Approved consolidated afforestation and reforestation baseline and monitoring methodology AR-ACM0002

"Afforestation or reforestation of degraded land without displacement of pre-project activities"

(Version 01.1.0)

I. SOURCE, DEFINITIONS AND APPLICABILITY

1. Sources

This methodology is based on elements from the following methodologies:

- AR-AM0001 "Reforestation of degraded land" (Version 3) based on the draft CDM-AR-PDD "Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin, China". The baseline study, monitoring and verification plan and project design document were prepared by the Institute of Forest Ecology and Environment, the Chinese Academy of Forestry, Joanneum Research (Austria), Guangxi Forestry Inventory and Design, (China), and World Bank reviewers;
- AR-AM0008 "Afforestation or reforestation on degraded land for sustainable wood production" (Version 3) based on the draft CDM-AR-PDD: "Reforestation on degraded land for sustainable wood production of woodchips in the eastern coast of the Democratic Republic of Madagascar".

For more information regarding the source methodologies and their consideration by the CDM Executive Board (the Board) please refer to <http://cdm.unfccc.int/goto/ARappmeth>.

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;
- Tool for the identification of degraded or degrading lands for consideration in implementing A/R CDM project activities;
- ~~Tool for estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of an A/R CDM project activity~~Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity;
- 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 ~~the~~ significance of GHG emissions in A/R CDM project activities;

- Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity.

All the above-mentioned tools and procedures are available at:
<http://cdm.unfccc.int/Reference/tools> and
<http://cdm.unfccc.int/Reference/Procedures/index.html>.

2. Selected baseline approach from paragraph 22 of the A/R CDM 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 project activities with the following conditions:

- The project activity does not lead to a shift of pre-project activities outside the project boundary, i.e. the land under the proposed A/R CDM project activity can continue to provide at least the same amount of goods and services as in the absence of the project activity;
- Lands to be afforested or reforested are degraded, or degrading and it may be expected that the land would remain degraded in the absence of the project activity;
- Environmental conditions and human-caused degradation do not permit the encroachment of natural forest vegetation;
- Soil organic carbon pool may be conservatively neglected in the proposed A/R CDM project activity;
- Carbon stocks in litter and deadwood can be expected to decrease more due to human intervention or increase less in the absence of the project activity, relative to the project scenario;
- Flooding irrigation is not applied in the project activity.

The latest version of the "Tool for the identification of degraded or degrading lands for consideration in implementing A/R CDM project activities" shall be applied for demonstrating that lands are degraded or degrading.

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 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 CDM 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
Below-ground	Yes	Major carbon pool subjected to the project activity
Dead wood	No	Conservative approach under applicability condition
Litter	No	Conservative approach under applicability condition
Soil organic carbon	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 5.1.2 *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 biomass	CO_2	~~Included~~ Excluded	Carbon stock decreases due to burning are accounted as a change in carbon stock
	CH_4	Included	
	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 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

In this methodology the baseline is determined *ex ante* and remains fixed during the ~~subsequent~~first crediting period hence, the baseline is not monitored.

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

Therefore the baseline net GHG removals by sinks will be determined as:

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

where:

ΔC_{BSL}	Baseline net greenhouse gas removals by sinks; t CO_2-e
$\Delta C_{BSL,tree}$	Sum of the changes in carbon stocks in above-ground and below-ground biomass of trees in the baseline; t CO_2-e

For those strata without growing trees, $\Delta C_{BSL} = 0$. For those strata with a few growing trees, ΔC_{BSL} is estimated using one of the following two methods that can be chosen based on the availability of data.

4.1 Changes in carbon stocks in above-ground and below-ground tree biomass

The estimation of change in carbon stock 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 change in carbon stocks 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 change in carbon stock in above-ground and below-ground tree biomass for stratum *i,* for 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 net change in carbon stocks in above-ground and below-ground tree biomass for stratum *i,* for 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", i.e., $\Delta C_{BSL,AG/BG,i,t}$, by $\Delta C_{L,i,t}$.

[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 tree biomass loss for stratum *i,* for 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, ...* M_B strata in the baseline scenario
t	*1, 2, 3, ...*t^* years elapsed since the start of the A/R CDM project activity

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

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, ...* 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

and

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

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

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

[2] This assumption implies that all baseline tree 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 net growth of the baseline biomass will cease at some point in time.

$I_{V,j,i,t}$	Current annual increment in stem 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^{-1} d.m.
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 Equation 6. 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 net average annual increment (i.e. the term $\Delta C_{L,i,t}$ is already implicitly allowed for and shall be set to zero in Equation 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 gross 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 fuelwood, or for animal consumption).

Method 2 (stock change method)[3]

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

$$C_{j,i,t} = A_{BSL,i} * V_{tree,j,i,t} * D_j * BEF_{2,j} * CF_j * (1 + R_j) \quad \textbf{(8)}$$

where:

$\Delta C_{BSL,AG/BG,i,t}$	Annual change in carbon stocks in above-ground and below-ground tree biomass for stratum *i*, for year *t*; t C yr^{-1}
C_{j,i,t_2}	Total carbon stock in living biomass of trees of species *j* in stratum *i*, calculated for year t_2; t C
C_{j,i,t_1}	Total carbon stock in living biomass of trees of species *j* in stratum *i*, calculated for year t_1; t C
T	Number of years between years t_2 and t_1; yr

[3] GPG-LULUCF Equation 3.2.3

$A_{BSL,i}$	Area of baseline stratum *i*; ha
$V_{tree,j,i,t}$	Pre-project tree stem volume for species *j*, stratum *i,* for 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 $C_{j,i,t}$ is to use allometric equations:

$$C_{AB\_tree,j,i,t} = A_{BSL,i} * nTR_{j,i,t} * CF_j * f_j\left(DBH, H\right) * (1 + R_j) \quad \textbf{(9)}$$

where:

$C_{AB\_tree,j,i,t}$	Carbon stock in above-ground tree biomass of species *j* in stratum *i*, for 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*, for year *t*; trees ha^{-1}
CF_j	Carbon fraction of dry matter for species *j*; t C t^{-1} d.m.
$f_j\left(DBH, H\right)$	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} (Note: 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”)
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

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 stocks 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 ~~with exception to significant increase in CO_2 emissions from loss of existing (pre-project) woody non-tree biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity (the most current version of "Tool for testing the significance of GHG emissions in A/R CDM project activities" allows determination if a source is significant)~~.

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.

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \qquad \textbf{(10)}$$

where:

ΔC_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e
ΔC_P	Sum of changes in the *C* stocks in all selected carbon pools ~~and the loss of existing (pre-project) woody non-tree biomass due to site-preparation, and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity in the project scenario~~; t CO_2-e
GHG_E	Increase in non-CO_2 GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary; t CO_2-e

Note: In this methodology Equation ~~12~~10 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 above-ground biomass and below-ground biomass and soil organic carbon within the project boundary are estimated using the following approach:[4]

~~$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_t * \frac{44}{12} * 1year - E_{BiomassLoss}$$~~

$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_t * \frac{44}{12} * 1year \qquad \textbf{(11)}$$

where:

ΔC_P	Sum of the changes in C stock in all selected carbon pools ~~and the loss of existing (pre-project) woody non-tree biomass due to site-preparation, and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity in the project scenario~~; t CO_2-e
ΔC_t	Annual change in carbon stock in all selected carbon pools for year *t* ~~(excluding loss of existing (pre-project) biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity)~~; t C yr^{-1}
~~$E_{BiomassLoss}$~~	~~Increase in CO_2 emissions from loss of existing (pre-project) woody non-tree biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity; t CO_2-e~~
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^{-1} C

~~$E_{BiomassLoss}$ shall be estimated using the most recent version of the approved methodological tool: "Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of an A/R CDM project activity".~~[5]

ΔC_t shall be estimated using the following equation:

$$\Delta C_t = \sum_{i=1}^{M_{PS}} (\Delta C_{AG,i,t} + \Delta C_{BG,i,t} + \Delta C_{d,SOC_t}) \qquad \textbf{(12)}$$

where:

ΔC_t	Annual change in carbon stock in all selected carbon pools for year *t* ~~(excluding loss of existing (pre-project) biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the A/R CDM project activity)~~; t C yr^{-1}
$\Delta C_{AG,i,t}$	Annual change in carbon stock in above-ground biomass of trees for stratum *i*,

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

~~[5] In accordance with the guidance contained in paragraph 35 of the EB 42 meeting report, GHG emissions due to removal (loss) of herbaceous vegetation as a component of non-tree biomass are neglected in this methodology. Hence, all references to GHG emission from removal of non-tree vegetation (or non-tree biomass) do not include GHG emissions from removal of herbaceous vegetation.~~

	(possibly average over a monitoring period); t C yr^{-1}
$\Delta C_{BG,i,t}$	Annual change in carbon stock in below-ground biomass of trees for stratum *i*, (possibly average over a monitoring period); t C yr^{-1}
$\Delta C_{d,SOC_t}$	Default annual change in carbon stock in the soil organic carbon pool for time *t* (if selected in Table 1); t C yr^{-1}
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

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

5.1.1 Changes in C Stock in 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 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 volume tables allow for deriving average volume of trees, or 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 *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:

$$C_{AB\_tree,l,j,i,sp,t} = V_{l,j,i,sp,t} * D_j * BEF_{2,j} * CF_j \quad \textbf{(13)}$$

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 time *t*; t C tree^{-1}
$V_{l,j,i,sp,t}$	Stem 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*; 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, ...* 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 5: Convert the carbon stock in above-ground biomass to the carbon stock in below-ground biomass via root-shoot ratio, given by:

$$C_{BB\_tree,l,j,i,sp,t} = C_{AB\_tree,l,j,i,sp,t} * R_j \quad \textbf{(14)}$$

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 time *t*; t C tree^{-1}
$C_{AB\_tree,l,j,i,sp,t}$	Carbon stock in above-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at time *t*; t C tree^{-1}
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 time *t* (i.e. summation over all trees *l* by species *j* followed by summation over all species *j* present in plot *sp*)

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} \sum_{l=1}^{N_{j,i,sp,t}} (C_{AB\_tree,l,j,i,sp,t} + C_{BB\_tree,l,j,i,sp,t}) \quad \textbf{(15)}$$

where:

$C_{tree,i,sp,t}$	Carbon stock in trees on plot *sp* of stratum *i* at time *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 time *t*; t C tree^{-1}
$C_{BB\_tree,l,j,i,sp,t}$	Carbon stock in below-ground biomass of tree *l* of species *j* in plot *sp* in stratum *i* at 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	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:

$$C_{tree,i,t} = \frac{A_i}{A_{sp_i}} \sum_{sp=1}^{P_i} C_{tree,i,sp,t} \quad \textbf{(16)}$$

where:

$C_{tree,i,t}$	Carbon stock in trees in stratum *i*, at time *t*; t C
$C_{tree,i,sp,t}$	Carbon stock in trees on plot *sp* of stratum *i* at time *t*; t C
A_{sp_i}	Total area in 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:

$$C_{AB\_tree,j,i,sp,t} = \sum_{l=1}^{N_{j,sp}} f_j(DBH,H) * CF_j \quad \textbf{(17)}$$

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 time *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 living trees; t d.m. $tree^{-1}$
i	*1, 2, 3, …* M_{PS} strata in the project scenario
j	*1, 2, 3, …* S_{PS} tree species in the project scenario
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:

$$C_{BB\_tree,j,i,sp,t} = C_{AB\_tree,j,i,sp,t} * R_j \quad \textbf{(18)}$$

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 time *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 time *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 time *t*:

$$C_{tree,i,sp,t} = \sum_{j=1}^{S_{PS}} (C_{AB\_tree,j,i,sp,t} + C_{BB\_tree,j,i,sp,t}) \quad \textbf{(19)}$$

where:

$C_{tree,i,sp,t}$	Carbon stock in trees on plot *sp* of stratum *i* at time *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 time *t*; t C $tree^{-1}$
$C_{BB\_tree,j,i,sp,t}$	Carbon stock in below-ground biomass of trees of species *j* in plot *sp* in stratum *i* at 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 tree biomass for each stratum, as per Equation 18 - i.e. Step 7 of the *BEF* method.

For both the *BEF* and allometric methods calculate annual changes in C stocks:

$$\Delta C_{AG,i,t} + \Delta C_{BG,i,t} = \frac{C_{tree,i,t_2} - C_{tree,i,t_1}}{T} \quad \textbf{(20)}$$

where:

$\Delta C_{AG,i,t}$	Annual change in carbon stock in above-ground biomass of trees for stratum *i*; t C yr^{-1}
$\Delta C_{BG,i,t}$	Annual change in carbon stock 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 time *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 Default Changes in Soil Organic Carbon Pool

For *ex ante* and *ex post* estimations, the changes in stocks of soil organic carbon in all eligible areas of land will be assessed using the default method as described below.

5.1.2.1 Default method

A/R CDM project activities are eligible for accounting of the default changes in the soil organic carbon pool in all areas of land included in their boundary which satisfy all conditions listed below:

(a) The area does not include organic soils (e.g. peat-lands), or wetlands;[6]

(b) 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;

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

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

(e) 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 (a) – (e) listed above, the part shall be included in accounting of the default changes in the soil organic carbon pool.

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 equations:

$$\Delta C_{d,SOC_t} = \sum_{k=1}^{K} \Delta C_{d,SOC_{k,t}} \quad \textbf{(21)}$$

and

$$\Delta C_{d,SOC_{k,t}} = A_k * \Delta C \text{ for } 0 < t \le t_{equilibrium}$$
$$\Delta C_{d,SOC_{k,t}} = 0 \text{ for } t > t_{equilibrium} \quad \textbf{(22)}$$

where:

$\Delta C_{d,SOC_{k,t}}$	Default annual change in carbon stock in soil organic matter for area of land *i*, in year *t*; t C yr^{-1}
A_k	Area of land *k* satisfying all conditions (a) - (e) listed above; hectare (ha)
ΔC	Default annual increase in carbon stock in soil organic carbon; t C ha^{-1} yr^{-1}

[6] "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.

$t_{equilibrium}$	Time until a new equilibrium in carbon stock in soil organic carbon pool is reached; years
k	*1, 2, 3, … K* index for area of land k satisfying all conditions (a) - (e) listed above

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 only possible increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary is non-CO_2 GHG emission from biomass burning for site preparation and/or forest management. It is estimated as:

$$GHG_E = \sum_{t=1}^{t^*} E_{BiomassBurn,t} \qquad \textbf{(23)}$$

where:

GHG_E	Increase in non-CO_2 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 GHG emissions due to biomass burning of existing 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 Equation ~~25~~23 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 non-CO_2 emissions due to biomass burning of existing vegetation as part of site preparation

Considering the limited combustible material in degraded lands, fire is not likely to be a major source of GHG emissions in the site preparation. However, if significant, the non-CO_2 emissions due to biomass burning of existing woody vegetation[7] as part of site preparation ($E_{BiomassBurn,t}$) shall be estimated using the relevant instructions provided by the most recent version of the methodological tool: "~~Tool for estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a A/R CDM project activity~~Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity".

If prescribed burning is included in the forest management cycle, the same tool should be used to account for the non-CO_2 emissions arising from this practice.

[7] GHG emissions from burning of herbaceous vegetation as per para 35, EB 42 guidance are negligible.

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.

Similarly, the A/R CDM project activity will not result in any reduction of afforestation or reforestation activities or increasing of deforestation activities outside of the project boundary. Under the baseline scenario, local farmers may collect a limited amount of fuel from the project sites. Dead wood and some living branch biomass from the A/R CDM project activity can continue to be collected by local farmers as fuelwood without compromising the growth of trees established under the project. Thus, as a result of the project activities, local farmers will not have to collect additional fuelwood on lands outside the project boundary.

Leakage shall be estimated as follows:

$$LK = 0 \quad \textbf{(24)}$$

where:

LK	Total GHG emissions due to leakage; t CO_2-e

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 ($C_{AR\text{-}CDM}$), in t CO_2-e.

$$C_{AR-CDM} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK \quad \textbf{(25)}$$

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 time $t^* = t_2$ (the date of verification) for the monitoring period $T = t_2 - t_1$, this methodology uses the most recent version of the equations approved by the Board,[8] which produces the same estimates as the following:

$$tCERs = C_{AR-CDM,t_2} \quad \textbf{(26)}$$

$$lCERs = C_{AR-CDM,t_2} - C_{AR-CDM,t_1} \quad \textbf{(27)}$$

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

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.

Data / Parameter:	$A_{BSL,i}$
Data unit:	ha
Used in equations:	4, 8, 9
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 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., IPCC literature: Table 3A.1.10[9] of the *GPG-LULUCF* (IPCC 2003), and Table 4.5[10] of the *AFOLU Guidelines* (IPCC 2006))
Measurement	

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

[10] 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 age-dependent wood density if available.

procedures (if any):	
Any comment:	• *BEFs* are age dependent, and use of average data may result in significant errors for both young and old stands, because *BEFs* are usually large for young stands and quite small for old stands; • *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:	$BEF_{2,j}$, ~~$BEF_{2,DS}$~~
Data unit:	Dimensionless
Used in equations:	8, 13
Description:	Biomass expansion factor for conversion of stem 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. *IPCC GPG-LULUCF 2003*)
Measurement procedures (if any):	
Any comment:	• $BEF_{2,DS}$ is equal to $BEF_{2,j}$ if the extracted wood is the stem one; • *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; • *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_j, ~~CF_{DS}~~
Data unit:	$t\ C\ t^{-1}$ d.m.
Used in equations:	4, 8, 9, 13, 17
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) 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) Globally species-specific or group of species-specific (e.g. *IPCC GPG-LULUCF 2003*);

	(d) The default value 0.5 t C t^{-1} d.m. may be used
Measurement procedures (if any):	N/A
Any comment:	~~Carbon fraction of dry matter for dominant species *DS* when *j=DS*~~

Data / Parameter:	D_j, ~~D_{DS}~~
Data unit:	t d.m. m^{-3}
Used in equations:	6, 8, 13
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) 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) Globally species-specific or group of species-specific (e.g. *IPCC GPG-LULUCF 2003*)
Measurement procedures (if any):	N/A
Any comment:	~~Basic wood density for dominant species *DS* when *j=DS*~~

Data / Parameter:	$f_j(DBH, H)$
Data unit:	t d.m. $tree^{-1}$
Used in equations:	9, 17
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[11] sub-samples from each of the wet stem and branch components,[12] 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 under- rather than over-estimate of project net anthropogenic removals by sinks)—then mean 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

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

[12] 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.

Any comment:	To be determined if the carbon gain-loss method is used in the estimation of changes in carbon stocks in above-ground and below-ground biomass in the baseline. Note: $I_{V,j,i,t}$ 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. 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:	$nTR_{j,i,t}$
Data unit:	trees ha^{-1}
Used in equations:	9
Description:	Pre-project tree stand density of species *j* in stratum *i*, at time *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 hectare
Any comment:	

Data / Parameter:	R_j
Data unit:	d.m. kg^{-1} d.m.
Used in equations:	8, 9, 14, 18
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) 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:	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 from Table 4.4 of the AFOLU Guidelines (IPCC 2006), by choosing a climatic zone and species that most closely matches the project circumstances; 3. Alternatively, given that many datasets of root-shoot ratios are relatively small because of the difficulty of determining this parameter, conservative selection of a value from the global study by Cairns *et al.* (1997) is likely to provide a reliable default value. For the purpose of estimating baseline removals by sinks, 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:	$R1_j$
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 chosen with priority from higher to lower preference as follows: (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:	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 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:	8
Description:	Pre-project tree stem volume of stratum *i,* species *j*, at time *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 changes in carbon stock 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)

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for two 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 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:	16
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_{sp_i}
Data unit:	ha
Used in equations:	16
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:	*DBH*
Data unit:	cm
Used in following equations	Implicitly used in Equation 9, 17
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 CDM 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 time *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 Equation 9, 17
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 time *t* using a growth model or yield table that gives the expected tree dimensions as a function of tree age

Data / Parameter:	t_2 and t_1
Data unit:	yr
Used in equations:	7, 20
Description:	Years of the monitoring activity
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Used for calculation $T = t_2 – t_1$

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 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;[13] or
- 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

[13] 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.

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 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(s)
01.1.0	EB 63, Annex 25 29 September 2011	The amendment: (i) Excludes from accounting the CO_2 emissions resulting from burning of woody non-tree biomass; (ii) Provides reference to the tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" following the request of the Board (EB 60, para 61); (iii) Applies a few editorial changes.
01	EB 46, Annex 13 25 March 2009	Initial adoption.