standing dead wood $B_{SDW,i,t}$

Step 1: Standing dead trees shall be measured on permanent sample plots (established for estimating tree biomass - see paragraph 5.1.1 above) using the same criteria and monitoring frequency used for measuring live trees. The decomposed portion that corresponds to the original above-ground and below-ground biomass is discounted.

Step 2: The decomposition class of the dead tree and the diameter at breast height shall be recorded and the standing dead wood is categorized under the following four decomposition classes:

- (1)   Tree with branches and twigs that resembles a live tree (except for leaves);
- (2)   Tree with no twigs, but with persistent small and large branches;
- (3)   Tree with large branches only;
- (4)   Bole only, no branches.

Step 3a: For tree in the decomposition class 1 biomass should be estimated using the allometric equation for live trees.

Step 3b: When the bole is in decomposition classes 2, 3 or 4, it is recommended to limit the estimate of the biomass to the main trunk of the tree. Usually, there is no allometric equations applicable for such boles and their biomass is estimated based on volume assessment. The volume of dead wood is converted to biomass using the dead wood density appropriate for the decomposition class.

5.1.3.2 Lying dead wood $B_{LDW,i,t}$

The lying dead wood pool is highly variable, and stocks increase as the stands grow hence; its monitoring may be taken up in the first, second or subsequent monitoring periods. The volume of lying dead wood can be assessed from the following survey:

Step 1: Lying dead wood should be sampled using the line intersect method (Harmon and Sexton, 1996).[5] Two 50-m lines bisecting each plot are established and the diameters of the lying dead wood (≥5 cm diameter) intersecting the lines are measured.

Step 2: The dead wood is assigned to one of the three density states *ds* (1 (sound), 2 (intermediate), and 3 (rotten)) using the 'machete test', as recommended by *IPCC Good Practice Guidance for LULUCF* (2003), Section 4.3.3.5.3.

Step 3: The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen, 1964)[6] as modified by van Wagner (1968)[7] separately for each density state:

$$V_{LDW,i,t} = \frac{\pi^2 * (\sum_{n=1}^{N} D_{n,i,t}{}^2)}{8 * L}$$
(31)

where:

$V_{LDW,i,t}$ Volume of lying dead wood per unit area in stratum *i*, at year *t*; m³ ha⁻¹

$D_{n,i,t}$ Diameter of piece *n* of dead wood along the transect in stratum *i*, at year *t*; cm

N Total number of wood pieces intersecting the transect; dimensionless

L Length of the transect; m

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

Step 4: Volume of lying dead wood shall be converted into biomass using the following relationship.

$$B_{LDW,i,t} = A_i * \sum_{ds=1}^{3} V_{LDW,i,t} * D_{DW,ds}$$
(32)

where:

$B_{LDW,i,t}$ Biomass of lying dead wood in stratum *i*, at year *t*; t d.m.

$V_{LDW,i,t}$ Volume of lying dead wood in stratum *i*, at year *t*; m³ ha⁻¹

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[5] Harmon, M. E. and J. Sexton. (1996) Guidelines for Measurements of Woody Detritus in Forest Ecosystems. US LTER Publication No. 20. US LTER Network Office, University of Washington, Seattle, WA, USA.

[6] Warren, W.G. and Olsen, P.F. (1964) A line transect technique for assessing logging waste, *Forest Science* 10: 267-276.

[7] Van Wagner, C. E. (1968): The line intersect method in forest fuel sampling. *Forest Science* 14: 20-26.

$D_{DW,ds}$	Basic wood density of dead wood in the density class *ds*; t d.m. m^{-3} Note: To estimate density of each class, follow the procedure described in IPCC Good Practice Guidance for LULUCF (2003), Section 4.3.3.5.3.
A_i	Area of stratum *i*; ha
ds	Index for density state: 1 (sound), 2 (intermediate) or 3 (rotten)
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

5.1.4 Litter (if selected in Table 1)

For *ex ante* estimates, the changes in carbon stocks of litter shall be conservatively neglected.

For *ex post* estimates, four litter samples shall be collected per sample plot and well mixed into one composite sample. Samples shall be taken at the same time of the year in order to account for natural and anthropogenic influences on the litter accumulation and to eliminate seasonal effects.

A sub-sample from the composite sample of litter is taken, oven dried and weighed to determine the dry weight. The dry to wet weight ratio of the sub-sample is calculated and used for estimations of the litter dry weight.

To estimate the dry litter biomass in tonnes per hectar, the wet litter biomass for the composite sample plots is multiplied by the dry to wet weight ratio and an expansion factor for the plot size to calculate the litter biomass in tonnes per hectar (10,000 m^2/(4 * area of sampling frame in m^2)).

$$B_{LI,i,sp} = 2.5 * B_{LI\_wet,i,sp} * \frac{MP_{LI}}{a_{i,sp}}$$ **(33)**

where:

$B_{LI,i,sp}$	Biomass of dry litter for plot *sp*, in stratum *i*, at monitor year *t*; t d.m. ha^{-1}
$B_{LI\_wet,i,sp}$	Wet weight (field) of the litter in plot *sp*, of stratum *i*; kg
MP_{LI}	Dry-to-wet weight ratio of the litter (dry weight/wet weight); dimensionless
$a_{i,sp}$	Area of sampling frame for plot *sp*, in stratum *i*; m^2
i	1, 2, 3, ... M_{PS} strata in the project scenario
sp	Index for sample plots

Calculate the biomass of the litter ($B_{LI,i,t}$ in t d.m.) for each stratum applying approach used in Eq. (18) - i.e., Step 7 of the *BEF* method and using litter specific data.

The average annual change in the carbon stock of litter from the data at two monitoring intervals shall be calculated. As recommended in the Good Practice Guidance on LULUCF (Chapter 3.2, p 3.35), the dry mass of litter is converted into carbon using 0.370 t C t^{-1} d.m. as a default value for the carbon fraction.[8]

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[8] Smith and Heath, 2002.

$$\Delta C_{LI,i,t} = \frac{B_{LI,i,t_2} - B_{LI,i,t_1}}{T} * CF_{LI} \tag{34}$$

where:

$\Delta C_{LI,i,t}$	Annual change in the litter carbon pool in stratum i (averaged over a monitoring period); t C yr^{-1}
$B_{LI,i,t}$	Biomass of litter in stratum i at year t; t d.m.
T	Number of years between monitoring time t_2 and t_1 ($T = t_2 - t_1$); yr
CF_{LI}	Carbon fraction of litter (default value 0.370 t C t^{-1} d.m.); t C t^{-1} d.m.
i	$1, 2, 3, \dots M_{PS}$ strata in the project scenario
t	$1, 2, 3, \dots t^*$ years elapsed since the start of the A/R CDM project activity

5.1.5 Soil Organic Carbon (if selected in Table 1)

For *ex ante* estimations, the changes in stocks of soil organic carbon may be assessed using the default method or the changes shall be conservatively neglected.

For *ex post* estimations, the changes in stocks of soil organic carbon may be assessed using the default method as described below.

5.1.5.1 Default method

A/R CDM project activities may account for changes in soil organic carbon pool using a default approach in areas of land included in their boundary which satisfy all conditions listed below:

   (i)   The area does not include organic soils (e.g., peat-lands), or wetlands;[9]

   (ii)   Removal of existing vegetation during site preparation for the A/R CDM project activity shall not occur on more than 10% of the area, unless it can be demonstrated that land clearance, e.g., by slash-and-burn activities, is a common practice in the region in which the project is located;

   (iii) Litter shall remain on site and not be removed;

   (iv)   Ploughing/ripping/scarification associated with site preparation for planting, seeding and/or the human-induced promotion of natural seed sources, shall not exceed 10% of the project area (during each occasion);

   (v)   If ploughing/ripping/scarification is used for site preparation, it shall follow the land contour.

If a part of an area of land included in the project boundary satisfies all conditions (i) - (v) listed above, the part shall be included in accounting of the default changes in the soil organic carbon pool.

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[9] "Wetlands", "settlements", "croplands" and "grasslands" are land uses as defined in the *Good Practice Guidance for Land Use, Land-use Change and Forestry* (IPCC, 2003). Any woody perennial vegetation on settlements, croplands or grasslands must be below the thresholds for forestland.

The default *ex ante* and *ex post* changes in the soil organic carbon pool $\Delta C_{d,SOC_t}$ shall be estimated using the following equation:

$$\Delta C_{d,SOC_t} = A_i \cdot \Delta C \text{ for } 0 < t \le t_{equilibrium}$$
$$\Delta C_{d,SOC_t} = 0 \text{ for } t > t_{equilibrium}$$
(35)

where:

$\Delta C_{d,SOC_t}$	Annual change in carbon stock in soil organic matter for area of land i, for year t; t C yr^{-1}
A_i	Area of land i that satisfies all conditions (i)-(v) listed above; hectar (ha)
ΔC	Default annual increase in carbon stock in soil organic carbon; t C ha^{-1} yr^{-1}
$t_{equilibrium}$	Time until a new equilibrium in carbon stock in soil organic matter is reached in area of land i; years

The default values of ΔC =0.5 t C ha^{-1} yr^{-1} and $t_{equilibrium}$ =20 years shall be used. Changes in carbon stock in soil organic matter shall not be monitored *ex post*.

5.2 Estimation of GHG emissions within the project boundary

The possible increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary is limited to burning of shrubs and trees of height lower than the threshold for height reported to EB according to paragraph 8 of annex to Decision 5/CMP.1. If it occurs, it shall be estimated as:

$$GHG_E = \sum_{t=1}^{t^*} E_{BiomassBurn,t}$$
(36)

where:

GHG_E	Increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary; t CO$_2$-e
$E_{BiomassBurn,t}$	Non-CO$_2$ emissions due to biomass burning of existing shrub vegetation as part of site preparation during the year t; t CO$_2$-e
t	1, 2, 3, ... t^* years elapsed since the start of the A/R CDM project activity

Note: In this methodology Eq. (33) is used to estimate the increase in GHG emissions for the period of time elapsed between project start (t =1) and the year $t = t^*$, t^* being the year for which actual net greenhouse gas removals by sinks are estimated.

The monitoring of emissions by sources is only required if significant; if insignificant, evidence should be provided (e.g., as a relevant part of the monitoring of the project implementation) that the assumptions for the exclusion made in the *ex ante* assessment still hold in the *ex post* situation.

5.2.1 Estimation of increase in non-CO$_2$ emissions due to the project activities

For the purpose of estimation of increase in non-CO$_2$ emissions, shrubs and trees of height lower than the threshold for height reported to EB according to paragraph 8 of annex to Decision 5/CMP.1 are treated as shrubs. The increase in non-CO$_2$ emissions usually results from prescribed burning and it shall be calculated for each burnt area using the following approach:

$$E_{BiomassBurn,t} = A_S * B_{AB,shrub}(1 - f_{BL,Shrub}) * CF_{shrub} * \frac{16}{12} * ER_{CH4} * GWP_{CH4} \qquad (37)$$

where:

$E_{BiomassBurn,t}$	Increase in non-CO$_2$ greenhouse gas emissions due to biomass burning during site preparation; t CO$_2$-e
A_S	Burnt area; ha
$B_{AB,shrub}$	Average above-ground biomass stock of shrub vegetation subject to burning; t d.m. ha^{-1}
$f_{BL,shrub}$	Average fraction of existing above-ground tree or shrub biomass (as indicated by subscripts in equations) left to decay after biomass burning; dimensionless. Default value derived from IPCC literature for shrub vegetation is: 0.05
CF_{shrub}	Average carbon fraction of biomass for trees or shrub vegetation (as indicated by subscripts in equations); t C (t d.m.)$^{-1}$. IPCC default value for shrub vegetation is 0.49
$\frac{16}{12}$	Conversion factor: ratio of molecular weights of CH$_4$ and C; mol mol^{-1}
ER_{CH4}	Emission ratio for CH$_4$ (IPCC default: 0.012),[10] kg C as CH$_4$ (kg C burned)$^{-1}$
GWP_{CH4}	Global warming potential for CH$_4$ (IPCC default: 21 for the first commitment period of the Kyoto Protocol); t CO$_2$-e (t CH$_4$)$^{-1}$

6. Leakage

Under applicability conditions for this methodology, the land used for the project can under the proposed A/R CDM project activity continue to provide at least the same amount of goods and services. Consequently, as a result of the A/R CDM project activity, agricultural or pastoral activities will not be displaced from the project sites to other locations.

Leakage shall be estimated as follows:

$$LK = 0 \qquad (38)$$

where:

LK	Total GHG emissions due to leakage; t CO$_2$-e

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[10] Table 3A.1.15, Annex 3A.1, *GPG-LULUCF* (IPCC 2003).

7. Net Anthropogenic GHG Removals by Sinks

The net anthropogenic GHG removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage, therefore, the following general formula can be used to calculate the net anthropogenic GHG removals by sinks of an A/R CDM project activity (C_{AR-CDM}), in t CO_2-e.

$$C_{AR-CDM} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK \tag{39}$$

where:

C_{AR-CDM}	Net anthropogenic greenhouse gas removals by sinks; t CO_2-e
ΔC_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e
ΔC_{BSL}	Baseline net greenhouse gas removals by sinks; t CO_2-e
LK	Total GHG emissions due to leakage; t CO_2-e

7.1 Calculation of tCERs and lCERs

To estimate the CERs that can be issued at year $t^* = t_2$ (the date of verification) for the monitoring period $T = t_2 - t_1$, this methodology uses the most recent version of the EB approved equations,[11] which produces the same estimates as the following:

$$tCERs = C_{AR-CDM,t_2} \tag{40}$$

$$lCERs = C_{AR-CDM,t_2} - C_{AR-CDM,t_1} \tag{41}$$

where:

$tCERs$	Number of units of temporary Certified Emission Reductions
$lCERs$	Number of units of long-term Certified Emission Reductions
C_{AR-CDM,t_2}	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_2$; t CO_2-e
C_{AR-CDM,t_1}	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_1$; t CO_2-e

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

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

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, PPs 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.

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[11] See <http://cdm.unfccc.int/Reference/Guidclarif/>.

Data / parameter:	$A_{BSL,i}$
Data unit:	ha
Used in equations:	(4), (9), (11)
Description:	Area of baseline stratum i
Source of data:	GPS coordinates and/or remote sensing data
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	$BEF_{1,j}$
Data unit:	Dimensionless
Used in equations:	(6)
Description:	Biomass expansion factor for conversion of annual net increment (including bark) in stem biomass to total above-ground tree biomass increment for species j
Source of data:	The source of data shall be either of the following: (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; (d) Globally species-specific or group of species-specific (e.g., IPCC literature: Table 3A.1.10[12] of the *GPG-LULUCF* (IPCC 2003), and Table 4.5[13] of the *AFOLU Guidelines* (IPCC 2006).)
Measurement procedures (if any):	
Any comment:	*BEFs* in IPCC literature and national inventory data are usually applicable to closed canopy forest. If applied to individual trees growing in open field it is recommended that the selected *BEF* be increased by a further 30%.

Data / parameter:	$BEF_{2,j}$
Data unit:	Dimensionless
Used in equations:	(9), (15)
Description:	Biomass expansion factor for conversion of stem biomass to above-ground tree biomass for tree species j

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[12] Use the parameter BEF_2 in Table 3A.1.10 in the GPG-LULUCF.

[13] Values of the *BEF* must be derived from the parameter $BCEF_S$ in Table 4.5 (AFOLU guidelines, IPCC 2006) according to the equation $BEF = BCEF_S/D_V$, using wood density.

Source of data:	The source of data shall be either of the following: (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; (d) Globally species-specific or group of species-specific (e.g., IPCC GPG-LULUCF 2003).
Measurement procedures (if any):	
Any comment:	*BEFs* in IPCC literature and national inventory are usually applicable to closed canopy forest. If applied to individual trees growing in open field it is recommended that the selected *BEF* be increased by a further 30%.

Data / parameter:	*CF*
Data unit:	t C t^{-1} d.m.
Used in equations:	(23), (24)
Description:	Carbon fraction of biomass for planted non-tree woody vegetation
Source of data:	Default value 0.49 t C t^{-1} d.m. shall be used
Measurement procedures (if any):	
Any comment:	

Data / parameter:	CF_{DW}
Data unit:	t C t^{-1} d.m.
Used in equations:	(30)
Description:	Carbon fraction of dry matter in dead wood
Source of data:	Default value 0.5 t C t^{-1} d.m. shall be used
Measurement procedures (if any):	
Any comment:	

Data / parameter:	CF_j
Data unit:	t C t^{-1} d.m.
Used in equations:	(4), (9), (11), (15), (19)
Description:	Carbon fraction of dry matter for species of type *j*
Source of data:	The source of data shall be either of the following: (a) National and species-specific or group of species-specific (e.g., from national GHG inventory); (b) Species-specific or group of species-specific from neighbouring countries with similar conditions; (c) Globally species-specific or group of species-specific (e.g., IPCC GPG-LULUCF 2003); (d) The default IPCC value 0.5 t C t^{-1} d.m.
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	CF_{LI}
Data unit:	t C t^{-1} d.m.
Used in equations:	(34)
Description:	Carbon fraction of litter
Source of data:	Default value 0.37 t C t^{-1} d.m. shall be used
Measurement procedures (if any):	
Any comment:	

Data / parameter:	D_j
Data unit:	t d.m. m^{-3}
Used in equations:	(6), (9), (15), (23)
Description:	Basic wood density for species j
Source of data:	The source of data shall be either of the following: (a) National and species-specific or group of species-specific (e.g., from national GHG inventory); (b) Species-specific or group of species-specific from neighbouring countries with similar conditions; (c) Globally species-specific or group of species-specific (e.g., IPCC GPG-LULUCF 2003).
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	$D_{DW,ds}$
Data unit:	t d.m. m^{-3}
Used in equations:	(32)
Description:	Basic wood density of dead wood in the density state: 1 (sound), 2 (intermediate) or 3 (rotten)
Source of data:	The source of data shall be either of the following: (a) National and species-specific or group of species-specific (e.g., from national GHG inventory); (b) Species-specific or group of species-specific from neighbouring countries with similar conditions; (c) Globally species-specific or group of species-specific (e.g., IPCC GPG-LULUCF 2003).
Measurement procedures (if any):	Project specific determination of the density is allowed
Any comment:	

Data / parameter:	$f_j(DBH, H)$
Data unit:	t d.m. tree^{-1}
Used in equations:	(11), (19)
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. Otherwise, default equations from IPCC literature, national inventory reports or published peer-reviewed studies may be used—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. Otherwise, it is necessary either to use conservatively assessed values, or to verify the applicability of the equation if mean predicted values are to be used.
	Allometric equations can be verified by:
	• Selecting at least 5 trees covering the range of *DBH* existing in the project area, and felling and weighing the above-ground biomass to determine the total (wet) weight of the stem and branch components;
	• Extracting and immediately weighing[14] sub-samples from each of the wet stem and branch components,[15] followed by oven drying at 70ºC to determine dry biomass;
	• Determining the total dry weight of each tree from the wet weights and the averaged ratios of wet and dry weights of the stem and branch components.
	If the biomass of the harvested trees is within about ±10% of the mean values predicted by the selected default allometric equation, and is not biased—or if biased is wrong on the conservative side (i.e., use of the equation results in an underestimate rather than overestimate of project net anthropogenic removals by sinks)—then mean values from the default equation may be used.

Data / parameter:	$f_j(Dh,H,...)_{non-tree,l,i,sp,t}$, $f_{Vj}(Dh,H,...)_{non-tree,l,i,sp,t}$
Data unit:	t d.m. non-tree^{-1}, m^3 non-tree^{-1}
Used in equations:	(23), (24)
Description:	Allometric equation for species *j* linking diameter at at grid, breast or other height as appropriate (*Dh*), height (*H*), crown cover (*CC*), number of stems (*NS*) or other numerical data to above-ground biomass or volume of planted non-tree woody vegetation individual *l* of species *j* in plot *sp* in stratum *i* at year *t*.
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. Otherwise, default equations from IPCC literature, national inventory reports or published peer-reviewed studies may be used.

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[14] Or, alternatively, seal the sub-samples immediately in plastic bags of known weight and determine wet weights in the laboratory.

[15] Use at least 3 sub-samples for branch material and at least 5 sub-samples for stem wood. If cutting slices of stem or branch wood using a chainsaw, ensure cutting does not cause excessive heating and evaporation of water from the wood before the sub-sample is weighed.

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), then the equation may be used and considered conservative. Otherwise, it is necessary either to use conservatively assessed values, or to verify the applicability of the equation if mean predicted values are to be used.
	Allometric equations can be verified by:
	• Selecting at least 5 individuals covering the range of size existing in the project area, and felling and weighing the above-ground biomass to determine the total (wet) weight of the stem and branch components;
	• Extracting and immediately weighing[16] sub-samples followed by oven drying at 70ºC to determine dry biomass;
	• Determining the total dry weight of each tree from the wet weights and the averaged ratios of wet and dry weights of the stem and branch components.
	If the biomass of the harvested individuals is within about ±20% of the values predicted by the selected default allometric equation, and is not biased—or if biased is wrong on the conservative side (i.e., use of the equation results in an underestimate rather than overestimate of project net anthropogenic removals by sinks)—then values from the default equation may be used.

Data / parameter:	$I_{V,j,i,t}$
Data unit:	$m^3\ ha^{-1}\ yr^{-1}$
Used in equations:	(6)
Description:	Average annual increment in stem volume of species j in stratum i, for year t
Source of data:	Shall be based on national/local growth curve/table that usually used in national / local forest inventory
Measurement procedures (if any):	N/A
Any comment:	To be determined if the carbon gain-loss method is used in the estimation of carbon stock changes in above-ground and below-ground biomass in the baseline
	<u>Note:</u> $I_{V,j,i,t}$ is estimated as the "current annual increment – CAI". The "mean annual increment" – MAI in the forestry jargon – can only be used if its use leads to conservative estimates.
	<u>Note:</u> The values read from tables if expressed on the per unit of area basis will usually apply to forest. Thus, they should be corrected to be applicable in the baseline conditions, e.g., by multiplication by the fraction of tree crown cover or fraction of number of stems in the baseline stratum of interest (other ways of correction may be proposed by project proponents).

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[16] Or, alternatively, seal the sub-samples immediately in plastic bags of known weight and determine wet weights in the laboratory.

Data / parameter:	$nTR_{j,i,t}$
Data unit:	trees ha^{-1}
Used in equations:	(11)
Description:	Pre-project tree stand density of species j in stratum i, at year t
Source of data:	Field measurements (pre-project)
Measurement procedures (if any):	Tree counts on sample plots. These tree counts are used to estimate number of trees per hectar.
Any comment:	

Data / parameter:	R_j
Data unit:	kg d.m.yr^{-1} (kg d.m.yr^{-1})$^{-1}$
Used in equations:	(10), (16), (20), (25)
Description:	Root-shoot ratio appropriate for biomass stock, for species j
Source of data:	The source of data shall be either of the following: (a)　National and species-specific or group of species-specific (e.g., from national GHG inventory); (b)　Species-specific or group of species-specific from neighbouring countries with similar conditions. Sometimes b) might be preferable to a); (c)　Species-specific or group of species-specific from global studies.
Measurement procedures (if any):	N/A
Any comment:	For the purpose of estimating baseline removals by sinks, a conservative value is about one standard deviation (circa 0.04) above the mean (0.26); i.e., a value of 0.3 kg d.m. kg^{-1} d.m. For the purpose of estimating the project removals by sinks, use a value about one standard deviation below the mean; i.e., 0.22 kg d.m. kg^{-1} d.m.

Data / parameter:	R_{1j}
Data unit:	kg d.m.yr^{-1} (kg d.m.yr^{-1})$^{-1}$
Used in equations:	(5)
Description:	Root-shoot ratio appropriate for biomass increment for species j
Source of data:	The source of data shall be either of the following: (a) National and species-specific or group of species-specific (e.g., from national GHG inventory); (b) Species-specific or group of species-specific from neighbouring countries with similar conditions. Sometimes b) might be preferable to a); (c) Species-specific or group of species-specific from global studies.

Measurement procedures (if any):	N/A
Any comment:	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 from 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:	$V_{tree,j,i,t}$
Data unit:	m^3 ha^{-1}
Used in equations:	(9)
Description:	Pre-project tree stem volume of stratum *i,* species *j*, at year *t*
Source of data:	Shall be estimated on the basis of number of trees and national/local growth curve / table that is usually covered by national/local forest inventory
Measurement procedures (if any):	
Any comment:	To be determined if the stock change method is used in the estimation of carbon stock changes in above-ground and below-ground biomass in the baseline. Note: The values read from tables if expressed on the per unit of area basis will usually apply to forest. Thus, they should be corrected to be applicable in the baseline conditions, e.g., by multiplication by the fraction of tree crown cover or fraction of number of stems in the baseline stratum of interest (other ways of correction may be proposed by PPs).

Data / parameter:	ΔC
Data unit:	t C ha^{-1} yr^{-1}
Used in equations:	(35)
Description:	Default annual increase in carbon stock in soil organic carbon
Source of data:	The default value of ΔC =0.5 t C ha^{-1} yr^{-1} shall be used.
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	$t_{equilibrium}$
Data unit:	years
Used in equations:	(35)
Description:	Time until a new equilibrium in carbon stock in soil organic matter is reached
Source of data:	The default value of $t_{equilibrium}$ =20 years shall be used
Measurement procedures (if any):	N/A
Any comment:	

III. MONITORING METHODOLOGY

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. One hundred percent of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted according to relevant standards. In addition, the monitoring provisions in the tools referred to in this methodology apply.

1. Monitoring of Project Implementation

Information shall be provided, and recorded in the project design document (PDD), to establish that:

> (a) The geographic position of the project boundary is recorded for all areas of land;

> > (i) The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This can be achieved by field survey (e.g., using GPS), or by using georeferenced spatial data (e.g., maps, GIS datasets, orthorectified aerial photography or georeferenced remote sensing images).

> (b) Commonly accepted principles of forest inventory and management are implemented:

> > (i) Standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of SOPs already applied in national forest monitoring, or available from published handbooks, or from the *IPCC GPG LULUCF 2003*, is recommended;

> > (ii) Apply SOPs, especially, for actions likely to minimize soil erosion in those circumstances in which site preparation or planting involves soil disturbance capable to increase soil erosion above the baseline value;

> > (iii) The forest planting and management plan, together with a record of the plan as actually implemented during the project shall be available for validation or verification, as appropriate.

2. Sampling design and stratification

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. PPs 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*).

2.1 Updating of strata

The *ex post* stratification shall be updated because of the following reasons:

- 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;

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

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

2.2 Sampling framework

To determine the sample size and allocation among strata, this methodology uses the latest version of the tool for the "Calculation of the number of sample plots for measurements within A/R CDM project activities", approved by the CDM Executive Board. The targeted precision level for biomass estimation within each stratum is ±10% of the mean at a 95% confidence level.

3. Data and parameters monitored

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, PPs 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 PPs 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:	(18), (27), (32), (35)
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:	
QA/QC procedures:	
Any comment:	

Data / parameter:	$a_{i,sp}$
Data unit:	m^2
Used in equations:	(33)
Description:	Area of sampling frame for plot sp in stratum i
Source of data:	Simple measurement or manufacturers data
Measurement procedures (if any):	Once selected, the selected size of the sampling frame shall be fixed until the end of the last crediting period.

Monitoring frequency:	
QA/QC procedures:	
Any comment:	Sampling frame will be used to collect litter samples

Data / parameter:	A_{sp_i}
Data unit:	ha
Used in equations:	(18), (27)
Description:	Total area of all sample plots in stratum i
Source of data:	Field measurement
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	$B_{LI\_wet,i,sp}$
Data unit:	kg
Used in equations:	(33)
Description:	Humid weight (field) of the litter in plot sp of stratum i
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	**Step 1:** Litter shall be sampled using a sampling frame. The frame is placed at four locations within the sample plot. **Step 2:** At each location, all litter (leaves, fruits, small wood, etc.) falling inside the frame shall be collected and the litter from four locations is mixed to get a representative sample for measuring the wet weight of the biomass.
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	$D_{n,i,t}$
Data unit:	cm
Used in equations:	(31)
Description:	Diameter of piece n of dead wood along the transect in stratum i, at year t
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	Lying dead wood should be sampled using the line intersect method (Harmon and Sexton, 1996).[17] Two 50-m lines bisecting each plot are established, and the diameters of the lying dead wood ($\geq$5 cm diameter) intersecting the lines are measured.

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[17] Harmon, M. E. and J. Sexton. (1996) Guidelines for Measurements of Woody Detritus in Forest Ecosystems. US LTER Publication No. 20. US LTER Network Office, University of Washington, Seattle, WA, USA.

Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	*DBH*
Data unit:	cm
Used in equations	Implicitly used in Eqs. (11), (19)
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 in the permanent sample plots all the trees above some minimum *DBH* 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:	
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 year *t* using a growth model or yield table that gives the expected tree dimensions as a function of tree age.

Data / parameter:	*H*
Data unit:	m
Used in equations:	Implicitly used in Eqs. (11), (19)
Description:	Height of tree
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	
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 year *t* using a growth model or yield table that gives the expected tree dimensions as a function of tree age

Data / parameter:	*L*
Data unit:	m
Used in equations:	(31)
Description:	Length of the transect to determine volume of lying dead wood
Source of data:	Field measurements
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	MP_{LI}
Data unit:	Dimensionless
Used in equations:	(33)
Description:	Dry-to-wet weight ratio of the litter (dry weight/wet weight)
Source of data:	Laboratory measurement of field samples
Measurement procedures (if any):	Litter samples shall be collected and well mixed into one composite sample at the same time of year in order to account for natural and anthropogenic influences on the litter accumulation and to eliminate seasonal effects. A subsample from the composite sample of litter is taken, oven dried and weighed to determine the dry weight.
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	N
Data unit:	Dimensionless
Used in equations:	(31)
Description:	Total number of wood pieces intersecting the transect
Source of data:	Field measurements
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

4.   Conservative Approach and Uncertainties

To help reduce uncertainties in the accounting of emissions and removals**,** this methodology uses whenever possible the proven methods from the GPG-LULUCF, GPG-2000, and the IPCC's Revised 2006 Guidelines. As well, tools and guidance from the CDM Executive Board on conservative estimation of emissions and removals are also used. Despite this, potential uncertainties still arise from the choice of parameters to be used. Uncertainties arising from, for example, biomass expansion factors (*BEFs*) or wood density, would result in uncertainties in the estimation of both baseline net GHG removals by sinks and the actual net GHG removals by sinks - especially when global default values are used.

It is recommended that PPs identify key parameters that would significantly influence the accuracy of estimates. Local values that are specific to the project circumstances should then be obtained for these key parameters, whenever possible. These values should be based on:

- Data from well-referenced peer-reviewed literature or other well-established published sources;[18] or

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[18] Typically, citations for sources of data used should include: the report or paper title, publisher, page numbers, publication date etc. (or a detailed web address). If web-based reports are cited, hardcopies should be included as Annexes in the CDM-AR-PDD if there is any likelihood such reports may not be permanently available.

- National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; or

- In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value should be briefly noted in the CDM-AR-PDD. For any data provided by experts, the CDM-AR-PDD shall also record the experts name, affiliation, and principal qualification as an expert (e.g., that they are a member of a country's national forest inventory technical advisory group) as well as of a 1-page summary CV for each expert consulted, included in an annex.

In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of default data, PPs should select values that will lead to an accurate estimation of net GHG removals by sinks, taking into account uncertainties. If uncertainty is significant, PPs should choose data such that it tends to under-estimate, rather than over-estimate, net GHG removals by sinks.

5.   References

All references are quoted in footnotes.

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History of the document

Version	Date	Nature of revision
05	EB 47, Annex 12 28 May 2009	Extended revision to apply the guidance provided in para 37 of the EB 44 report, including: • Change in applicability conditions to avoid data intensive option for land use change in baseline and large leakage; • Introduction of a default approach to assess changes in SOC; • Reformatting according to the design applied in AR-ACM0001 (including unification of variables, equations and approaches).
04	EB 42, Para 35 26 September 2008	Revisions mainly in the following sections: • Section II. Baseline methodology 6.2 GHG emissions by sources 7 Leakage • Section III. Monitoring Methodology 5.2 GHG emissions by sources 7 Leakage • To apply the guidance provided in para 35, EB 42 meeting report regarding accounting of GHG emissions in A/R CDM project activities, from the following sources (i) fertilizer application, (ii) removal of herbaceous vegetation, and (iii) transportation. The Board agreed that emissions from these sources may be considered as insignificant.
03	EB 42, Annex 11 26 September 2008	Allowing displacement of grazing activities, improvement of land use change approach, many editorial changes.
02	EB 36, Para 39 30 November 2007	Clarification to the application of the definition of the project boundary in A/R CDM project activities.
01	EB 29, Annex 7 16 February 2007	Initial adoption.