Draft revision to the A/R Methodological Tool

"Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"

(Version 02.1.0)

I. SCOPE, APPLICABILITY AND ASSUMPTIONS

Scope

1. This tool can be used for estimation of carbon stocks and change in carbon stocks of trees and shrubs in the baseline and project scenarios of an A/R CDM project activity.

Applicability

2. This tool has no internal applicability conditions.

Assumptions

3. This tool makes the following assumptions:

(a) Linearity of biomass growth for trees and shrubs

Growth of biomass in trees and shrubs may be assumed to proceed on average at an approximately constant rate between two points in time at which biomass is estimated;

(b) Appropriateness of root-shoot ratios

Root-shoot ratios appropriate for estimation of below-ground biomass from above-ground biomass under forest/continuous-cover conditions are appropriate for all trees and shrubs within the project boundary.

Parameters

4. This tool provides procedures to determine the following parameters:

Table 1: Parameters determined by the tool

Parameter	SI Unit	Description
$C_{TREE,t}$	tCO_2-e	Carbon stock in tree biomass within the project boundary at a given point of time in year *t*
$\Delta C_{TREE,t}$	tCO_2-e	Change in carbon stock in tree biomass within the project boundary in year *t*
$C_{SHRUB,t}$	tCO_2-e	Carbon stock in shrub biomass within the project boundary at a given point of time in year *t*
$\Delta C_{SHRUB,t}$	tCO_2-e	Change in carbon stock in shrub biomass within the project boundary in year *t*

5. While applying this tool in a methodology, the following notation should be used:

In the baseline scenario:

$C_{TREE\_BSL,t}$ for $C_{TREE,t}$ and $C_{SHRUB\_BSL,t}$ for $C_{SHRUB,t}$

$\Delta C_{TREE\_BSL,t}$ for $\Delta C_{TREE,t}$ and $\Delta C_{SHRUB\_BSL,t}$ for $\Delta C_{SHRUB,t}$.

In the project scenario:

$C_{TREE\_PROJ,t}$ for $C_{TREE,t}$ and $C_{SHRUB\_PROJ,t}$ for $C_{SHRUB,t}$

$\Delta C_{TREE\_PROJ,t}$ for $\Delta C_{TREE,t}$ and $\Delta C_{SHRUB\_PROJ,t}$ for $\Delta C_{SHRUB,t}$.

II. ESTIMATION OF C STOCK AND CHANGE IN C STOCK IN TREES

6. Carbon stock in tree biomass is estimated on the basis of one or more tree biomass strata.

7. For the purpose of this tool, the term "species" also implies a group of species when a biometric parameter (e.g. biomass expansion factor, root-shoot ratio, basic wood density, carbon fraction) or a model (e.g. allometric equation, volume table) is applicable to more than one species.

8. Carbon stock and change in carbon in trees is estimated by applying one of the following methods, each applicable under its specific conditions:

(a) Stock change method

This method is applicable when temporary or permanent sample plots are used. Under this method, first the carbon stock in trees at a point of time is estimated and then the change in carbon stock in a year is calculated on the basis of two successive stock estimates.

(b) Increment method

This method is applicable when permanent sample plots are used and are re-measured on successive verifications. Under this method, first the change in carbon stock between two successive verifications is estimated and then the carbon stock at a given point of time in a year is calculated on the basis of the change in carbon stock and the previous value of carbon stock at a given point of time;

(c) Default method

This method is applicable only for estimation of carbon stock and change in carbon stock in trees in the baseline when any of the methods (a) and (b) above cannot be applied for lack of data, or when the mean tree crown cover in the baseline is less than 20% of the threshold crown cover reported by the host Party under paragraph 8 of the annex to decision 5/CMP.1.

Stock change method

9. Under stock change method carbon stock in trees within the project boundary is estimated at successive points of time (e.g. in project, ex post estimation at successive verifications; in

baseline, ex ante estimation at the start and the end of the crediting period). Change in carbon stock in trees between two successive points of time is calculated as the difference between the two estimated stocks.

Estimation of biomass stock in trees

10. Biomass of trees of species *j* per unit area in stratum *i* at a given point of time in year *t* is calculated on the basis of one or more tree dimensions (e.g. diameter, basal area, height).

11. The tree dimensions are obtained using one of the following procedures:

(a) For ex ante estimation, the tree dimensions are taken from existing data sources such as yield tables, tree growth curves, or tree growth models;

(b) For ex post estimation, the tree dimensions are obtained from field measurements. Measurements are carried out on all the trees in sample plots laid down in each stratum. Number of sample plots and their allocation to different strata required for a targeted precision may be calculated using the tool "Calculation of the number of sample plots for measurements within A/R CDM project activities". In exceptional situations, measurements may be carried out on all the trees in a stratum where trees are few and scattered out.

12. Tree dimensions are converted to tree biomass by applying one of the following methods:

(a) Biomass expansion factor (*BEF*) method;

(b) Allometric equation method.

Estimation of tree biomass using the BEF method

13. Under this method volume tables or volume equations are used to convert tree dimensions to stem volume of trees. Stem volume of trees is converted to above-ground tree biomass using basic wood density and biomass expansion factors, and the above-ground tree biomass is expanded to total tree biomass using root-shoot ratios. Thus, biomass of trees of species *j* in sample plot *p* is estimated as:

$$B_{TREE,j,p,i,t} = V_{TREE,j,p,i,t} * D_j * BEF_{2,j} * (1 + R_j) \quad \textbf{(1)}$$

where:

$B_{TREE,j,p,i,t}$	Biomass of trees of species *j* in sample plot *p* of stratum *i* at a point of time in year *t*; t d.m.
$V_{TREE,j,p,i,t}$	Stem volume of trees of species *j* in sample plot *p* of stratum *i* at a point of time in year *t*, estimated by using the tree dimension(s) as entry data into a volume table or volume equation; m^3
D_j	Basic wood density of tree 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*; dimensionless
R_j	Root-shoot ratio for tree species *j*; dimensionless
j	*1, 2, 3, …* tree species in plot *p*

p	*1, 2, 3, …* sample plots in stratum *i*
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

14. For ex ante estimation the volume table or volume equation applicable to a tree species is selected from the following sources (the most preferred source being listed first):

(a) Existing data applicable to local situation (e.g. represented by similar ecological conditions);

(b) National data (e.g. from national forest inventory or national GHG inventory);

(c) Data from neighbouring countries with similar conditions;

(d) Globally applicable data.

15. For ex post estimation, the volume table or volume equation used must be demonstrated to be appropriate for the purpose of estimation of tree biomass by applying the "Tool for demonstration of appropriateness of volume equations for estimation of aboveground tree biomass in A/R CDM project activities."

16. While applying Equation (1), it is ensured that the parameters $V_{TREE,j,p,i,t}$ and $BEF_{2,j}$ are compatible, i.e. both are based either on over-bark volume or on under-bark volume. If $V_{TREE,j,p,i,t}$ is obtained from a volume table or volume equation giving under-bark volume (i.e. commercial volume, rather than gross stem volume), and the biomass expansion factor $BEF_{2,j}$ is based on over-bark volume (or *vice versa*), then a bark correction factor is applied. For the purpose of applying this correction, volume of bark is assumed to be 15% of the volume of the wood (i.e. the under-bark volume), unless transparent and verifiable information can be provided to justify a different value.

17. While applying Equation (1), it is ensured that the parameter D_j is based on all tree components. If the density D_j is wood density, then a bark correction factor is applied. For the purpose of applying this correction, volume of bark is assumed to be 15% of the volume of the wood and has a density of 0.24 kg/m^3, unless transparent and verifiable information can be provided to justify a different value. In such a case: $D_j = D_{wood} * 87\% + 0.24 * 13\%$.

Estimation of tree biomass using the allometric equation method

18. Under this method allometric equations are used to convert tree dimensions to above-ground biomass of trees and the above-ground tree biomass is expanded to total tree biomass using root-shoot ratios. Thus, biomass of trees of species *j* in sample plot *p* is calculated as:

$$B_{TREE,j,p,i,t} = f_j(DBH_t, H_t) * (1 + R_j) \quad \textbf{(2)}$$

where:

$B_{TREE,j,p,i,t}$	Biomass of trees of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m.
$f_j(DBH_t, H_t)$	Sum of above-ground biomass of trees of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t* calculated using allometric function applicable to species *j* returning total above-ground tree biomass on the basis of tree dimensions as entry data; t d.m. Alternatively, other approaches allowing estimation of tree biomass per hectare (e.g. using a relascope) may be applied to calculate the total above-ground biomass of trees of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t*
R_j	Root-shoot ratio for tree species *j*; dimensionless
j	*1, 2, 3, …* tree species in plot *p*
p	*1, 2, 3, …* sample plots in stratum *i*
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

19. For ex ante estimation the allometric equation applicable to a tree species is selected using the same procedure as prescribed for selection of volume tables or volume equations in paragraph 14 above.

20. For ex post estimation, the allometric equation used must be demonstrated to be appropriate for the purpose of estimation of tree biomass by applying the "Tool for demonstration of appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities."

Ex ante estimation of the total tree biomass within the project boundary

21. For ex ante estimation of tree biomass within the project boundary, individual tree biomass obtained from Equation (1) or Equation (2) is multiplied by expected time-series stocking density in various strata.

Ex post estimation of the total tree biomass within the project boundary

22. Tree biomass in sample plot *p* of stratum *i* is estimated as follows:

$$B_{TREE,p,i,t} = \sum_{j} B_{TREE,j,p,i,t} \qquad \textbf{(3)}$$

where:

$B_{TREE,p,i,t}$	Tree biomass in sample plot *p* in stratum *i* at a given point of time in year *t*; t d.m.
$B_{TREE,j,p,i,t}$	Biomass of trees of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m.

j	*1, 2, 3,* … species in plot *p*
p	*1, 2, 3*, … sample plots in stratum *i*
i	*1, 2, 3,* … strata used for tree biomass estimation within the project boundary
t	*1, 2, 3,* ... years counted from the start of the A/R CDM project activity

23. Tree biomass per hectare in plot *p* in stratum *i* is estimated as follows:

$$b_{TREE,p,i,t} = \frac{B_{TREE,p,i,t}}{A_{p,i}} \qquad \textbf{(4)}$$

where:

$b_{TREE,p,i,t}$	Tree biomass per hectare in sample plot *p* in stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
$B_{TREE,p,i,t}$	Tree biomass in sample plot *p* in stratum *i* at a given point of time in year *t*; t d.m.
$A_{p,i}$	Area of sample plot *p* in stratum *i*; ha
p	*1, 2, 3*, … sample plots in stratum *i*
i	*1, 2, 3,* … tree biomass estimation strata within the project boundary
t	*1, 2, 3,* ... years counted from the start of the A/R CDM project activity

24. Mean tree biomass per hectare in stratum *i* and the variance of tree biomass per hectare in the stratum are estimated as follows:

$$b_{TREE,i,t} = \frac{\sum_{p=1}^{n_i} b_{TREE,p,i,t}}{n_i} \qquad \textbf{(5)}$$

$$s_i^2 = \frac{n_i * \sum_{p=1}^{n_i} b_{TREE,p,i,t}^2 - \left(\sum_{p=1}^{n_i} b_{TREE,p,i,t}\right)^2}{n_i * (n_i - 1)} \qquad \textbf{(6)}$$

where:

$b_{TREE,i,t}$	Mean tree biomass per hectare in stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
$b_{TREE,p,i,t}$	Tree biomass per hectare in sample plot *p* in stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
n_i	Number of sample plots in stratum *i*
s_i^2	Variance of tree biomass per hectare in stratum *i* at a given point of time in year *t*; (t d.m. ha^{-1})^2

25. Mean tree biomass per hectare within the project boundary and its variance are estimated as follows:

$$b_{TREE,t} = \sum_{i=1}^{M} w_i * b_{TREE,i,t} \tag{7}$$

$$s_{b_{TREE}}^2 = \sum_{i=1}^{M} w_i^2 * \frac{s_i^2}{n_i} \tag{8}$$

where:

$b_{TREE,t}$	Mean tree biomass per hectare within the project boundary at a given point of time in year *t*; t d.m. ha^{-1}
w_i	Ratio of the area of stratum *i* to the sum of areas of biomass estimation strata; dimensionless
$b_{TREE,i,t}$	Mean tree biomass per hectare in stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
$s_{b_{TREE}}^2$	Variance of mean tree biomass per hectare within the project boundary at a given point of time in year *t*; (t d.m. $ha^{-1})^2$
s_i^2	Variance of tree biomass per hectare in stratum *i* at a given point of time in year *t*; (t d.m. $ha^{-1})^2$
n_i	Number of sample plots in stratum *i*
M	Number of tree biomass estimation strata within the project boundary

26. Margin of error of the mean tree biomass per hectare within the project boundary is estimated as:

$$e_{b_{TREE}} = t_{VAL} * s_{b_{TREE}} \tag{9}$$

where:

$e_{b_{TREE}}$	Margin of error of the mean tree biomass per hectare within the project boundary; t d.m. ha^{-1}
t_{VAL}	Two-sided Student's *t*-value for: (i) Degrees of freedom equal to $n - M$, where *n* is total number of sample plots within the project boundary, and *M* is the total number of tree biomass estimation strata; and (ii) The confidence level required by the methodology applying this tool (e.g. 90% or 95%); dimensionless. E.g. Two-sided Student's *t*-value for a probability value of 10% (which implies a 90% confidence level) and 45 degrees of freedom can be obtained in Excel spreadsheet as "=TINV(0.10,45)" which returns a value of 1.6794
$s_{b_{TREE}}$	Square root of the variance of mean tree biomass per hectare within project boundary at a given point of time in year *t* (i.e. the standard error of the mean); t d.m. ha^{-1}

27. If $e_{b_{TREE}} / b_{TREE,t}$ *100% is greater than the maximum allowable relative margin of error of the mean prescribed in the methodology, then one of the following options is selected:

(a) Additional sample plots are installed so that this value is equal to or less than the maximum allowable relative margin of error of the mean prescribed in the methodology. The number of sample plots for achieving the required precision may be calculated using the tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" using the stratum standard deviations equal to square root of the stratum variances estimated in Equation (6) above.

(b) The value of $b_{TREE,t}$ estimated from Equation (7) is discounted by multiplying it by a conservativeness factor as follows:[1]

Value of $e_{b_{TREE}} / b_{TREE,t}$ *100%	Value of conservativeness factor
Greater than 10 and less than or equal to 30	0.94
Greater than 30 and less than or equal to 50	0.89
Greater than 50 and less than or equal to 100	0.82

28. Total tree biomass within the project boundary at a given point of time in year *t* is estimated as follows:

$$B_{TREE,t} = A * b_{TREE,t} \qquad \textbf{(10)}$$

where:

$B_{TREE,t}$	Total tree biomass within the project boundary at a given point of time in year *t*; t d.m.
A	Sum of areas of the biomass estimation strata within the project boundary; ha
$b_{TREE,t}$	Mean tree biomass per hectare within the project boundary at a given point of time in year *t*; t d.m. ha^{-1}

29. Carbon stock in tree biomass within the project boundary at a given point of time in year *t* is estimated as follows:

$$C_{TREE,t} = \frac{44}{12} * B_{TREE,t} * CF_{TREE} \qquad \textbf{(11)}$$

[1] Conservativeness factors taken from appendix III, paragraph 9, of decision 20/CMP.1.

where:

$C_{TREE,t}$	Carbon stock in tree biomass within the project boundary at a given point of time in year *t*; t CO_2-e
$B_{TREE,t}$	Total tree biomass within the project boundary at a given point of time in year *t*; t d.m.
CF_{TREE}	Carbon fraction of tree biomass; t C t d.m.$^{-1}$ A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value

Estimation of change in carbon stock in trees (ΔC_{TREE})

30. The rate of change of tree biomass over a period of time is calculated assuming a linear growth. Therefore, the rate of change in carbon stock in tree biomass over a period of time is calculated as follows:

$$dC_{TREE,(t_1,t_2)} = \frac{C_{TREE,t_2} - C_{TREE,t_1}}{T} \qquad \textbf{(12)}$$

where:

$dC_{TREE,(t_1,t_2)}$	Rate of change in carbon stock in tree biomass within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2; tCO_2-e yr^{-1}
C_{TREE,t_2}	Carbon stock in tree biomass within the project boundary at a point of time in year t_2; tCO_2-e
C_{TREE,t_1}	Carbon stock in tree biomass within the project boundary at a point of time in year t_1; tCO_2-e
T	Time elapsed between two successive estimations ($T=t_2 - t_1$); yr

31. For the first verification, the variable C_{TREE,t_1} in Equation (12) is assigned the value of carbon stock in the tree biomass at the start of the A/R CDM project activity, that is: $C_{TREE,t_1} = C_{TREE\_BSL}$ for the for the first verification, where $t_1 = 1$ and t_2 = year of first verification.

32. Change in carbon stock in tree biomass within the project boundary in year *t* ($t_1 \le t \le t_2$) is calculated as follows:

$$\Delta C_{TREE,t} = dC_{TREE,(t_1,t_2)} * 1 year \text{ for } t_1 \le t \le t_2 \qquad \textbf{(13)}$$

where:

$\Delta C_{TREE,t}$	Change in carbon stock in tree biomass within the project boundary in year *t*; tCO_2-e
$dC_{TREE,(t_1,t_2)}$	Rate of change in carbon stock in tree biomass within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2; t CO_2-e yr^{-1}

Increment method

33. Increment method is used when trees in the same sample plots are measured on two successive verifications. Individual trees are identified and biomass increment of each tree between two successive verifications is estimated. If a tree measured at the time of the earlier verification cannot be found at the time of the later verification (i.e. the tree is missing or is dead), then its biomass on the later verification is recorded as zero.[2] If a new tree is found at the time of the later verification, then its biomass at the time of earlier verification is recorded as zero.

Estimation of change in carbon stock in trees

34. Biomass of an individual tree *l* of species *j* in sample plot *p* is estimated as follows:

$$B_{TREE,l,j,p,i,t} = V_{TREE,l,j,p,i,t} * D_j * BEF_{2,j} * (1 + R_j) \quad \textbf{(14)}$$

Or

$$B_{TREE,l,j,p,i,t} = f_j(DBH_{l,t}, H_{l,t}) * (1 + R_j) \quad \textbf{(15)}$$

where:

$B_{TREE,l,j,p,i,t}$	Biomass of tree *l* of species *j* in sample plot *p* of stratum *i* at a point of time in year *t*; t d.m.
$V_{TREE,l,j,p,i,t}$	Stem volume of tree *l* of species *j* in sample plot *p* of stratum *i* at a point of time in year *t*, estimated by using the tree dimension(s) as entry data into a volume table or volume equation; m^3
D_j	Basic wood density of tree 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*; dimensionless
R_j	Root-shoot ratio for tree species *j*; dimensionless
$f_j(DBH_{l,t}, H_{l,t})$	Above-ground biomass of tree *l* of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t* calculated using allometric function applicable to species *j* returning total above-ground tree biomass on the basis of tree dimensions as entry data; t d.m.
l	*1, 2, 3, …* trees of species *j* in plot *p*
j	*1, 2, 3, …* tree species in plot *p*
p	*1, 2, 3, …* sample plots in stratum *i*
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

35. While applying Equation (14), it is ensured that the parameters $V_{TREE,j,p,i,t}$ and $BEF_{2,j}$ are compatible, that is. both are based either on over-bark volume or on under-bark volume. If $V_{TREE,j,p,i,t}$ is obtained from a volume table or volume equation giving under-bark volume (i.e.

[2] However, this does not preclude the possibility of counting the dead tree in the dead wood pool.

commercial volume, rather than gross stem volume), and the biomass expansion factor $BEF_{2,j}$ is based on over-bark volume (or vice versa), then a bark correction factor is applied. For the purpose of applying this correction, volume of bark is assumed to be 15% of the volume of the wood (i.e. the under-bark volume), unless transparent and verifiable information can be provided to justify a different value.

36. While applying Equation (14), it is ensured that the parameter D_j is based on all tree components. If the density D_j is wood density, then a bark correction factor is applied. For the purpose of applying this correction, volume of bark is assumed to be 15% of the volume of the wood and has a density of 0.24 kg/m^3, unless transparent and verifiable information can be provided to justify a different value. In such a case: $D_j = D_{wood} * 87\% + 0.24 * 13\%$

37. Change in biomass of an individual tree *l* of species *j* in sample plot *p* of stratum *i* between two successive verifications is estimated as follows:

$$\Delta B_{TREE,l,j,p,i,(t_1,t_2)} = B_{TREE,l,j,p,i,t_2} - B_{TREE,l,j,p,i,t_1} \quad \textbf{(16)}$$

where:

$\Delta B_{TREE,l,j,p,i,(t_1,t_2)}$	Change in biomass of tree *l* of species *j* in sample plot *p* of stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.
B_{TREE,l,j,p,i,t_2}	Biomass of tree *l* of species *j* in sample plot *p* of stratum *i* at time t_2; t d.m.
B_{TREE,l,j,p,i,t_1}	Biomass of tree *l* of species *j* in sample plot *p* of stratum *i* at time t_1; t d.m.
l	*1, 2, 3, …* trees of species *j* in plot *p*
j	*1, 2, 3, …* tree species in plot *p*
p	*1, 2, 3, …* sample plots in stratum *i*
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

38. Change in tree biomass in plot *p* in stratum *i* is estimated as follows:

$$\Delta B_{TREE,p,i,(t_1,t_2)} = \sum_j \sum_l \Delta B_{TREE,l,j,p,i,(t_1,t_2)} \quad \textbf{(17)}$$

where:

$\Delta B_{TREE,p,i,(t_1,t_2)}$	Change in tree biomass in sample plot *p* of stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.
$\Delta B_{TREE,l,j,p,i,(t_1,t_2)}$	Change in biomass of tree *l* of species *j* in sample plot *p* of stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.

l	*1, 2, 3, …* trees of species j in plot p
j	*1, 2, 3, …* tree species in plot p
p	*1, 2, 3, …* sample plots in stratum i
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

39. Change in tree biomass per hectare in plot p in stratum i is estimated as follows:

$$\Delta b_{TREE,p,i,(t_1,t_2)} = \frac{\Delta B_{TREE,p,i,(t_1,t_2)}}{A_{p,i}} \qquad \textbf{(18)}$$

where:

$\Delta b_{TREE,p,i,(t_1,t_2)}$	Change in tree biomass per hectare in sample plot p of stratum i between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
$\Delta B_{TREE,p,i,(t_1,t_2)}$	Change in tree biomass in sample plot p of stratum i between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.
$A_{p,i}$	Area of sample plot p in stratum i; ha
p	*1, 2, 3, …* sample plots in stratum i
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

40. Mean change in tree biomass per hectare in stratum i and variance of the change in tree biomass per hectare in the stratum are estimated as follows:

$$\Delta b_{TREE,i,(t_1,t_2)} = \frac{\sum_{p} \Delta b_{TREE,p,i,(t_1,t_2)}}{n_i} \qquad \textbf{(19)}$$

$$s^2_{\Delta,i} = \frac{n_i * \sum_{p=1}^{n_i} \Delta b^2_{TREE,p,i,(t_1,t_2)} - \left(\sum_{p=1}^{n_i} \Delta b_{TREE,p,i,(t_1,t_2)} \right)^2}{n_i * (n_i - 1)} \qquad \textbf{(20)}$$

where:

$\Delta b_{TREE,i,(t_1,t_2)}$	Mean change in tree biomass per hectare in stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
$\Delta b_{TREE,p,i,(t_1,t_2)}$	Tree biomass per hectare in sample plot *p* in stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
n_i	Number of sample plots in stratum *i*
$s^2_{\Delta,i}$	Variance of change in tree biomass per hectare in stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; (t d.m. $ha^{-1})^2$
p	*1, 2, 3, …* sample plots in stratum *i*
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary

41. Mean change in tree biomass per hectare within the project boundary and its variance are estimated as follows:

$$\Delta b_{TREE,(t_1,t_2)} = \sum_{i=1}^{M} w_i * \Delta b_{TREE,i,(t_1,t_2)} \quad \textbf{(21)}$$

$$s^2_{\Delta b_{TREE}} = \sum_{i=1}^{M} w_i^2 * \frac{s^2_{\Delta,i}}{n_i} \quad \textbf{(22)}$$

where:

$\Delta b_{TREE,(t_1,t_2)}$	Mean change in tree biomass per hectare within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
w_i	Ratio of the area of stratum *i* to the sum of areas of biomass estimation strata; dimensionless
$\Delta b_{TREE,i,(t_1,t_2)}$	Mean change in tree biomass per hectare in stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
$s^2_{\Delta b_{TREE}}$	Variance of mean change in tree biomass per hectare within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; (t d.m. $ha^{-1})^2$
$s^2_{\Delta,i}$	Variance of change in tree biomass per hectare in stratum *i* between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; (t d.m. $ha^{-1})^2$
n_i	Number of sample plots in stratum *i*
M	Number of tree biomass estimation strata within the project boundary
i	*1, 2, 3, …* tree biomass estimation strata within the project boundary

42. Margin of error of the mean change in tree biomass per hectare within the project boundary is estimated as:

$$e_{\Delta b_{TREE}} = t_{VAL} * s_{\Delta b_{TREE}} \quad \textbf{(23)}$$

where:

$e_{\Delta b_{TREE}}$	Margin of error of the mean change in tree biomass per hectare within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}
t_{VAL}	Two-sided Student's *t*-value for: (i) Degrees of freedom equal to $n – M$, where n is total number of sample plots within the project boundary, and M is the total number of tree biomass estimation strata; and (ii) The confidence level required by the methodology applying this tool (e.g. 90% or 95%); dimensionless
$s_{\Delta b_{TREE}}$	Square root of the variance of mean change in tree biomass per hectare within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2 (i.e. the standard error of the mean); t d.m. ha^{-1}

43. If the relative margin of error of the mean calculated as $e_{\Delta b_{TREE}} / \Delta b_{TREE,(t_1,t_2)} * 100\%$ is greater than the maximum allowable relative margin of error of the mean prescribed in the methodology, then the value of $\Delta b_{TREE,(t_1,t_2)}$ estimated from Equation (21) is discounted by multiplying it by a conservativeness factor as follows:[3]

Value of $e_{b_{TREE}} / b_{TREE,t} * 100\%$	Value of conservativeness factor
Greater than 10 and less than or equal to 30	0.94
Greater than 30 and less than or equal to 50	0.89
Greater than 50 and less than or equal to 100	0.82
Greater than 100	0.73

44. Change in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2 is estimated as follows:

$$\Delta B_{TREE,(t_1,t_2)} = A * \Delta b_{TREE,(t_1,t_2)} \quad \textbf{(24)}$$

[3] Conservativeness factors taken from appendix III, paragraph 9, of decision 20/CMP.1.

where:

$\Delta B_{TREE,(t_1,t_2)}$	Change in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.
A	Sum of areas of the biomass estimation strata within the project boundary; ha
$\Delta b_{TREE,(t_1,t_2)}$	Mean change in tree biomass per hectare within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m. ha^{-1}

45. Change in carbon stock in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2 is estimated as follows:

$$\Delta C_{TREE,(t_1,t_2)} = \frac{44}{12} * \Delta B_{TREE,(t_1,t_2)} * CF_{TREE} \qquad \textbf{(25)}$$

where:

$\Delta C_{TREE,(t_1,t_2)}$	Change in carbon stock in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; tCO_2-e
$\Delta B_{TREE,(t_1,t_2)}$	Change in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; t d.m.
CF_{TREE}	Carbon fraction of tree biomass; tC t d.m.$^{-1}$ A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value

Estimation of carbon stock in trees

46. Rate of change of carbon stock in trees between the years t_2 and t_1 is estimated as follows:

$$dC_{TREE,(t_1,t_2)} = \frac{\Delta C_{TREE,(t_1,t_2)}}{T} \qquad \textbf{(26)}$$

where:

$dC_{TREE,(t_1,t_2)}$	Rate of change in carbon stock in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; tCO_2-e yr^{-1}
$\Delta C_{TREE,(t_1,t_2)}$	Change in carbon stock in tree biomass within the project boundary between the earlier verification carried out at time t_1 and the later verification carried out at time t_2; tCO_2-e

T	Time elapsed between two successive verifications ($T = t_2 - t_1$); yr If the two successive verifications of carbon stock in trees are carried out at different points of time in year t_2 and t_1, (e.g. in the month of April in year t_1 and in the month of September in year t_2), then a fractional value is assigned to T

47. Carbon stock in tree biomass within the project boundary at a point of time in year t falling between t_1 and t_2 is estimated as follows:

$$C_{TREE,t} = C_{TREE,t-1} + dC_{TREE,(t_1,t_2)} * 1 year \quad \textbf{(27)}$$

where:

$C_{TREE,t}$	Carbons stock in tree biomass within the project boundary at a point of time in year t; t CO_2-e
$C_{TREE,t-1}$	Carbons stock in tree biomass within the project boundary at a point of time in year $t - 1$; tCO_2-e
$dC_{TREE,(t_1,t_2)}$	Rate of change in carbon stock in tree biomass within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2; tCO_2-e yr^{-1}

Default estimation method (applicable only in the baseline)

48. This method is applicable only for estimation of carbon stock and change in carbon stock in trees in the baseline when any of the methods above cannot be applied for lack of data, or when the mean tree crown cover in the baseline is less than 20% of the threshold crown cover reported by the host Party under paragraph 8 of the annex to decision 5/CMP.1

49. Carbon stock and change in carbon stock in trees in the baseline are estimated as follows:

$$C_{TREE\_BSL,i} = \frac{44}{12} * CF_{TREE\_BSL} * B_{FOREST} * (1 + R_{TREE\_BSL}) * CC_{TREE\_BSL,i} * A_{BSL,i} \quad \textbf{(28)}$$

$$\Delta C_{TREE\_BSL,i} = \frac{44}{12} * CF_{TREE\_BSL} * \Delta B_{FOREST} * (1 + R_{TREE\_BSL}) * CC_{TREE\_BSL,i} * A_{BSL,i} \quad \textbf{(29)}$$

where:

$C_{TREE\_BSL,i}$	Carbon stock in living trees in the baseline, in baseline stratum i, at the start of the A/R CDM project activity; tCO_2-e. Baseline strata are delineated on the basis of tree crown cover
CF_{TREE_BSL}	Carbon fraction of tree biomass in the baseline; t C $(t.d.m.)^{-1}$ A default value of 0.47 t C $(t.d.m.)^{-1}$ is used
B_{FOREST}	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located; t d.m. ha^{-1}

R_{TREE_BSL}	Root-shoot ratio for the trees in the baseline; dimensionless. A default value of 0.25 is used unless transparent and verifiable information can be provided to justify a different value
$CC_{TREE\_BSL,i}$	Crown cover of trees in the baseline, in baseline stratum *i*, at the start of the A/R CDM project activity, expressed as a fraction (e.g. 10% crown cover implies $CC_{TREE\_BSL,i}$ = 0.10); dimensionless
$\Delta C_{TREE\_BSL,i}$	Average annual change in carbon stock in tree biomass in the baseline; tCO_2-e yr^{-1}
ΔB_{FOREST}	Default average annual increment of above-ground biomass in forest in the region/country where the A/R CDM project is located; t d.m. ha^{-1} yr^{-1}
$A_{BSL,i}$	Area of stratum *i* in the baseline, delineated on the basis of tree crown cover at the start of the A/R CDM project activity; ha

III. ESTIMATION OF C STOCK AND CHANGE IN C STOCK IN SHRUBS

Estimation of carbon stock in shrubs (C_{SHRUB})

50. Carbon stock in shrub biomass is estimated for each shrub biomass stratum delineated on the basis of shrub crown cover. Once the area within the project boundary has been stratified on the basis of shrub crown cover, carbon stock in shrub biomass within the project boundary at a given point of time in year *t* is calculated as:

$$C_{SHRUB,t} = \frac{44}{12} * CF_S * (1 + R_S) * \sum_i A_{SHRUB,i,t} * B_{SHRUB,i,t} \qquad \textbf{(30)}$$

where:

$C_{SHRUB,t}$	Carbon stock in shrub biomass within the project boundary at a given point of time in year *t*; t CO_2-e
CF_S	Carbon fraction of shrub biomass; t C $(t.d.m.)^{-1}$ IPCC default value of 0.47 t C $(t.d.m.)^{-1}$ is used
R_S	Root-shoot ratio for shrubs; dimensionless
$A_{SHRUB,i,t}$	Area of shrub biomass stratum *i* at a given point of time in year *t*; ha
$B_{SHRUB,i,t}$	Shrub biomass per hectare in shrub biomass stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
i	*1, 2, 3, …* shrub biomass strata delineated on the basis of shrub crown cover
t	*1, 2, 3, ...* years counted from the start of the A/R CDM project activity

51. Shrub biomass per hectare ($B_{SHRUB,i,t}$) is estimated as follows:

(a) For those areas where the shrub crown cover is less than 5%, the shrub biomass per hectare is considered negligible and hence accounted as zero;

(b) For those areas where the shrub crown cover is 5% or more, shrub biomass per hectare is estimated as follows:

$$B_{SHRUB,i,t} = BDR_{SF} * B_{FOREST} * CC_{SHRUB,i,t} \quad \textbf{(31)}$$

where:

$B_{SHRUB,i,t}$	Shrub biomass per hectare in shrub biomass stratum *i*, at a given point of time in year *t*; t d.m. ha^{-1}
BDR_{SF}	Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 and default above-ground biomass content per hectare in forest in the region/country where the A/R CDM project is located; dimensionless
B_{FOREST}	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located; t d.m. ha^{-1}
$CC_{SHRUB,i,t}$	Crown cover of shrubs in shrub biomass stratum *i* at a given point of time in year *t* expressed as a fraction (e.g. 10% crown cover implies $CC_{SHRUB,i,t}$ = 0.10); dimensionless

Estimation of change in carbon stock in shrubs (ΔC_{SHRUB})

52. The rate of change of shrub biomass over a period of time is estimated as follows:

$$dC_{SHRUB,(t_1,t_2)} = \frac{C_{SHRUB,t_2} - C_{SHRUB,t_1}}{T} \quad \textbf{(32)}$$

where:

$dC_{SHRUB,(t_1,t_2)}$	Rate of change in carbon stock in shrub biomass within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2; tCO_2-e yr^{-1}
C_{SHRUB,t_2}	Carbon stock in shrub biomass within the project boundary at a point of time in year t_2; tCO_2-e
C_{SHRUB,t_1}	Carbon stock in shrub biomass within the project boundary at a point of time in year t_1; tCO_2-e
T	Time elapsed between two successive estimations ($T = t_2 - t_1$); yr

53. For the first verification, the variable C_{SHRUB,t_1} in Equation (32) is assigned the value of carbon stock in the shrub biomass at the start of the A/R CDM project activity, that is: $C_{SHRUB,t_1} = C_{SHRUB\_BSL}$ for the for the first verification, where t_1 = 1 and t_2 = year of first verification.

54. Change in carbon stock in shrub biomass within the project boundary in year *t* ($t_1 \leq t \leq t_2$) is calculated as follows:

$$\Delta C_{SHRUB,t} = dC_{SHRUB,(t_1,t_2)} * 1 year \text{ for } t_1 \leq t \leq t_2 \quad \textbf{(33)}$$

where:

$\Delta C_{SHRUB,t}$	Change in carbon stock in shrub biomass within the project boundary in year *t*; tCO_2-e
$dC_{SHRUB,(t_1,t_2)}$	Rate of change in carbon stock in shrub biomass within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2; tCO_2-e yr^{-1}

IV. DATA AND PARAMETERS USED IN THE TOOL

55. The following tables describe the data and parameters used in this tool. The guidelines contained in these tables regarding selection of data sources and procedures to be followed in measurement, where applicable, should be treated as an integral part of this tool.

Data and parameters not measured

Data / Parameter:	$BEF_{2,j}$
Data unit:	Dimensionless
Used in equations:	1, 14
Description:	Biomass expansion factor for conversion of stem biomass to above-ground biomass for tree species *j*
Source of data:	Values from Table 3A.1.10 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values[4]
Comments:	*BEFs* in IPCC literature and national inventory are usually applicable to closed canopy forest. If applied to individual trees growing in an open field the selected *BEF* is increased by 30%

Data / Parameter:	BDR_{SF}
Data unit:	Dimensionless
Used in equations:	31
Description	Ratio of biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100%) and the default above-ground biomass content in forest in the region/country where the A/R CDM project is located
Source of data:	A default value of 0.10 should be used unless transparent and verifiable information can be provided to justify a different value

Data / Parameter:	B_{FOREST}
Data unit:	t d.m. ha^{-1}
Used in equations:	28, 31

[4] Although the *BEFs* in Table 3A.1.10 apply to biomass, the dimensionless factors can be equally applied for wood volume expansions.

Description:	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located
Source of data:	Values from Table 3A.1.4 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values

Data / Parameter:	ΔB_{FOREST}
Data unit:	t d.m. ha^{-1} yr^{-1}
Used in equations:	29
Description:	Default average annual increment in above-ground biomass in forest in the region/country where the A/R CDM project is located
Source of data:	Values from Table 3A.1.5 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values
Comments:	(a) Tree biomass may reach a steady state when biomass growth becomes zero or insignificant – either because of biological maturity of trees or because the rate of anthropogenic biomass extraction from the area is equal to the rate of biomass growth. Therefore, this parameter should be taken to be zero after the year in which tree biomass in baseline reaches a steady state. The year in which tree biomass in baseline reaches steady-state is taken to be the 20th year from the start of the CDM project activity, unless transparent and verifiable information can be provided to justify a different year. (b) When land is subjected to periodic slash-and-burn practices in the baseline, the average tree biomass is constant, and hence value of this parameter is set equal to zero

Data / Parameter:	D_j
Data unit:	t d.m. m^{-3}
Used in equations:	1, 14
Description:	Basic density for tree species *j*
Source of data:	Values from Table 3A.1.9 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values

Data / Parameter:	R_j
Data unit:	Dimensionless
Used in equations:	1, 2, 15
Description:	Root-shoot ratio for tree species *j*
Source of data:	If the living trees in a sample plot have grown from coppice regeneration after a harvest, then the value of *Rj* should be multiplied by a factor equal to $v_{HARVEST}/v_{TREE}$ or 1, whichever is greater, where $v_{HARVEST}$ is the volume per hectare of trees harvested and v_{TREE} is the volume per hectare of trees standing in the plot at the time of verification

299

Data / Parameter:	R_S
Data unit:	Dimensionless
Used in equations:	30
Description:	Root-shoot ratio for shrubs
Source of data:	The value of R_S shall be 0.40 (*see* Table 4.4 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories) unless transparent and verifiable information can be provided to justify different values

300 **Data and parameters measured**

Data / Parameter:	$A_{p,i}$
Data unit:	ha
Used in equations:	4, 18
Description:	Area of sample *p* in stratum *i*
Source of data:	Field measurement
Measurement procedures:	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Monitoring frequency:	Every five years since the year of the initial verification
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Comments:	Sample plot location is registered with a GPS and marked on the project map

301

Data / Parameter:	$A_{SHRUB,i,t}$
Data unit:	ha
Used in equations:	30
Description:	Area of shrub biomass stratum *i* at a given point of time in year *t*
Source of data:	Field measurement
Measurement procedures:	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Monitoring frequency:	Every five years since the year of the initial verification
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied

302

Data / Parameter:	$CC_{SHRUB,i,t}$
Data unit:	dimensionless
Used in equations:	31
Description:	Crown cover of shrubs in shrub biomass stratum *i* at a given point of time in year *t*
Source of data:	Field measurement
Measurement procedures :	Considering that the biomass in shrubs is smaller than the biomass in trees, a simplified method of measurement may be used for estimating shrub crown cover. Ocular estimation of crown cover may be carried out or any other method such as the line transect method or the relascope method may be applied
Monitoring frequency:	Every five years since the year of the initial verification
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied

Comments:	(a) When land is subjected to periodic slash-and-burn practices in the baseline, an average shrub crown cover equal to default value of 0.5 is used in Equation (31) unless transparent and verifiable information can be provided to justify a different value; (b) Ex ante estimation of shrub crown cover at a time other than at the start of the project is carried out with the following considerations in view: (i) Shrub crown cover is assumed to remain at the pre-project level unless transparent and verifiable information can be provided to justify a different rate of change; (ii) When land is abandoned, shrubs may encroach such land and shrub crown cover may reach the maximum value of 1.0 over a period of 20 years from the year in which the land is abandoned. If the year in which the land is abandoned is not known, then an average crown cover of 0.50 is assumed at the start of the project

303

Data / Parameter:	$CC_{TREE\_BSL,i}$
Data unit:	dimensionless
Used in equations:	28, 29
Description:	Crown cover of trees in the baseline, in baseline stratum *i*, expressed as a fraction (e.g. 10% crown cover implies $CC_{TREE\_BSL,i}$ =0.10)
Source of data:	Field measurement
Measurement procedures :	Considering that the biomass in trees in the baseline is smaller compared to the biomass in trees in the project, a simplified method of measurement may be used for estimating tree crown cover. Ocular estimation of tree crown cover may be carried out or any other method such as the line transect method or the relascope method may be applied
Monitoring frequency:	NA
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied

304

Data / Parameter:	*DBH*
Data unit:	cm or any unit of length
Used in following equations:	2, 15

Description:	Usually the diameter at breast height of the tree, but it could be any other diameter or dimensional measurement (e.g. basal diameter, root-collar diameter, basal area, etc.) applicable for the model or data source used
Source of data:	Field measurements in sample plots. For ex ante estimations, *DBH* values should be estimated using a growth curve, a growth model, or a yield table that gives the expected tree dimensions as a function of tree age
Measurement procedures (if any):	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Monitoring frequency:	Every five years since the year of the initial verification
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied

Data / Parameter:	*H*
Data unit:	m or any other unit of length
Used in equations:	2, 15
Description:	Height of tree
Source of data:	Field measurements in sample plots. For ex ante estimations, *H* values should be estimated using a growth curve, a growth model, or a yield table that gives the expected tree dimensions as a function of tree age
Measurement procedures (if any):	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Monitoring frequency:	Every five years since the year of the initial verification
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the *IPCC GPG LULUCF 2003*, are applied
Comments:	Models used may be based on total tree height (top height) or height of stem (clear bole height). The relevant height should be measured/estimated and used

Data / Parameter:	*T*
Data unit:	Year
Used in equations:	12, 26, 32
Description:	Time period elapsed between two successive estimations of carbon stock in trees and shrubs
Source of data:	Recorded time
Measurement procedures :	N/A
Comments:	If the two successive estimations of carbon stock in trees are carried out at different points of time in year t_2 and t_1, (e.g. in the month of April in year t_1 and in the month of September in year t_2), then a fractional value is assigned to *T*

IV. References

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. URL: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>.

IPCC, 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, prepared by the National Greenhouse Gas Inventories Programme, Jim Penman, Michael Gytarsky, Taka Hiraishi, Thelma Krug, Dina Kruger, Riitta Pipatti, Leandro Buendia, Kyoko Miwa, Todd Ngara (eds). Published: IGES, Japan. URL: <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html>.

- - - - -

History of the document

Version	Date	Nature of revision(s)
02.1.0	EB 60, Annex 13 15 April 2011	In this amendment: (i) Equations for estimation of the means and variances of tree biomass at stratum level and at project level have been included; (ii) Estimation of tree biomass is made on a per hectare basis, so that plotless sampling (point sampling) methods can be seamlessly applied; (iii) An approach for estimation of change in biomass based on successive measurements of the same plots has been added; (iv) Some entries in data and parameter tables have been updated to include more clear guidance in commonly encountered field situations; (iv) Bark correction has been proposed in cases where a volume table based on under-bark volume is used in conjunction with biomass expansion factors based on over-bark volume (or vice versa).
02.0.0	EB 56, Annex 13 17 September 2010	In this revision: (i) Scope of the tool has been expanded so that it can be applied in both baseline scenario and project scenario; (ii) Procedure for estimation of shrub biomass has been simplified by adopting a default estimation approach based on a fraction of forest biomass; (iii) The mathematical notation and equations have been changed so to streamline these; (iv) General layout and style of the document has been changed so as to make it in conformity with other documents such as the recently approved A/R methodologies; and (v) The title was changed to "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" from the previous title "Estimation of changes in the carbon stocks of existing trees and shrubs within the boundary of an A/R CDM project activity". Due to the overall modification of the document, no highlights of the changes are provided.
01	EB 46, Annex 18 25 March 2009	Initial adoption.
Decision Class: Regulatory **Document Type**: Tool **Business Function**: Methodology		