Approved afforestation and reforestation baseline and monitoring methodology AR-AM0010

"Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas"

Source

This methodology is based on the draft CDM-AR-PDD: "AES-Tiete Afforestation/Reforestation Project Activity Around the Borders of Hydroelectric Plant Reservoirs" whose baseline study, monitoring and verification plan and project design document were prepared by AES Tietê (Brasil). For more information regarding the proposal and its consideration by the Executive Board please refer to case ARNM0034: "Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas" at: http://cdm.unfccc.int/goto/ARpropmeth.

SECTION I. SUMMARY AND APPLICABILITY OF THE BASELINE AND MONITORING METHODOLOGIES

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

"Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts."

2. Applicability

The methodology is applicable to the following categories of project activities:

Afforestation and reforestation (A/R) implemented on unmanaged grassland in reserves or protected areas that are not likely to be converted to any other land use except forestry, and which have no potential to revert to forest without direct human intervention.

The methodology anticipates as the baseline scenario:

Maintenance of the present land use as unmanaged grassland, including allowing for implementation of non-CDM forestry on lands with similar characteristics to the project area at a rate (the non-CDM baseline forestry rate) that is much smaller than the planned rate of A/R under the CDM project activity.

The conditions under which this methodology is applicable to A/R CDM project activities are:

- The methodology is applicable only if project proponents can clearly show that baseline approach 22(c) of the CDM Modalities and Procedures—*Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts*—is the most plausible baseline scenario
- The most likely land use at the time the project starts shall be unmanaged grassland with A/R implemented at a non-CDM baseline forestry rate. This rate may be zero, in which case the most likely land use at the time the project starts is continuation as unmanaged grassland.
- Land to be afforested or reforested shall comprise unmanaged grassland which is designated as a reserve/protected area, and is not likely to be converted to any other land use except forestry. The grassland may include areas with either a steady-state or slowly regenerating woody cover of shrubs and/or scattered trees. However, the land shall have no potential to revert to forest

without direct human intervention (through planting, seeding, or promotion of natural seed sources).

- The project activity does not lead to a shift of pre-project activities to outside of 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.
- The biomass of herbaceous vegetation within the project boundary at the start of the project is at steady-state, or is declining due to competition from woody species, and so baseline removals by herbaceous vegetation can be conservatively neglected.
- The soil carbon pool within the project boundary is at steady state at project commencement: that is, the project boundary shall not include areas that within the last 20 years were either severely degraded[1], or have been used for agricultural cropping for more than 3 years.
- Site preparation to afforest or reforest is carried out in such a way as to avoid levels of soil disturbance or soil erosion sufficient to significantly[2] reduce the soil carbon pool over the project lifetime.
- The land within the project boundary will be afforested or reforested by direct planting and/or seeding of trees to establish a forest that complies with the minimum forest thresholds advised to the CDM Executive Board by the host country's DNA.
- Nitrogen-fixing (N-fixing) trees planted as part of the A/R CDM project activity account for less than 10% of the total planted forest crown area, so nitrous oxide (N_2O) emissions from decomposition of litter from the N-fixing trees can therefore be considered insignificant.
- No direct human-induced activities leading to loss of carbon stocks (such as harvesting, selective logging, fuel gathering, removal of litter, or removal of dead wood) shall occur on lands within the project boundary.
- Carbon stocks in the dead organic matter pools (litter and dead wood) are expected to be smaller in the absence of the proposed A/R CDM project activity, relative to the project scenario, and therefore accounting of these pools can be conservatively neglected.
- Flood irrigation or drainage of primarily saturated soils are not permitted as part of A/R CDM project activities, so non-CO_2 greenhouse gas emissions from these activities can therefore be neglected.
- If the non-CDM baseline forestry rate is other than zero, the only approach to address non-permanence is to claim emissions reductions as tCERs.

---

[1] Severely degraded land, here, refers to the definition in the IPCC 2006 Guidelines (Chapter 6, Table 6.2, pp. 6.16; IPCC 2006), implying "major long-term loss of productivity and vegetation cover, due to severe mechanical damage to the vegetation and/or severe soil erosion".

[2] Whether the risk of increased soil erosion is significant can be determined using the criteria provided in EB Meeting Report 33, Annex 15: *Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected in CDM A/R project activities.*

3. Selected Carbon Pools and Emissions Sources

Table A: Selected carbon pools

Carbon pools	Selected (Yes or No)	Justification / Explanation of choice
Above-ground biomass	Yes	Major carbon pool subject to the project activity
Below-ground biomass	Yes	Major carbon pool subject to the project activity
Dead wood	No	Conservative approach under applicability condition
Litter	No	Conservative approach under applicability condition
Soil organic carbon	No	Conservative approach under applicability condition

Table B: Emissions sources included in or excluded from the project boundary

Sources	Gas	Included/ excluded	Justification /Explanation of choice
Combustion of fossil fuels	CO_2	Included	Main gas of this source
	CH_4	Excluded	Potential emissions are negligibly small
	N_2O	Excluded	Potential emissions are negligibly small
Use of fertilizers	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Included	Main gas for this source. Only direct emissions need be considered for A/R activities.
Removal of grassland vegetation during site preparation for A/R	CO_2	Included	Main gas for this source
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable
Biomass burning (use of slash-and-burn practices during site preparation, or from wildfire)	CO_2	Included	Important gas of this source
	CH_4	Included	Non-CO_2 gas emitted from biomass burning
	N_2O	Included	Non-CO_2 gas emitted from biomass burning

4. Summary of Baseline and Monitoring Methodologies

Baseline methodology (summary/steps)

This baseline methodology is applicable only for a proposed A/R project activity implemented on unmanaged grassland in reserves or protected areas, and in regions where non-CDM forestry on lands with similar characteristics to the project area occurs at a rate that is smaller than the planned average rate of afforestation or reforestation under the CDM project activity. The methodology comprises the following major elements:

- *Definition of the project boundary.* The project boundary is defined for all discrete parcels of land that are eligible for afforestation or reforestation (as applicable) under a A/R CDM project activity, and that are under the control of the project participants at the starting date of the project. The perimeter of the area(s) where the A/R CDM project activity will be implemented shall be geographically identified using one or more of: geo-referenced remotely sensed data of adequate spatial/spectral resolution, direct survey of boundary features or markers using a Global Positioning Satellite (GPS) receiver, or delineation of recognisable features on national topographic or other maps of adequate spatial/thematic resolution.
- *Carbon pools accounted.* Carbon stock changes in only the above-ground and below-ground living biomass pools are estimated. The omission of the other pools (dead wood—including standing dead wood—and litter and soil organic matter) is conservative because it can be justified that such pools would in the absence of the project:
    - Either decrease more or increase less, relative to the project scenario—the case for the dead organic matter pools.
    - Either remain static or, if decreased through A/R activities, any decrease would be more than offset by retention on site of the litter and dead wood pools—the case for the soil organic matter pool.
- *Stratification.* The proposed A/R project area is stratified in a manner consistent with available information on key factors controlling average GHG removals and emissions, for the *ex ante* baseline and project scenarios. The *ex ante* project scenario is straightforward: stratification is based on parameters that are key variables in any method (e.g., growth models, or yield curves/tables) used to estimate biomass. Typically these are forest species, age class (planting date), stocking, and possibly management regime—obtained from the project planting plan.

  For *ex ante* estimation of baseline removals, a relatively complex approach to stratification is required to account for the presence of areas with regenerating vegetation. This requires a hierarchical approach be taken, beginning with identification of two categories of baseline strata: those with a static vegetation cover, and those with a regenerating cover of woody species. Strata with a static vegetation cover are further subdivided into areas either with biomass at steady state (i.e. no carbon removals—including, under one of the applicability conditions, all areas of herbaceous vegetation), or with actively growing woody biomass for which removals are estimated. Strata with a regenerating vegetation cover are assumed to develop biomass equal to the average observed for that vegetation cover in a climax successional state, so strata with vegetation in both regenerating and climax states must be identified.

  Also identified as part of stratification are those reserve/protected lands outside the boundary of the proposed project that have a similar climate, physical characteristics, and land-use history to the proposed project area, and also have a similar history of financial, legal, and regulatory/policy constraints/conditions/incentives. Such lands, together with the proposed project area, form what is termed in this methodology: *the non-CDM baseline forestry stratum*. Non-CDM forest planting rates in this stratum are used to determine what is termed in this methodology: *the non-CDM baseline forestry rate*.

- *Baseline approach and additionality.* The methodology applies Approach 22(c) as the baseline approach for the proposed A/R project activity. Plausible and credible land use alternatives are developed by taking into account current and historic land use/cover changes; national, local and sectoral policies and regulations; and private activities that influence use of land in reserves and protected areas. The level of enforcement of policies and regulations, together with consideration of common practice in the region[3] in which the project is located, are also considered.

  This methodology is applicable only if project participants demonstrate transparently that the most likely land use at the time the project starts is unmanaged grassland with a non-CDM baseline forestry rate (which may be zero). Additionality is established using the latest version of the "*Tool for the demonstration and assessment of additionality for afforestation and reforestation CDM project activities*"[4], under a combined barriers, investment and common-practice analysis. Assessment of additionality must also establish transparently that if there is non-CDM forestry on similar lands in the region (i.e., within the non-CDM baseline forestry stratum), the increased rate of A/R proposed by the project activity would not occur in the absence of the project activity, and results from direct intervention by the project participants[5]. This is achieved by demonstrating that the average annual non-CDM baseline forestry proportional forestry rate ($PFR_{non\text{-}CDM}$)—that is, the average annual forest planting rate (ha yr^{-1}) in the non-CDM baseline forestry stratum, divided by the stratum area (ha)—is less than the average annual rate of project A/R calculated as the A/R area (in ha) within the proposed project boundary, divided by the project duration (in years).

- *Estimation of baseline net GHG* removals *by sinks.* Baseline net GHG removals by sinks are determined *ex ante* for each stratum that includes growing woody species. A conservative approach is adopted by assuming no carbon stock losses occur due to grazing animals, disturbances (such as fire), or mortality. For strata with growing trees or shrubs, removals are estimated by assuming that regenerating areas eventually reach the average biomass observed for areas with these vegetation types in a climax successional state—that is, areas with mature vegetation at maximum biomass and crown cover. It is envisaged that:
  - Grassland areas with regenerating shrubs, but with no trees or tree seedlings, can be assumed to develop over time the average biomass of areas of shrubland in a climax state.
  - Grassland areas with regenerating trees, but with no shrubs or shrub seedlings, can be assumed to develop over time the average biomass of areas of trees in a climax state.
  - Grassland areas with regenerating shrubs and trees can be assumed to develop over time the average biomass of areas of mixed trees and shrubs in a climax state. This may be

---

[3] For this methodology, a "region" shall be considered to be that area centred on the proposed project area, and within a radius sufficient to include an area of the non-CDM baseline forestry stratum equal to at least 20 times the proposed project area.

[4] Throughout this document the phrase "*A/R additionality tool*" refers to the document approved by the CDM Executive Board at its 21st meeting (EB 21, Annex 16) and any subsequent amendments, as applicable. The document is available at <hppt://cdm.unfccc/int/methodologies/ARmethodologies/approved_ar.html>.

[5] As required by the CDM Executive Board at its 24th meeting (EB24, Annex 19, "Afforestation/reforestation in the baseline scenario").

conservatively approximated as the sum of the individual average biomass of trees in a climax state, and shrubs in a climax state.

- *Accounting for the effect of A/R in the baseline scenario.* If there is non-CDM forestry in the baseline scenario, its effect is that—in the absence of the project—a fraction of the proposed project area equal to $PFR_{non\text{-}CDM}$ would on average still likely be forested each year. This is equivalent to each year further reducing (i.e. discounting) the project area by the fraction $PFR_{non\text{-}CDM}$, and thus discounting the project net anthropogenic removals by sinks. Accounting for A/R in the baseline scenario as a discount on project net anthropogenic removals thus provides a very simple and direct approach for dealing with A/R in the baseline scenario that is consistent with the requirements of the CDM Executive Board[5]. In any year, the discount factor applied is equal to $PFR_{non\text{-}CDM}$ multiplied by the number of years that have elapsed since the project started. A value for $PFR_{non\text{-}CDM}$ is determined in a conservative manner from average non-CDM planting rates observed in the non-CDM baseline forestry stratum (see Section II.2.2).
- *Estimation of GHG removals by sinks:* The *ex ante* estimation of GHG removals by sinks accounts for changes in carbon stock in the living biomass pools according to the standard *carbon gain-loss* method found in the IPCC's Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF)[6]. Estimation of biomass stocks uses available data on growth models or yield curves from national or regional inventory, IPCC literature, or peer-reviewed scientific publications and reports. These same sources of information are used to provide, as required, biomass expansion factors (BEFs) and root-shoot ratios to convert estimates of merchantable volume to total biomass, or to provide allometric equations to estimate total (or above-ground) biomass more directly. As noted earlier, net anthropogenic GHG removals by sinks are discounted to account for the rate of non-CDM forestry in the baseline scenario.
- *Estimation of project emissions.* The loss of living biomass that existed at the start of the project, due to site preparation or competition from planted trees, is accounted as an emission within the project boundary. This is done in a conservative manner *ex ante*, by assuming all living biomass is oxidized at the start of the project. In addition, increases in GHG emissions as a result of the following activities within the project boundary are accounted: biomass burning, combustion of fossil fuels, and application of nitrogenous fertilizers.
- *Estimation of leakage emissions.* Leakage is accounted as emissions from use of fossil fuel in transportation to the project area of staff, seedlings, and other materials attributable to implementation of the proposed A/R project activity. These emissions are expected to be minor.

Monitoring methodology (summary/steps)

The monitoring methodology is based on standard forest inventory practice, and comprises the following major elements:

- *Assessment of project* implementation. Provision of information, recorded in the project design document (PDD), to establish that:
  - The geographic position of the project boundary is recorded for all parcels.
  - Applicability conditions are met.
  - Commonly accepted principles of forest inventory are implemented.

---

[6] *Good Practice Guidance for Land Use, Land-use Change and Forestry* (IPCC 2003). This is available from the IPCC Secretariat (www.ipcc.ch), or may be downloaded from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

  - Implementation of forest planting and management activities are in accordance with the project plan used as the basis for making *ex ante* estimates of net GHG removals by sinks[7].

- *Stratification and sampling. Ex post* stratification for project removals by sinks will in general be the same as that used for *ex ante* estimates: that is, based on important variations in growth rate due to variation in tree species, age, stocking, climate, and site class. Stratification should be reviewed once sampled biomass data become available, and adjusted if necessary to account for differences between planned and actual forest establishment and management, or unexpected disturbances, or merging of strata where changes in biomass stocks are similar. The methodology uses permanent sample plots to monitor carbon stock changes in living biomass pools, with the number of plots needed in each stratum based on achieving a targeted precision level in estimated biomass of ± 10% of the mean at a 95% confidence level.

  It is not mandatory that baseline net GHG removals by sinks be determined *ex post*. However, project participants may choose to determine baseline removals *ex post* if required, following the *ex ante* approach. This methodology does, however, require that assumptions and applicability conditions relating to the baseline state be reassessed if a renewal of the crediting period is chosen, and baseline removals re-calculated if necessary. This includes reassessment of the non-CDM baseline forestry rate, which remains fixed within crediting periods. Project participants shall provide transparent and verifiable information at each renewal of the crediting period to determine whether the original baseline approach and scenario are still valid, or have to be updated.

- *Estimation of GHG removals by sinks.* The *ex post* estimation of GHG removals by sinks uses standard permanent plot-based forest inventory methodology to quantify changes in carbon stocks in above-ground biomass for each stratum. Above-ground biomass stocks at each sampling date are estimated using verified allometric equation(s) or BEF approaches, based on measurements of stem diameter at breast height (and preferably also of height). Root-shoot ratios from authoritative published literature are used to estimate below-ground biomass.

- *Estimation of project emissions.* Increases in GHG emissions as a result of the following *ex post* activities within the project boundary are accounted: loss of living biomass that existed at the start of the project due to site preparation or forest planting, biomass burning, combustion of fossil fuels, and application of nitrogenous fertilizers.

- *Estimation of leakage emissions.* Leakage is accounted as emissions from use of fossil fuel in transportation to the project area of staff, seedlings, and other materials attributable to implementation of the proposed A/R project activity. These emissions are expected to be minor.

SECTION II. BASELINE METHODOLOGY DESCRIPTION

1. Project Boundary and Eligibility of Land

The A/R project activity may comprise more than one discrete parcel of land, and all parcels shall have a unique geographically-referenced identifier. The geographic boundary of each parcel shall also be delineated to make the entire project boundary geographically verifiable. All information related to establishing the project boundary shall be recorded, archived, and listed in the CDM-AR-PDD.

---

[7] In general any deviation from the project plan should result in a lower value of actual net anthropogenic GHG removals being achieved by the project compared with the equivalent *ex ante* estimate—otherwise any investment analysis used to establish project additionality may become invalid.

The geographic boundary of each land parcel can be determined using one or more of the following geo-referenced products, provided the data are current: orthorectified satellite imagery of adequate spatial/spectral resolution[8], aerial orthophotography (better than about 1:50,000 scale), or nationally-certified topographic maps and other nationally-recognised maps in hardcopy or digital form with adequate spatial/thematic resolution[9]. If geo-referenced products are not available, the project boundary can be established by identifying boundary features visible on imagery or photography, and obtaining geographic coordinates from suitable topographic maps or by using a Global Positioning Satellite (GPS) receiver[9] directly in the field. Alternatively, project participants can simply use GPS receivers to determine all vertices of land parcel polygons directly, by field survey.

All parcels of land within the project boundary shall either be under the control of the project participants at the starting date of the project activity, or expected to come under the control of the project participants during the crediting period as a result of implementation of the project activity. Parcels of land not under the control of the project participants at the start date of the proposed A/R project activity, but expected to come under the control of the project participants during the first crediting period, may be included within the project boundary only if all of the following conditions are met:

- The total area (hectares) of those parcels of land not yet under the control of the project participants is clearly defined in the CDM-AR-PDD; and
- A justification describing the conditions under which these parcels of land will come under the control of the project participants, including description of a verifiable basis for expectation that these parcels of land will come under the control of the project participants, is provided in the CDM-AR-PDD; and
- The candidate land areas among which the particular parcels of land will be chosen have been identified and are unambiguously geographically identified in the CDM-AR-PDD using GPS coordinates, maps, or other georeferenced data of sufficient accuracy; and
- All candidate land areas have been included in the baseline assessment, and it can be shown that the candidate areas are not significantly different from the land areas already under the control of the project participants at the start of the proposed AR CDM project activity in terms of: land eligibility, baseline net GHG removal by sinks, actual net GHG removal by sinks, leakage, socio-economic and environmental impacts, and policy/regulatory restrictions or incentives.

The eligibility of lands for A/R project activities under the clean development mechanism shall be assessed under new procedures approved by the Executive Board, when these become available. Until

---

[8] For satellite imagery, adequate spatial/spectral resolution (or, equivalently for maps, adequate spatial/thematic resolution) means a combination of pixel resolution and spectral information content sufficient to allow reliable identification of land cover and land-cover change relevant to discrimination of forest and non-forest land. If spectral information is sufficient at the pixel scale (or, equivalently for maps, thematic content at the map resolution and/or minimum mapping unit), it is still necessary to consider the size and shape of land parcels when choosing suitable imagery (or maps). Imagery with pixels representing a 30 m ground equivalent dimension will be suitable for larger areas, but higher spatial resolution imagery ($\leq$ 5 m ground equivalent dimension) may be needed for small land parcels or those with narrow and/or convoluted shapes—in which case, use of aerial orthophotographs, or direct field survey using GPS receivers, should also be considered.

[9] If GPS receivers are used, those with at least 8 channels are recommended (if available), to ensure overall accuracy of area estimation. This is especially the case if accurate placement of boundaries and estimation of areas is required for small land parcels (e.g. $\leq$ 1 ha), for which surveys should be completed quickly to avoid significant changes in the satellite constellation geometrical configuration.

that time, the eligibility of land for an A/R project activity shall be demonstrated based on definitions provided in Paragraph 1 of the Annex to Decision 16/CMP.1 ("Land use, land-use change and forestry"), as requested by Decision 5/CMP.1 ("Modalities and procedures for A/R project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol").

2. Stratification

If the project activity or area is not homogeneous, simple stratification should be carried out to improve the accuracy and precision of *ex ante* estimates of baseline and project removals by sinks. This methodology requires a specific baseline stratification approach to deal with the possibility that lands within the project boundary may have a regenerating cover of woody species, that however has no potential to reach forest proportions without direct human intervention. As well, the baseline stratification approach must also provide spatial delineation of the non-CDM baseline forestry stratum used to determine the non-CDM baseline proportional forestry rate, $PFR_{non\text{-}CDM}$. For this methodology, baseline stratification will likely require extensive access to current and historical spatial data in the form of land cover/use maps and geo-referenced satellite imagery or aerial photography—supplemented by field surveys, ecological surveys, and information on land-use history—to transparently and verifiably determine the potential for regeneration of woody species (shrubs and trees). By contrast, stratification for estimation of *ex ante* project removals by sinks is not methodology specific, and so is dealt with only briefly here.

2.1. Stratification for *ex ante* estimation of existing biomass and baseline removals by sinks

The baseline scenario requires the land within the project boundary to comprise unmanaged grassland, which may include areas of woody vegetation—shrubs and trees—that are below the thresholds of the definition of forest, and that are not expected to reach without direct human intervention the thresholds for forest land adopted by the host country. Stratification of the project area may be achieved using the hierarchical scheme depicted in Table 1, according to the following steps:

Step 2.1.1. Stratify by current vegetation

Subdivide the project area into an initial set of five strata on the basis of current vegetation cover (Table 1, *Current vegetation* column):

- Herbaceous vegetation[10] only.
- Herbaceous vegetation and shrubs[11] only.
- Herbaceous vegetation and trees only.
- Shrubs and trees only.
- Herbaceous vegetation, shrubs and trees.

Step 2.1.2. Stratify by regeneration as indicated by increasing crown cover

---

[10] The biomass of herbaceous vegetation is assumed to be at steady-state or declining through competition from woody species. Removals for herbaceous vegetation can thus be conservatively neglected.

[11] There is no universal definition that uniquely distinguishes shrubs from smaller trees. If both smaller trees and shrubs are part of existing vegetation, then a practical working definition to distinguish these vegetation types under field conditions shall be developed, and recorded in the CDM-AR-PDD as part of forest inventory standard operating procedures (SOPs). Any such definition should be consistent with common practice in the region or country in which the project exists, and shall be applied uniformly to both existing vegetation, and vegetation established as part of the project.

Using available data on current and historical land cover, subdivide in a transparent and verifiable manner each of the four strata formed in Step 2.1.1 that include woody species to create a new set of strata that comprise areas with woody species with crown cover that is either at steady state, or is significantly increasing (i.e. regenerating). The historical land cover data shall be available for a date at least 10 years prior to the start of the project. Areas for which the crown cover of either shrubs or trees has increased by more than an average of 0.5% per annum between the dates at which current and historical land cover are determined, and have not been subject to disturbance events, shall be considered to be regenerating—remaining areas shall be considered to have a crown cover at steady state.

If no suitable historical data are available for this stratification, or the area is known to be subject to disturbance but the exact disturbance or recovery state is unknown, assume all project areas with a current land cover including woody species are regenerating to a land cover of trees, shrubs and herbaceous species.

Step 2.1.3. Stratify non-regenerating areas by change in biomass

Use available data to establish in a transparent and verifiable manner the expected maximum height, or maximum diameter at the base or at breast height (as applicable), likely to be reached at maturity by trees and shrubs in the project area. Then, on the basis of field survey—and/or stereo interpretation of aerial photographs if a height criterion is used—subdivide the strata formed in Step 2.1.2, with a steady-state crown cover, into a new set of strata that comprises areas with trees and/or shrubs that are either at maturity (for which baseline removals are at steady state, and thus zero) or are still growing (for which removals must be estimated). Alternatively, if a good sequence of historical land use/cover data is available, use this to create the new strata based directly on separating out areas with trees and/or shrubs expected, because of age, to be at maturity and thus to possess biomass at a maximum steady-state value.

If no suitable data are available for this stratification, assume all project areas with a steady-state crown cover of trees and/or shrubs include trees and/or shrubs that are still growing.

Table 1. A stratification scheme for use in estimating existing biomass, and baseline removals by sinks. The scheme is hierarchical, and begins at the left with definition of strata by current vegetation. Successive subdivision (from left to right) of these initial strata by evidence of regeneration (i.e. increasing crown cover), evidence of increasing biomass, and likely climax vegetation is described in Steps 2.1.1 to 2.1.4, above. Herbaceous vegetation is considered to have a cover and biomass that is either at steady-state, or declining, under an applicability condition of the methodology.

Current vegetation	Crown cover	Biomass	Climax vegetation
Herbaceous	Not applicable	Steady state	Herbaceous
Herbaceous, shrubs	Steady state	Steady state	Herbaceous, shrubs
		Increasing	Herbaceous, shrubs
	Regenerating	Increasing	Herbaceous, shrubs
			Herbaceous, shrubs, trees
Herbaceous, trees	Steady state	Steady state	Herbaceous, trees
		Increasing	Herbaceous, trees

Current vegetation	**Crown cover**	**Biomass**	**Climax vegetation**
	Regenerating	Increasing	Herbaceous, trees
			Herbaceous, trees, shrubs
Shrubs, trees	Steady state	Steady state	Shrubs, trees
		Increasing	Shrubs, trees
	Regenerating	Increasing	Shrubs, trees
			Shrubs, trees
Herbaceous, shrubs, trees	Steady state	Steady state	Herbaceous, trees, shrubs
		Increasing	Herbaceous, trees, shrubs
	Regenerating	Increasing	Herbaceous, trees, shrubs
			Herbaceous, trees, shrubs

Step 2.1.4. Stratify regenerating areas by the likely climax state of vegetation

There are four strata identified in Step 2.1.2. that comprise regenerating areas of either shrubs and/or trees. The successional pathway for these strata is that they will either retain the present vegetation composition, or become areas comprising a more complex vegetation mix. Use available ecological information on factors controlling the success of regeneration and succession to develop in a transparent and verifiable manner a relationship between current vegetation, site factors and likely climax vegetation. The site factors shall preferably be available as existing spatial datasets covering the project area, or may if required be established by special purpose field surveys. Using the developed relationship, split strata with regenerating cover into areas that will retain the present vegetation components, or will become strata with a combined herbaceous/shrub/tree cover (see Table 1). Site factors may include, *inter alia*, such variables as: climate, soil types or properties (e.g., water holding capacity, fertility), soil parent material, landform (e.g., elevation, slope gradient), historical land use, management practices prior to land abandonment, systematic occurrence of fire, presence of pests, lack of an on-site seed pool, or lack of external seed sources.

If no suitable data on site factors are available, conservatively assume—since this will give rise to the largest baseline removals under the present methodology—that all project strata with a current vegetation cover that includes a regenerating woody component will achieve a climax vegetation cover of trees, shrubs and herbaceous vegetation.

Step 2.1.5. Stratify by variables likely to result in important variations in biomass

If the project area spans a sufficiently large or inhomogeneous area, variations in climate, soils or other factors controlling growth conditions may be important enough to warrant further subdivision of strata formed in steps 2.1.1 to 2.1.4. Such re-stratification may be useful if variation in factors controlling growth give rise to mean differences in biomass between areas within the project boundary of more than about 30%, in cases where baseline biomass and/or removals will be determined by measurement. However, if estimates of biomass and removals by sinks are to be developed using as defaults existing data in national or regional inventory, or data from IPCC or other peer-reviewed literature, this re-stratification step will only be appropriate if the default data available appear as an explicit function the variables used for re-stratification—and if not, stratification in this step should not be performed.

Step 2.1.5. Produce a final baseline stratification map

This is done according to the above steps, preferably completed in digital form using a Geographical Information System (GIS).

2.2. Stratification for estimation of the non-CDM proportional forestry rate

A critical part of this methodology is identification of the non-CDM baseline forestry stratum. This stratum comprises lands in the region[12] (and/or optionally up to national scales if credible information is available) that have a similar climate, physical characteristics, and land-use history to those in the proposed project area; and that also have been subject to similar financial, legal, and regulatory/policy constraints/conditions/incentives. Initially, the non-CDM baseline forestry stratum includes all lands within the project boundary, but once project areas are planted as part of project activities forest lands within the project boundary are excluded from the stratum (e.g., when re-evaluating the validity of the non-CDM baseline forestry stratum at a future re-crediting period).

The non-CDM baseline forestry stratum, and the non-CDM baseline annual proportional forestry rate, shall be determined in a transparent and verifiable manner from information on change in land cover/use between a current and historical date. Current land cover/use shall be determined at a date within a period of 2 years prior to the start of the project, but as close to the project start date as feasible. Historical land cover/use shall be determined at a date about 5 years prior to the date at which current land cover/use is determined. The date at which historical land use is determined may also be extended to up to 10 years prior to the date at which current land cover/use is determined—provided that it can be shown that applicable financial, legal, and regulatory/policy constraints/conditions/incentives that have operated over this longer period are not likely to have led to a significant increase[13] in forest planting rates over time, within the non-CDM baseline forestry stratum.

Stratification to define the non-CDM baseline forestry stratum shall be carried as give below. The procedure requires use of time sequential land cover/use maps of adequate spatial/thematic resolution, or remote sensing imagery (or aerial photography) of adequate spatial/spectral resolution—or some combination of these.

(i) At the current date, identify those lands in the region (or nationally, as applicable) that are reserves or protected lands, and are similar to the project area in terms of: climate and physical characteristics (soils and topography, primarily); land use history; and financial, legal, and regulatory/policy constraints/conditions/incentives. Include all reserves or protected areas even if the land cover is different from the project area, provided all other conditions are similar.

(ii) Remove from the area identified in step (i) all areas of planted forest for which transparent and credible evidence can be provided to prove that the planted forest was created in direct response

---

[12] For this methodology, a "region" shall be considered to be that area centred on the project area, and within a radius sufficient to include an area of the non-CDM baseline forestry stratum equal to at least 20 times the proposed project area.

[13] For the purposes of this methodology, a significant increase is one in which the average forest planting rate during the 5 years prior to the current date is 20% more than the average between 5 and 10 years before the current date. Forest planting rates can be determined from official national or regional forest statistics, as applicable, or from other credible sources.

to national and/or sectoral policies, or regulations, that have been implemented since 11 November 2001[14].

(iii) Also remove from the area identified in step (i) all areas of planted forest for which transparent and credible evidence can be provided to prove that the planted forest was created as a CDM project (if any).

(iv) The area remaining after application of steps (i)–(iii) defines the non-CDM baseline forestry stratum.

(v) Determine the increase in planted forest area within the non-CDM baseline forestry stratum between the historical and current dates. Divide this increase in area by the time between the dates to get the average annual area of non-CDM forest.

(vi) Identify also that area of forest in the non-CDM baseline forestry stratum previously planted by the project proponents, on the basis of transparent and verifiable information supplied.

(vii) To ensure a conservative approach, the average annual non-CDM proportional forestry rate, $PFR_{non\text{-}CDM}$, is estimated from the above land-use change analysis as the greater of:

- The average annual average area of forest planting in the non-CDM baseline forestry stratum, divided by the stratum area or;
- The average annual rate of forest planting by project proponents in the non-CDM baseline forestry stratum, divided by the proposed project area.

2.3. Use of baseline strata in estimation of existing biomass and baseline removals by sinks

Baseline biomass and removals are estimated by making use of the strata developed in Sections II.2.1 and II.2.2, as follows:

2.3.1. Estimation of existing biomass

Biomass stocks in vegetation existing at the time the project commences are estimated for the strata identified in Step 2.1.1 and listed in the *Current vegetation* column of Table 1. Estimation may be based either on nested plot-based sampling using temporary sample plots, or on use of default biomass data. Further stratification by site growth conditions may be performed, if warranted. If default data are used, an estimate of the proportion of each stratum occupied by trees, shrubs and herbaceous species will be required. This can be obtained either by field-based sampling, or from remotely sensed data (including aerial photography) of appropriate spatial/spectral resolution.

2.3.2. Estimation of biomass removals in non-regenerating strata

Biomass removals in non-regenerating areas need only be estimated for strata identified in Step 2.1.3 as having a steady-state crown cover, but increasing biomass (see Table 1). Estimation may be based either on use of biomass increment default data, or on repeat sampling of biomass in nested permanent sample plots. Further stratification by site growth conditions may be performed, if warranted. If default data are used, an estimate of the proportion of each stratum occupied by trees, shrubs and herbaceous species will be required. This can be obtained either by field-based sampling, or from remotely sensed data (including aerial photography) of appropriate spatial/spectral resolution.

---

[14] Such forest need not be considered when determining the non-CDM baseline stratum or non-CDM baseline forestry rate, in accordance with a ruling of the CDM Executive Board of the CDM: meeting EB16, Annex 3 (see http://cdm.unfccc.int/EB/Meetings).

2.3.3. Estimation of biomass removals in regenerating strata

Regenerating strata are identified in Step 2.1.2, and listed as “Regenerating” in the *Crown cover* column of Table 1. Biomass removals for regenerating strata are estimated as: the difference between the biomass of the climax state and that of the current vegetation, divided by the time required for the current vegetation to reach the climax state, t_{cv-c}. Estimation of biomass removals for regenerating strata thus requires that the following steps first be completed:

- Locate areas within the project boundary that have vegetation in the climax state identified for each stratum: those states identified in Step 2.1.4 and listed in the *Climax vegetation* column of Table 1. These areas will be in strata identified in Step 2.1.3 and listed as “Steady state” in the *Biomass* column of Table 1.
- If there are no such strata within the project boundary—or if the crown cover of either trees or shrubs in “Regenerating” strata exceeds that of the cover of trees or shrubs in “Steady state” strata—then Steps 2.1.1–2.1.3 shall be performed for the non-CDM baseline forestry stratum to identify areas of likely mature vegetation in a climax successional state.
- Estimate by using data from existing published peer-reviewed studies or official reports, or by plot-based sampling, the average age of tree and shrub vegetation in “Regenerating” strata within the project boundary. Estimate in the same way the average age of mature tree and shrub vegetation (i.e. with both crown cover and biomass at a climax steady state) in strata within the project boundary, or (if necessary) within the wider non-CDM baseline forestry stratum. If age varies widely, demonstrate that conservative average values are chosen (i.e. weighted by older trees and shrubs within the “Regenerating” strata, and younger trees and shrubs within “Steady state” strata). The variable t_{cv-c} is equal to the difference between the conservatively estimated average ages of trees, or shrubs (as applicable), in the climax “Steady state” and “Regenerating” strata. Average removals for regenerating strata are then calculated as the difference between: the tree or shrub biomass at the climax “Steady state”, and the tree or shrub biomass in “Regenerating” strata within the project boundary, as applicable; divided by the appropriate value of t_{cv-c} for trees or shrubs, as applicable.
- As a conservative alternative to the above step, which avoids the effort associated with determining average biomass levels, the following may also be adopted. Estimate by using data from existing published peer-reviewed studies or official reports, or by plot-based sampling, the maximum biomass of mature tree and shrub vegetation (i.e. with both crown cover and biomass at a climax steady state) achieved in relevant strata within the wider non-CDM baseline forestry stratum. Assume under these circumstances that the variable t_{cv-c} is equal to 30 years for trees, and 10 years for shrubs. Average removals for regenerating strata are then calculated as the maximum tree or shrub biomass divided by the appropriate value of t_{cv-c} for trees or shrubs, as applicable.

All information required to conservatively establish the average age of tree and shrub vegetation shall be summarised in the CDM-AR-PDD and archived for audit.

2.4. Stratification for estimation ex ante project removals by sinks

For *ex ante* estimation GHG removals by sinks, strata should be defined by:

(i) Using procedures to stratify lands for A/R project activities under the clean development mechanism as approved by the Executive Board; or

(ii) On the basis of parameters that are key variables in any method (e.g., growth models, or yield curves/tables) used to estimate biomass.

In most cases the project planting plan will contain sufficient information to complete *ex ante* stratification for estimating project removals by sinks—that is, subdivision of the project area by forest species, age class (planting date), stocking, and possibly management regime. Further subdivision of the project strata to represent spatial variation in the distribution of project removals by sinks is not usually warranted, unless methods used for *ex ante* estimates explicitly include variables for which spatial data also exist. For example, stratification by rainfall or pruning regime is not warranted when estimating biomass stocks or removals unless the estimation methods are formulated with rainfall or pruning regime as explicit variables.

2.5. Stratification to identify areas within the project boundary at risk of erosion

Project participants shall provide a map or digital spatial dataset identifying those lands within the project boundary for which the risk of soil erosion by water and/or wind is increased by implementation of the A/R project activity, if the increased risk is significant[15]. If areas of increased risk are identified, project participants may either exclude them from the project boundary, or plan for the implementation of practices to reduce the risk to insignificant[15] levels. Such practices shall be clearly described in the CDM-AR-PDD, and verified as being in place as part of monitoring activities (refer to *Section III.2. Monitoring of forest establishment*).

3. Procedure for Selection of the Most Plausible Baseline Scenario

Project participants should determine the most plausible baseline scenario using the following steps:

Step 1. Identify and list plausible and credible alternative land uses, including known public or private activities on similar reserve/protected lands (such as any similar forestry activity undertaken as a non-CDM project, or any other feasible land development activities). This should also include consideration of relevant national and or sectoral land-use policies or regulations that would impact the proposed project area, including provision of evidence that non-compliance is widespread if proposing a land-use alternative contrary to policies or regulations. This step should make use of, *inter alia*, land use records, field surveys, data and feedback from stakeholders, and information from other appropriate sources. As part of this, at least the land use alternatives below shall be considered:

- Continuation of the current land use as unmanaged grassland during the crediting period.
- The proposed project activity undertaken as a non-CDM project.
- Establishment of forest on unmanaged grassland at a mean annual non-CDM proportional forestry rate, $PFR_{non\text{-}CDM}$ (ha ha^{-1} yr^{-1}).

Step 2. Demonstrate that no natural regeneration of trees sufficient to exceed the host country's forest threshold is likely, by:

- Demonstrating that there is a lack of an on-site and external seed pools/sources that may result in natural regeneration with the project boundary; or

---

[15] Whether the increased risk is significant can be determined using the criteria provided in EB Meeting Report 33, Annex 15: *Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected in CDM A/R project activities.*

- Demonstrating that there are limited possibilities for seed germination and/or growth of seedlings or young trees within the project boundary because of natural climate/soil conditions, pest/disease impacts, or anthropogenic pressures; or
- Demonstrating through use of current and historical datasets, including supplementary surveys of current vegetation cover if necessary, that over a minimum period of 10 years prior to the project:
    - Either there was no significant[16] natural regeneration of trees with the project boundary;
    - Or that there are no significant[17] areas of naturally regenerated forest in the non-CDM baseline forestry stratum; or
- Using any other evidence that demonstrates in a transparent and verifiable way that natural regeneration of trees within the project boundary sufficient to exceed the host country's forest threshold is unlikely.

Step 3. If there is no evidence from Step 2 above, or obtained during the stratification process, that there is significant regeneration of trees likely to exceed the host country's definition of forest within the project area, then determine the mean annual non-CDM baseline proportional forestry rate, $PFR_{non\text{-}CDM}$, in the non-CDM baseline forestry stratum by:

- Performing a transparent and verifiable analysis of land-use change to determine the average annual rate of forest planted in the non-CDM baseline forestry stratum (see Section II.2.2).
- To ensure a conservative approach, $PFR_{non\text{-}CDM}$ is estimated from the land-use change analysis as the greater of:
    - The average annual regional or national rate of forest planting in the non-CDM baseline forestry stratum, divided by the stratum area or;
    - The average annual rate of forest planting by project proponents in that area of the non-CDM baseline forestry stratum, divided by the proposed project area as specified in transparent and verifiable information supplied on past A/R activities.

Step 4. Demonstrate that under the scenarios identified in Step 1, the most plausible scenario is that the most likely land use at the time the project starts—in the absence of the A/R CDM project activity—is either unmanaged grassland, or A/R of unmanaged grassland implemented at a non-CDM baseline forestry rate. This can be done in at least one of the following ways:

- *Generally:* by demonstrating that similar lands in the vicinity are not, and are not planned to be, used for any alternative land use. Show that apparent legal, regulatory, financial and/or other barriers, which prevent the plausible alternative land uses, can be identified.
- *Specifically, for forest as an alternative land use:* use the investment analysis, barrier analysis, or common practice analysis steps of the "*Tool for the demonstration and assessment of additionality*" to demonstrate that this land use, in the absence of revenues from the CDM A/R activity, is unattractive.
- *Specifically, for forest establishment at a non-CDM baseline proportional forestry rate (if other than zero):* use the investment analysis, barrier analysis, or common practice analysis steps of the

---

[16] Regeneration shall be considered significant if the crown cover of trees in undisturbed areas increased by more than an average of 0.5% per annum between the current and historical dates.

[17] The naturally regenerated forest area shall be considered significant if more than 5% of the area in which naturally regenerated trees occur in the non-CDM baseline forestry stratum exceeds the host country's definition of forest under the Marakesh Accords.

"*Tool for the demonstration and assessment of additionality*" to demonstrate that this land use, in the absence of the CDM A/R activity, is only likely to be implemented at an annual rate less than the average annual rate of project A/R calculated as the forested area (in ha) within the project boundary divided by the project duration (in years).

Step 5. Demonstrate that national and/or sectoral land-use policies or regulations that create policy-driven market distortions that give comparative advantage to A/R activities, and that have been adopted before 11 November 2001, do not influence the area of the proposed A/R project activity (e.g., because the policy is not implemented, the policy does not target this area, or because there are prohibitive barriers to the policy in this area, etc[18]). Otherwise, this methodology cannot be used.

Step 6. This methodology is applicable only if project proponents can clearly show that application of Steps 1 to 5 above results in identification of baseline approach 22(c)—"Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts"—is the most plausible baseline scenario. To ensure transparency when establishing the baseline approach, all information used in the analysis shall be verifiable, listed in the CDM-AR-PDD, and archived.

4. Additionality

This methodology addresses the issue of additionality in two steps, with the second step included to account for the fact that there is a possibility of A/R in the baseline scenario:

Step 1. The methodology uses the latest version of the *"Tool for the demonstration and assessment of additionality for afforestation and reforestation CDM project activities",* approved by the CDM Executive Board[19], to demonstrate additionality through investment, barrier and common practice analyses, as applicable.

Step 2. For projects with A/R in the baseline scenario, it is also required by the CDM Executive Board that "Assessment of additionality shall include justification that the increased rate of afforestation/ reforestation would not occur in the absence of the project activity and results from direct intervention by project participants."[20] In this methodology this shall be demonstrated through a transparent and verifiable analysis (as given in Section II.2) that shows the average annual non-CDM baseline proportional forestry rate ($PFR_{non\text{-}CDM}$)—which is applied as an annual accumulating discount to net anthropogenic GHG removals by sinks—is less than the average rate of project A/R calculated as the forested area (in ha) within the project boundary divided by the project duration (in years).

5. Estimation of Baseline Net GHG Removals by Sinks

The baseline net GHG removals by sinks is the sum of the changes in carbon stocks in the carbon pools within the project boundary that would have occurred in the absence of an A/R CDM project activity. The baseline is determined *ex ante*, and may also be determined *ex post* if required. It remains fixed during a crediting period, and is re-evaluated at the start of each subsequent crediting period. In estimating baseline net GHG removals by sinks, a conservative approach should be taken when choosing key parameters and making critical assumptions. That is, if different values or assumptions for a parameter are plausible, a value that does not lead to an under-estimation of baseline net GHG removals by sinks should be applied.

---

[18] This is to comply with a ruling of the Executive Board of the CDM, see Annex 3 of the 16th meeting of the Board at http://cdm.unfccc.int/EB/Meetings.

[19] Hereafter referred as "A/R additionality tool". Please refer to http://cdm.unfccc.int/goto/ARappmeth

[20] CDM Executive Board Meeting Report EB24, Annex 10, Paragraph 3.

For this methodology, baseline net GHG removals by sinks comprise two components: project baseline net GHG removals by sinks, and a second component that provides for simplified and conservative accounting of the effect of non-CDM forestry in the baseline scenario. For this methodology, it is assumed leakage emissions[21] (and, conservatively, project emissions) for non-CDM baseline forestry projects are similar to those for the proposed project, given that the non-CDM baseline forestry stratum comprises areas similar in all respects to the project area. Estimation of baseline removals by sinks thus proceeds by:

(i) Determining the sum of baseline carbon stock changes for each stratum within the project boundary. Strata are formed according to the hierarchical scheme given in Sections II.2.2 and II.2.3, and summarized in Table 1. For strata with:

- Biomass, or biomass components (trees, shrubs, or herbaceous species), at steady-state—carbon stock changes are zero.
- Crown cover at steady-state, but increasing biomass—the carbon stock change in shrub and/or tree biomass is determined based on the growth projections made using growth models (e.g., yield tables), biomass expansion factors or allometric equations, and/or on local, national, or IPCC default parameters and data
- Crown cover regenerating, and increasing biomass—the carbon stock change in shrub and/or tree biomass is determined from: the difference between the average biomass of the climax state of that stratum (see Table 1) and that of the current vegetation, divided by the time required for the current vegetation to reach the climax state, $t_{cv\text{-}c}$. Alternatively, removals may be conservatively estimated as: the maximum biomass of the climax state of the stratum (see Table 1) divided by a default time for $t_{cv\text{-}c}$ of 30 years for trees and 10 years for shrubs. Biomass in the climax state may be estimated directly from areas where vegetation is known to be in this state, or may be based on the growth projections made using growth models (e.g., yield tables), biomass expansion factors or allometric equations, and/or on local, national, or IPCC default parameters and data.

(ii) Summing the baseline net GHG removals by sinks across all strata within the project boundary.

(iii) Adding the contribution attributable to non-CDM forestry in the baseline scenario, by:

- Calculating the annual non-CDM baseline proportional forestry rate,$PFR_{non\text{-}CDM}$ (as described in Section II.2).
- Accounting for the effect of non-CDM forestry in the baseline scenario on project net anthropogenic removals by sinks by applying $PFR_{non\text{-}CDM}$ as an annually accumulating discount factor to reduce claimed CERs.

Thus, for any year *t*, total baseline net GHG removals by sinks are given by:

$$\Delta C_{BSL,t} = \Delta C_{BSL\text{-}project,t} + \Delta C_{BSL\text{-}A/R,t} \qquad \textbf{(B1)}$$

where:

$\Delta C_{BSL,t}$ Total annual baseline net GHG removals by sinks, for year *t*; t CO_2-e yr^{-1}

---

[21] Guidance on accounting of A/R in the baseline scenario was given by CDM Executive Board at its 24th meeting (EB24, Annex 19, “Afforestation/reforestation in the baseline scenario”).

$\Delta C_{BSL-project,t}$	Annual baseline net GHG removals by sinks within the project boundary, for year *t*; t CO_2-e yr^{-1}
$\Delta C_{BSL\text{-}A/R,t}$	Equivalent annual baseline net GHG removals by sinks due to A/R in the baseline scenario, for year *t*; t CO_2-e yr^{-1}
t	Time elapsed since the start of the project; *0 ... n*, yrs

5.1. Estimation of net GHG removals by sinks within the project boundary

Baseline removals by sinks within the project boundary are calculated for woody species only (i.e. shrubs and trees), as the biomass of herbaceous species is considered to be at steady-state under an applicability condition of the methodology. Thus[22]:

$$\Delta C_{BSL,\,project,\,t} = \sum_{i=1}^{n_{st}} \Delta C_{BSL-project,\,i,\,t} \tag{B2}$$

where:

$\Delta C_{BSL\text{-}project,\,t}$	Annual baseline net GHG removals by sinks within the project boundary, for year *t*; t CO_2-e yr^{-1}
$\Delta C_{BSL-project,i,t}$	Annual baseline net GHG removals by sinks within the project boundary for stratum *i*, for year *t*; t CO_2-e yr^{-1}
i	Number of strata; *1 ...* n_{st}
t	Time elapsed since the start of the project; *0 .... n*, yrs

The annual baseline net GHG removals by sinks are calculated as the annual stock change in biomass for shrubs and trees in those strata with increasing biomass (see Table 1).

5.1.1. Strata with a steady-state crown cover and increasing woody biomass

For stratum *i* with a steady-state crown cover of woody species, but with an increasing woody biomass (see Table 1), the baseline carbon stock change in living biomass of woody species is estimated using the carbon gain-loss method, with an annual time step assumed throughout[23]:

$$\Delta C_{i,\,t} = \Delta C_{G,i,\,t} - \Delta C_{L,i,\,t} \tag{B3}$$

where:

$\Delta C_{i,\,t}$	Annual carbon stock change in biomass of woody species in stratum *i,* for year *t*; t CO_2 yr^{-1}
$\Delta C_{G,\,i,\,t}$	Annual increase in carbon stock due to growth of woody species in stratum *i,* for year *t*; t CO_2 yr^{-1}
$\Delta C_{L,\,i,\,t}$	Annual decrease in carbon stock due to loss of biomass in woody species in stratum *i,* for

---

[22] Throughout this methodology, calculations are performed on an annual basis. These are integrated over a crediting period to provide data for estimating CERs. If changes in emissions and removals are determined by measurement at times separated by an interval longer than a year, divide the resultant data by the measurement interval in years to provide annual values for use in equations.

[23] IPCC 2006 Guidelines; equations 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, and 2.14.

	year t; t CO_2 yr^{-1}
i	Number of strata; $1 \ldots n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

<u>Note:</u> as a conservative assumption in this *ex ante* methodology, $\Delta C_{L,i,t} = 0$, for all strata and species.

Each stratum may comprise either a single woody species, or mixed types, depending on the stratification scheme adopted. In the general case, the annual increase in carbon stock in each stratum *i* due to growth of woody species in each year is this given by:

$$\Delta C_{G,i,t} = \Delta C_{G,i,\,tree,\,t} + \Delta C_{G,i,\,shrub,\,t} \qquad \textbf{(B4)}$$

where:

$\Delta C_{G,i,t}$	Annual increase in carbon stock due to growth of woody species in stratum i, for year t; t CO_2 yr^{-1}
$\Delta C_{G,i,tree,t}$	Annual increase in carbon stock due to growth of trees in stratum i, for year t; t CO_2 yr^{-1}
$\Delta C_{G,i,shrub,t}$	Annual increase in carbon stock due to growth of shrubs in stratum i, for year t; t CO_2 yr^{-1}
i	Number of strata; $1 \ldots n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

Biomass within each stratum is thus the sum of estimates derived by applying one, or more as appropriate, of the following two equations:

$$\Delta C_{G,i,tree,\,t} = \sum_{j_{tree}=1}^{n_{sp}} A_i \; G_{w,i,\,j_{tree},\,t} \; (1 + R_{1,j_{tree}}) \; CF_{tree} \; {}^{44}\!/_{12} \qquad \textbf{(B5)}$$

$$\Delta C_{G,i,\,shrub,\,t} = \sum_{j_{shrub}=1}^{n_{sp}} A_i \; G_{w,i,\,j_{shrub},\,t} \; (1 + R_{1,j_{shrub}}) \; CF_{shrub} \; {}^{44}\!/_{12} \qquad \textbf{(B6)}$$

where:

$\Delta C_{G,i,tree,t}$	Annual increase in carbon stock due to growth of trees in stratum i, for year t; t CO_2 yr^{-1}
A_i	Area of stratum i; ha
$G_{w,i,j_{tree},t}$	Annual above-ground biomass increment of tree species j in stratum i, for year t; t d.m. ha^{-1} yr^{-1}
$R_{1,j_{tree}}$	Root-shoot ratio appropriate for above-ground biomass increment for tree species j; t d.m. $(t\ d.m.)^{-1}$
CF_{tree}	Average carbon fraction of biomass for trees; t C $(t\ d.m.)^{-1}$
$\Delta C_{G,i,shrub,t}$	Annual increase in carbon stock due to growth of shrubs in stratum i, for year t; t CO_2 yr^{-1}
$G_{w,i,j_{shrub},t}$	Annual above-ground biomass increment of shrub species j in stratum i, for year t; t d.m. ha^{-1} yr^{-1}

$R_{1,j_{shrub}}$	Root-shoot ratio appropriate for above-ground biomass increment for shrub species *j*; t d.m. (t d.m.)$^{-1}$
CF_{shrub}	Average carbon fraction of biomass for shrubs; t C (t d.m.)$^{-1}$
j	Number of tree, shrub, or herbaceous species, as appropriate; *1 …n*$_{sp}$
t	Time elapsed since the start of the project; *0 …. n*, yrs
$44/12$	Ratio of molecular weight of CO$_2$ to carbon; g mol^{-1} (g mol^{-1})$^{-1}$

Estimation of above-ground tree and shrub biomass increment may be performed using existing data, or by direct destructive harvest including determination of age (see section II.5.2.3, below, for further information). However, in the particular case that the existing woody species are trees that have some commercial value, it is likely the above-ground biomass increment will be able to be estimated from (preferably, age-dependent) data available on mean annual increment of merchantable wood volume. When such data are available, the annual increment of above-ground biomass is given by:

$$G_{w,j,t} = I_{V,j,t} \;\; D_j \;\; BEF_{1,j,t} \tag{B7}$$

where:

$G_{w,j,t}$	Annual above-ground biomass increment for tree species *j* for year *t*; t d.m. ha^{-1} yr^{-1}
$I_{V,j,t}$	Annual increment in merchantable volume for tree species *j* for year *t*; m^3 ha^{-1} yr^{-1}
D_j	Wood density of tree species *j*; t d.m. m^{-3}
$BEF_{1,j,t}$	Biomass expansion factor for conversion of annual increment in merchantable volume to above-ground biomass increment for tree species *j* for year *t*[24]; t d.m. yr^{-1} (m^3 yr^{-1})$^{-1}$
j	Number of tree species; *1 …n*$_{sp}$
t	Time elapsed since the start of the project; *0 …. n*, yrs

5.1.2. Strata with a regenerating woody vegetation cover

For strata with a regenerating cover of woody species (see Table 1), the annual carbon stock change in living biomass for each year is estimated using the carbon gain-loss method in a similar manner to the last section above, using eqns. B2–B6. However, to account for the fact that both the crown cover and biomass of these strata are increasing, the annual above-ground biomass increment for woody species is calculated as: the difference between the average above-ground biomass of the climax state of that stratum (see Table 1) and that of the current vegetation, divided by the time required for the current vegetation to reach the climax state, $t_{cv\text{-}c}$. For trees and shrubs, respectively:

$$G_{w,i,j_{tree},t} = \left(B_{AB,C,i,j_{tree}} - B_{AB,i,j_{tree},t}\right) \big/ t_{cv\text{-}c,i,j_{tree}} \tag{B8}$$

$$G_{w,i,j_{shrub},t} = \left(B_{AB,C,i,j_{shrub}} - B_{AB,i,j_{shrub},t}\right) \big/ t_{cv\text{-}c,i,j_{shrub}} \tag{B9}$$

---

[24] If age dependent data are not available, a single value of the BEF can be used for all *t*.

where:

$G_{w,i,j_{tree},t}$	Annual above-ground biomass increment of tree species *j* in stratum *i,* for year *t*; t d.m. ha^{-1} yr^{-1}
$B_{AB,C,i,j_{tree}}$	Climax above-ground biomass stock of tree species *j,* in an area with similar growing conditions to project baseline stratum *i*; t d.m. ha^{-1}
$B_{AB,i,j_{tree},t}$	Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
$t_{cv\text{-}c,i,j_{tree}}$	Time estimated for the above-ground biomass stock of tree species *j* in stratum *i* and year *t* to reach the climax above-ground biomass stock $B_{AB,C,i,j_{tree}}$; yrs
$G_{w,i,j_{shrub},t}$	Annual above-ground biomass increment of shrub species *j* in stratum *i,* for year *t*; t d.m. ha^{-1} yr^{-1}
$B_{AB,C,i,j_{shrub}}$	Climax above-ground biomass stock of shrub species *j,* in an area with similar growing conditions to project baseline stratum *i*; t d.m. ha^{-1}
$B_{AB,i,j_{shrub},t}$	Above-ground biomass stock of shrub species *j* in stratum *i*, and year *t*; t d.m. ha^{-1}
$t_{cv\text{-}c,i,j_{shrub}}$	Time estimated for the above-ground biomass stock of shrub species *j* in stratum *i* and year *t* to reach the climax above-ground biomass stock $B_{AB,C,i,j_{shrub}}$; yrs
t	Time elapsed since the start of the project; *0 .... n*, yrs

As a conservative alternative, the above-ground biomass increment in equations (B8) and (B9) above may be estimated from the maximum above-ground biomass of the climax state alone, by assuming a default value of $t_{cv\text{-}c}$ of 30 years for trees or 10 years for shrubs (and setting the biomass of the current vegetation to zero).

Estimation of above-ground biomass may be performed using existing data, or by direct destructive harvest (see section II.5.2.3, below, for further information)—including determination of age to determine $t_{cv\text{-}c}$.

In the particular case that the existing woody species are trees that have some commercial value, it is likely the above-ground biomass will be able to be estimated from available data on merchantable wood volume (available as a function of stand age from yield curves or similar data). When such data are available, the above-ground biomass is given by:

$$B_{AB,j,t} = V_{j,t}\ D_j\ BEF_{2,j} \tag{B10}$$

where:

$B_{AB,j,t}$	Above-ground biomass stock of tree species *j,* for year *t*; t d.m. ha^{-1}
$V_{j,t}$	Merchantable volume for tree species *j* for year *t*; m^3 ha^{-1}
$D_{j,}$	Wood density of tree species *j*; t d.m. m^{-3}
$BEF_{2,j}$	Biomass expansion factor for conversion of merchantable volume to above-ground biomass for tree species *j* for year *t*; t d.m. m^{-3}

5.1.3. Determining parameters and data for estimation of GHG removals by sinks

Data required to estimate GHG removals by sinks may include: above-ground biomass or biomass increment of woody species, above-ground biomass of woody species in a climax state, and the time t_{cv-c} required for the current woody biomass to achieve that of the climax state. Values may also be needed for such parameters as the carbon fraction (*CF*), root-shoot ratio (*R*), wood density (*D*), and biomass expansion factors (*BEF*s). This information can be obtained by a combination of:

- Destructive harvest of vegetation in sample plots (see Section III.5 for details):
    - Above-ground biomass: destructive harvest within the appropriate strata identified in Section II.2.2, and depicted in Table 1, can be used to determine current and climax above-ground biomass. The maximum age of destructively harvested species in regenerating strata, and minimum age of destructively harvested species in climax strata, should be determined by growth-ring counting to provide a direct and conservative estimate of t_{cv-c}. If shrubs are being harvested, below-ground biomass could also be determined relatively easily, to provide a direct estimate of the root-shoot ratio (for which limited published data exist).
    - Above-ground biomass increment: an average value for this parameter can be calculated from the dry above-ground biomass of woody species divided by the species age (as determined from counting of growth rings from a basal stem section).
- Destructive harvest of individual trees or shrubs (see Section III.5 for details):
    - Above-ground biomass: allometric equations and/or BEFs can be developed to convert simply measured parameters such as stem diameter and height to above-ground woody biomass. If shrubs are being harvested, below-ground biomass could also be determined relatively easily, to provide a direct estimate of the root-shoot ratio (for which limited published data exist).
    - Above-ground biomass increment: allometric equations and/or BEFs developed from destructive harvest can be used in repeat measurements to estimate above-ground mean biomass increment. Alternatively, mean increment can be determined from a single biomass estimate if the age of the woody species is known or can be determined from stem core samples, or from counting of growth rings. If shrubs are being harvested, below-ground biomass could also be determined relatively easily, to provide a direct estimate of the root-shoot ratio (for which limited published data exist).
- Making use of data from available studies, chosen with the following priority:
    - (i) Existing local species-specific data from peer-reviewed studies or official reports; or
    - (ii) Regional/national species-specific data (e.g., from regional/national forest inventory); or
    - (iii) Species-specific data from neighbouring countries with similar climatic conditions. In the case of a large country that encompasses very different biome types, option (iii) might be preferable to option (ii) if project conditions differ substantially from those reported in national data; or
    - (iv) Global species-specific data (e.g., from the GPG-LULUCF).

If making use of existing data, note that:

(a) If species-specific information is not available, information for similar species—that is, with similar shape/form, and from the same species family (e.g., evergreen coniferous, or deciduous broadleaved)—can be used, with the data source priority as listed above for species-specific information.

(b) If using existing growth models to predict biomass, or to predict parameters (e.g., diameter at breast height, height) for use in existing allometric equations, the growth models must be valid for the age(s) of the woody species present in the project area. If using existing yield curves, these must be similarly valid.

(c) Note that trees under the baseline scenario are trees outside of a forest, and BEFs for such isolated trees are generally higher than for forest trees. If there are no data on BEFs of trees outside of a forest, then increasing BEFs of forest species by 30% is considered a conservative default.

5.2. Simplified accounting for A/R in the baseline scenario

If the project did not exist, it is likely that A/R in the baseline scenario would on average result in those lands that would have been in the project area becoming gradually afforested or reforested, at a rate equal to the non-CDM baseline proportional forestry rate $PFR_{non\text{-}CDM}$. By definition, forestry in the baseline scenario is occurring on similar lands to those within the project boundary. It is thus a reasonable assumption that that forest in the non-CDM baseline forestry stratum would achieve very similar net GHG removals by sinks to A/R for the project. The only significant difference might be that forest species with inherently different growth rates may possibly be used in the non-CDM, and project, A/R scenarios.

Accounting for forestry in the baseline scenario can therefore be simply implemented by successively reducing project net anthropogenic GHG removals by an amount equal to the annually aggregated area within the project boundary that would have likely been forested in the absence of the project: that is, by annual non-CDM baseline proportional forestry rate, $PFR_{non\text{-}CDM}$, multiplied by the time elapsed since the project commenced. Estimation of $PFR_{non\text{-}CDM}$ is described above in Section II.2. The effect of forestry in the baseline scenario can thus be accounted as:

$$\Delta C_{BSL-A/R,t} = PFR_{non-CDM} \;\; t \;\; R_{G,tree} \;\; \left(\Delta C_{ACTUAL,t} - \Delta C_{BSL-project,t} - LE_t\right) \qquad \textbf{(B11)}$$

where:

$\Delta C_{BSL-A/R,t}$	Equivalent annual baseline net GHG removals by sinks due to forestry in the baseline scenario, for year *t*; t CO_2-e yr^{-1}
$PFR_{non\text{-}CDM}$	The average annual non-CDM baseline proportional forestry rate (constant during a crediting period); ha ha^{-1} yr^{-1}
t	Time elapsed since the start of the project; *0 ... n*, yrs
$R_{G,\ tree}$	Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1); t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1} $)^{-1}$
$\Delta C_{ACTUAL,\ t}$	Annual actual net GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
$\Delta C_{BSL\text{-}project,\ t}$	Annual baseline net GHG removals by sinks within the project boundary, for year *t*; t CO_2-e yr^{-1}
LE_t	Total annual GHG emissions from leakage activities for year *t*; t CO_2-e yr^{-1}

Note that:

- The term in parenthesis in eqn. (B11) is equal to the project annual net anthropogenic GHG removals by sinks in the absence of A/R in the baseline scenario and is, together with eqn. (B11), evaluated in Sections II.8 and III.9.
- The parameter $R_{G,\,tree}$ need only take a value other than its default of 1 if quite different species from those being used for non-CDM forest in the baseline scenario are planned to be used in the A/R CDM project activity. Otherwise, published information can be used to provide data on annual above-ground biomass increment, selected according to the priority given in Section II.5.1.3. If $PFR_{non\text{-}CDM}$ is a small fraction (less than about 0.02 ha ha^{-1} yr^{-1}), differences in annual growth rates need to be considered only for the dominant non-CDM baseline and project forest species. Otherwise, a weighted average biomass increment for those tree species likely to account for about 90% of the total biomass increment should be estimated. Full references shall be provided for the sources of data used, and conservative choices shall be made, when selecting biomass increment data—with archiving and full referencing of all data used.

6. *Ex ante* Actual Net GHG Removals by Sinks

The actual net GHG removals by sinks are the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in GHG emissions—measured in CO_2 equivalents—by sources within the project boundary and attributable to the A/R CDM project activity:

$$\Delta C_{ACTUAL,\,t} = \sum_{i=1}^{n_{st}} \sum_{j=1}^{n_{sp}} \Delta C_{i,j,t} - PE_t \qquad \textbf{(B12)}$$

where:

$\Delta C_{ACTUAL,t}$	Annual actual net GHG removals by sinks, for year *t*; t CO_2-e yr^{-1}
$\Delta C_{i,j,t}$	Annual carbon stock change in biomass of tree species *j* in stratum *i*, for year *t*; t CO_2 yr^{-1}
PE_t	Total annual GHG emissions by sources within the project boundary from implementation of the A/R project activity, for year *t*; t CO_2-e yr^{-1}
i	Number of strata; *1 ....* n_{st}
j	Number of tree species; *1 ....* n_{sp}
t	Time elapsed since the start of the project; *0 ... n*, yrs

In choosing key parameters and making critical assumptions when estimating net GHG removals by sinks, project participants should retain a conservative approach: that is, if different values for a parameter are plausible, a value that does not lead to an over-estimation of actual net GHG removals by sinks should be applied.

6.1. Verifiable changes in carbon stocks in the carbon pools

The annual carbon stock change in the living biomass of trees established by the project—for stratum *i,* species *j,* for year *t*; $\Delta C_{ij,\,t}$—is estimated using the carbon gain-loss method described in Section II.5.1, using equations (B3) to (B6). As with *ex ante* estimation of baseline removals by sinks, *ex ante* estimation of change in carbon stocks in the carbon pools assumes losses are zero. This is because the project prohibits felling and fuelwood gathering through applicability conditions, and conservatively—

from the viewpoint of any investment analysis conducted as part of additionality—assumes that losses due to disturbance or mortality are zero over the project lifetime. Guidance on selection of parameters and data for *ex ante* estimation of the carbon stock change in the living biomass of trees established by the project is given in Section II.5.1.3, above.

6.2. GHG emissions by sources

The A/R project activity may cause GHG emissions within the project boundary. The emission of CO_2, CH_4 and N_2O from the following sources, also listed in Table B in Section II.3, may occur:

- Decrease in carbon stocks in living biomass of vegetation that existed at the time the project commenced, caused either by site preparation or competition from planted trees.
- Emissions of non-CO_2 GHG from biomass burning during slash-and-burn site preparation[25];
- Emissions of GHG from combustion of fossil fuels for site preparation, thinning and logging.
- Direct N_2O emissions caused by nitrogen fertilization application.

The total GHG emissions that result from implementation of the proposed A/R project activity within the project boundary are thus given by:

$$PE_t = E_{biomassloss,\,t} + E_{Non-CO2,\,BiomassBurn,\,t} + E_{FuelBurn,\,t} + E_{N-fertiliser,\,t} \qquad \textbf{(B13)}$$

where:

PE_t	Total annual GHG emissions by sources within the project boundary from implementation of the A/R project activity, for year *t*; t CO_2-e yr^{-1}
$E_{biomassloss,\,t}$	Annual CO_2 emissions from a decrease in carbon stock in vegetation biomass for year *t*; t CO_2 yr^{-1}
$E_{Non\text{-}CO2,\,BiomassBurn,\,t}$	Annual emissions from biomass burning, if this is used, for year *t*; t CO_2-e yr^{-1}
$E_{FuelBurn,\,t}$	Annual emissions from combustion of fossil fuels, for year *t*; t CO_2-e yr^{-1}
$E_{N\text{-}fertiliser,\,t}$	Annual emissions from application of nitrogenous fertiliser, for year *t*; t CO_2-e yr^{-1}
t	Time elapsed since the start of the project; *0 ... n*, yrs

Note—when estimating PE_t in the context of this methodology, accounting of emissions from site preparation involving clearance and/or burning of existing vegetation is performed only once, during the first monitoring period.

6.2.1. Calculation of CO_2 emissions from a decrease in existing vegetation

An increase in emissions of CO_2 may occur either as a result of clearance of existing trees, shrubs and herbaceous vegetation during site preparation (including by slash-and-burn practices), and/or from decay of un-cleared existing vegetation that subsequently dies as a result of competition from forest established as part of the A/R project activity. As a conservative assumption, for *ex ante* estimates it is assumed that

---

[25] It is possible that wildfire after the project starts may also cause emissions from trees existing at the time the project commences. Because the extent of such disturbance is unknown ex *ante*, such emissions are not considered here, but are for generality included as part of the monitoring methodology, in Section III. 5.

all existing vegetation in areas that will be subject to site preparation or forest establishment during the duration of the project is instantaneously oxidised at the time the project commences (i.e. at $t = 0$)[26].

In general, existing vegetation within the project boundary may comprise trees, shrubs and herbaceous vegetation (see Table 1), and thus the total CO_2 emissions can be estimated as:

$$E_{biomassloss,t} = \sum_{i=1}^{n_{st}} \left(E_{biomassloss,i,tree,t} + E_{biomassloss,i,shrub,t} + E_{biomassloss,i,herb,t} \right) \qquad \textbf{(B14)}$$

where:

$E_{biomassloss,i,tree,t}$	Annual CO_2 emissions in stratum i from a decrease in carbon stock in tree biomass, for year t; t CO_2 yr^{-1}
$E_{biomassloss,i,shrub,t}$	Annual CO_2 emissions in stratum i from a decrease in carbon stock in shrub biomass, for year t; t CO_2 yr^{-1}
$E_{biomassloss,i,herb,t}$	Annual CO_2 emissions in stratum i from a decrease in carbon stock in herbaceous biomass, for year t; t CO_2 yr^{-1}
i	Number of strata; $1 \ldots n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

Each stratum may comprise either a single vegetation type, or mixed types, depending on the stratification scheme adopted. Biomass within each stratum is thus the sum of estimates derived by applying one, or more as appropriate, of the following equations:

$$E_{biomassloss,i,tree,t} = \sum_{j_{tree}=1}^{n_{sp}} A_i \; f_{SP,i,t} \; B_{AB,i,j_{tree},t} \; (1+R_{2,j_{tree}}) \; CF_{tree} \; {}^{44}\!/_{12} \qquad \textbf{(B15)}$$

$$E_{biomassloss,i,shrub,t} = \sum_{j_{shrub}=1}^{n_{sp}} A_i \; f_{SP,i,t} \; B_{AB,i,j_{shrub},t} \; (1+R_{2,j_{shrub}}) \; CF_{shrub} \; {}^{44}\!/_{12} \qquad \textbf{(B16)}$$

$$E_{biomassloss,i,herb,t} = \sum_{j_{herb}=1}^{n_{sp}} A_i \; f_{SP,i,t} \; B_{AB,i,j_{herb},t} \; (1+R_{2,j_{herb}}) \; CF_{herb} \; {}^{44}\!/_{12} \qquad \textbf{(B17)}$$

where:

$E_{biomassloss,i,tree,t}$	Annual CO_2 emissions in stratum i from a decrease in carbon stock in tree biomass, for year t; t CO_2 yr^{-1}
A_i	Area of stratum i; ha
$f_{SP,i,t}$	Fraction of stratum i cleared during site preparation for year t, or planted at any time as part of project activities, whichever is greater; dimensionless

---

[26] For generality, the terms in equations (B14)–(B17) are expressed as functions of time, as the same equations are used for *ex post* calculations where site preparation could potentially occur in different parts of the project area in different years. However, for application of the equation in *ex ante* circumstances, the equations are applied only once (i.e. for *ex ante* calculations, if $t \neq 0$ then $E_{biomassloss,t} = 0$).

$B_{AB,i,j_{tree},t}$	Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
$R_{2,j_{tree}}$	Root-shoot ratio appropriate for above-ground biomass stock of tree species *j*; t d.m. (t d.m)$^{-1}$
CF_{tree}	Average carbon fraction for biomass of trees; t C (t d.m.)$^{-1}$
$E_{biomassloss,i,shrub,t}$	Annual CO_2 emissions in stratum *i* from a decrease in carbon stock in shrub biomass, for year *t*; t CO_2 yr^{-1}
$B_{AB,i,j_{shrub},t}$	Above-ground biomass stock of shrub species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
$R_{2,j_{shrub}}$	Root-shoot ratio appropriate for above-ground biomass stock of shrub species *j*; t d.m. (t d.m)$^{-1}$
CF_{shrub}	Average carbon fraction for biomass of shrubs; t C (t d.m.)$^{-1}$
$E_{biomassloss,i,herb,t}$	Annual CO_2 emissions in stratum *i* from a decrease in carbon stock in herbaceous biomass, for year *t* ; t CO_2-yr^{-1}
$B_{AB,i,j_{herb},t}$	Above-ground biomass stock of herbaceous species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
$R_{2,j_{herb}}$	Root-shoot ratio appropriate for above-ground biomass stock of herbaceous species *j*; t d.m. (t d.m)$^{-1}$
CF_{herb}	Average carbon fraction for biomass of herbaceous species; t C (t d.m.)$^{-1}$
j	Number of tree, shrub, or herbaceous species, as appropriate; $1 \ldots n_{sp}$
i	Number of strata; $1 \ldots n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs
$44/12$	Ratio of molecular weights of CO_2 and carbon; g mol^{-1} (g mol^{-1})$^{-1}$

Guidance on selection of parameters and data for *ex ante* estimation of the biomass of trees, shrubs and herbaceous species existing at the time the project commences is given in Section II.5.1.3, above—including the use of direct measurement, as described in more detail in Section III.5. If using data from local, regional or national inventory; or from peer-reviewed literature or official reports; it will be necessary to take into account the project circumstances in terms of, *inter alia*, any differences in species, mean (crown) cover, and overall growth conditions.

6.2.2. Calculation of GHG emissions from biomass burning

If slash-and-burn methods are practiced during site preparation for planting, this results in non-CO_2 emissions from burning of above-ground biomass—CO_2 emissions from loss of above-ground biomass will always be accounted in Section 6.2.1, above. As a conservative assumption, it is assumed that all burning of vegetation for site preparation occurs at the time the project commences (i.e. at $t = 0$)[27]

---

[27] For generality, the terms in equations (B18)–(B24) are expressed as functions of time, as the same equations are used for *ex post* calculations where site preparation could potentially occur in different parts of the project area in different years. As well, these equations are applied *ex post* if emissions due to wildfire need to be calculated. However, for application of the equation in *ex ante* circumstances, the equations are applied only once, at $t = 0$ (i.e. for *ex ante* calculations, if $t \neq 0$ then $E_{Non\text{-}CO2,\ BiomassBurn,\ t} = 0$).

The annual total equivalent CO_2 emissions from non-CO_2 gases released during biomass burning can be estimated as follows[28]:

$$E_{Non\text{-}CO2,\,BiomassBurn,\,t} = \sum_{i=1}^{n_{st}} \left(E_{BiomassBurn,\,N2O,\,i,\,t} + E_{BiomassBurn,CH4,\,i,\,t} \right) \qquad \textbf{(B18)}$$

where:

$E_{Non\text{-}CO2,BiomassBurn,\,t}$	Annual emissions from biomass burning, for year t; t CO_2-e yr^{-1}
$E_{BiomassBurn,\ N2O,\,i,\,t}$	Annual N_2O emissions from biomass burning in stratum i, for year t; t CO_2-e yr^{-1}
$E_{BiomassBurn,\ CH4,\,i,\,t}$	Annual CH_4 emissions from biomass burning in stratum i, for year t; t CO_2-e yr^{-1}
i	Number of strata; $1 \ldots n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

Emissions of N_2O and CH_4 due to biomass burning are given by:

$$E_{BiomassBurn,\,N2O,\,i,\,t} = L_{BiomassBurn,\ i,C_{AB},\ t} \left({}^{N}\!/_{C}\, ratio \right) ER_{N20}\ {}^{44}\!/_{28}\ GWP_{N20} \qquad \textbf{(B19)}$$

$$E_{BiomassBurn,CH4,\,i,\,t} = L_{BiomassBurn,\ i,C_{AB},\ t}\ ER_{CH4}\ {}^{16}\!/_{12}\ GWP_{CH4} \qquad \textbf{(B20)}$$

where:

$E_{BiomassBurn,\ N2O,\,i,\,t}$	Annual N_2O emissions from biomass burning in stratum i, for year t; t CO_2-e yr^{-1}
$E_{BiomassBurn,\ CH4,\,i,\,t}$	Annual CH_4 emissions from biomass burning in stratum i, for year t; t CO_2-e yr^{-1}
$L_{BiomassBurn,\ i,C_{AB},\ t}$	Annual carbon loss in above-ground biomass in stratum i due to biomass burning, for year t; t C yr^{-1}
${}^{N}\!/_{C}\ ratio$	Average nitrogen-carbon ratio for burned biomass; kg kg^{-1} (IPCC default: 0.01)
ER_{N2O}	Emission ratio for N_2O; mol N_20 (mol $N_2)^{-1}$ (IPCC default: 0.007)
ER_{CH4}	Emission ratio for CH_4; mol CH_4 (mol $C)^{-1}$ (IPCC default: 0.012)
GWP_{N2O}	Global Warming Potential for N_2O; kg CO_2-e (kg $N_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)
GWP_{CH4}	Global Warming Potential for CH_4, kg CO_2-e (kg $CH_4)^{-1}$ (IPCC default = 21, valid for the first commitment period)
${}^{44}\!/_{28}$	Ratio of molecular weights of N_2O and nitrogen; g mol^{-1} (g $mol^{-1})^{-1}$
${}^{16}\!/_{12}$	Ratio of molecular weights of CH_4 and carbon; g mol^{-1} (g $mol^{-1})^{-1}$

Each stratum may comprise either a single vegetation type, or mixed types, depending on the stratification scheme adopted. That is, for each stratum:

---

[28] Based on eqn. 3.2.20 in the GPG-LULUCF (IPCC 2003)

$$L_{BiomassBurn,\ i,\ C_{AB},\ t} = L_{BiomassBurn,\ i,\ C_{AB\text{-}tree},\ t} + L_{BiomassBurn,\ i,\ C_{AB\text{-}shrub},\ t} + L_{BiomassBurn,\ i,\ C_{AB\text{-}herb},\ t} \qquad \textbf{(B21)}$$

where:

$L_{BiomassBurn,\ i,\ C_{AB},\ t}$	Annual carbon loss in above-ground biomass in stratum *i* due to biomass burning, for year *t*; t C yr^{-1}
$L_{BiomassBurn,\ i,\ C_{AB\text{-}tree},\ t}$	Loss of carbon stock in the stratum *i* due to burning of tree above-ground biomass, for year *t*; t C yr^{-1}
$L_{BiomassBurn,\ i,\ C_{AB\text{-}shrub},\ t}$	Loss of carbon stock in the stratum *i* due to burning of shrub above-ground biomass, for year *t*; t C yr^{-1}
$L_{BiomassBurn,\ i,\ C_{AB\text{-}herb},\ t}$	Loss of carbon stock in the stratum *i* due to burning of herbaceous species above-ground biomass, for year *t*; t C yr^{-1}
i	Number of strata; $1 \ldots. n_{st}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

The carbon stock loss in above-ground biomass due to biomass burning is thus the sum of estimates derived by applying one, or more as appropriate, of the following equations:

$$L_{BiomassBurn,i,C_{AB-tree},t} = \sum_{j_{tree}=1}^{n_{sp}} A_i\ f_{Burn,i,t}\ B_{AB,i,j_{tree},t}\ CF_{tree}\ CE_{tree} \qquad \textbf{(B22)}$$

$$L_{BiomassBurn,i,C_{AB-shrub},t} = \sum_{j_{shrub}=1}^{n_{sp}} A_i\ f_{Burn,i,t}\ B_{AB,i,j_{shrub},t}\ CF_{shrub}\ CE_{shrub} \qquad \textbf{(B23)}$$

$$L_{BiomassBurn,i,C_{AB-herb},t} = \sum_{j_{herb}=1}^{n_{sp}} A_i\ f_{Burn,i,t}\ B_{AB,i,j_{herb},t}\ CF_{herb}\ CE_{herb} \qquad \textbf{(B24)}$$

where:

$L_{BiomassBurn,\ i,\ C_{AB\text{-}tree},\ t}$	Loss of carbon stock in stratum *i* due to burning of tree above-ground biomass, for year *t*; t C yr^{-1}
A_i	Area of stratum *i*; ha
$f_{Burn,\ i,\ t}$	Fraction of stratum *i* subject to biomass burning, for year *t*; dimensionless
$B_{AB,i,j_{tree},t}$	Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
CF_{tree}	Average carbon fraction for biomass of trees; t C (t d.m.)$^{-1}$
CE_{Tree}	Average combustion efficiency for trees; t d.m. burned (t d.m.)$^{-1}$
$L_{BiomassBurn,\ i,\ C_{AB\text{-}shrub},\ t}$	Loss of carbon stock in the stratum *i* due to burning of shrub above-ground biomass, for year *t*; t C yr^{-1}
$B_{AB,i,j_{shrub},t}$	Above-ground biomass stock of shrub species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
CF_{shrub}	Average carbon fraction of biomass for shrubs; t C (t d.m.)$^{-1}$
CE_{shrub}	Average combustion efficiency for shrubs; t d.m. burned (t d.m.)$^{-1}$

$L_{BiomassBurn,\ i,\ C_{AB\text{-}herb},\ t}$	Loss of carbon stock in the stratum *i* due to burning of herbaceous above-ground biomass, for year *t*; t C yr^{-1}
$B_{AB,i,j_{herb},t}$	Above-ground biomass stock of herbaceous species *j* in stratum *i*, for year *t*; t d.m. ha^{-1}
CF_{herb}	Average carbon fraction for biomass of herbaceous species; t C (t d.m.)$^{-1}$
C_{herb}	Average combustion efficiency for herbaceous species; t d.m. burned (t d.m.)$^{-1}$
i	Number of strata; $1 \ldots n_{st}$
j	Number of tree, shrub, or herbaceous species, as appropriate; $1 \ldots n_{sp}$
t	Time elapsed since the start of the project; $0 \ldots n$, yrs

Combustion efficiencies may be chosen from Table 3.A.1.14 of GPG-LULUCF (IPCC 2003). If no appropriate value is available from this Table, the IPCC default of 0.5 should be used—see Section 3.2.1.4.2.2 of the GPG-LULUCF (IPCC 2003). The nitrogen-carbon ratio (N/C ratio) is approximated as 0.01 (IPCC 2003). This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available.

Guidance on selection of parameters and data for *ex ante* estimation of the biomass of trees, shrubs and herbaceous species existing at the time the project commences is given in Section II.5.1.3, above—including the use of direct measurement, as described in more detail in Section II.5. If using data from local, regional or national inventory; or from peer-reviewed literature or official reports; it will be necessary to take into account the project circumstances in terms of, *inter alia*, any differences in species, mean (crown) cover, and overall growth conditions.

6.2.3. Calculation of GHG emissions from combustion of fossil fuels

Annual emissions from combustion of fossil fuels within the project boundary for year *t*, $E_{FuelBurn,\ t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[29]

6.2.4. Calculation of GHG emissions from application of nitrogenous fertilisers

Annual emissions from application of nitrogenous fertiliser within the project boundary, $E_{N\text{-}fertiliser,\ t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of direct nitrous oxide emission from nitrogen fertilisation*[30]

7. Leakage

In choosing key parameters and making critical assumptions about leakage, project participants should retain a conservative approach, i.e. if different values for a parameter are equally plausible, a value that is least likely to lead to over-estimation of leakage emissions should be applied.

Under the applicability conditions for the methodology, the only potential leakage emissions attributable to the proposed A/R project activity are those from vehicle fossil fuel combustion during transportation

---

[29] CDM Executive Board Meeting Report EB33, Annex 14: Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.

[30] CDM Executive Board Meeting Report EB33, Annex 16: Estimation of direct nitrous oxide emission from nitrogen fertilisation.

of seedlings, labor, materials and harvest products to and/or from project sites (while avoiding double-counting of emissions accounted for in $E_{FuelBurn,t}$ above). Thus:

$$LE_t = LE_{FuelBurn,\ t} \tag{B25}$$

where:

LE_t	Total annual GHG emissions due to leakage activities for year *t*; t CO_2-e yr^{-1}
$LE_{FuelBurn,\ t}$	Annual leakage emissions from combustion of fossil fuels, for year *t*; t CO_2 yr^{-1}

Annual emissions from combustion of fossil fuels outside the project boundary but attributable to project activities, $LE_{FuelBurn,\ t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[31]

Table C: Emissions sources included in or excluded from leakage

Sources	**Gas**	**Included/ excluded**	**Justification / Explanation of choice**
Combustion of fossil fuels by vehicles	CO_2	Included	Major gas for this source
	CH_4	Excluded	Potential emission is negligibly small
	N_2O	Excluded	Potential emission is negligibly small

8. *Ex ante* Net Anthropogenic GHG Removals by Sinks

Annual net anthropogenic GHG removals by sinks are calculated as actual net GHG removals by sinks, minus the baseline net GHG removals by sinks, minus leakage:

$$C_{AR\_CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LE_t \tag{B26}$$

where:

$C_{AR\_CDM,\ t}$	Annual net anthropogenic GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
$\Delta C_{ACTUAL,\ t}$	Annual actual net GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
$\Delta C_{BSL,\ t}$	Total equivalent annual baseline net GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
LE_t	Total annual GHG emissions from leakage activities for year *t*; t CO_2-e yr^{-1}
t	Years elapsed since the start of the project; *0 … n*, yrs

The term $\Delta C_{BSL,t}$ in eqn. (B26) includes baseline removals terms due both to the project scenario and to A/R in the baseline scenario, as given in eqn. (B1) and further described in eqn. (B11). Substituting for these terms in eqn. (B26) gives a general expression for annual net anthropogenic removals by sinks that accounts for baseline removals in both the project scenario and due to the effect of A/R in the baseline scenario:

---

[31] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

$$C_{AR\_CDM,t} = \left(\Delta C_{ACTUAL,t} - \Delta C_{BSL-project,t} - LE_t\right)\left(1 - PFR_{non-CDM}\ \mathrm{t}\ R_{G,tree}\right) \quad \textbf{(B27)}$$

where:

$C_{AR\_CDM,t}$	Annual net anthropogenic GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
$\Delta C_{ACTUAL,t}$	Annual actual net GHG removals by sinks for year *t*; t CO_2-e yr^{-1}
$\Delta C_{BSL-project,t}$	Annual baseline net GHG removals by sinks within the project boundary, for year *t*; t CO_2-e yr^{-1}
LE_t	Total annual GHG emissions from leakage activities for year *t*; t CO_2-e yr^{-1}
$PFR_{non-CDM}$	The average annual non-CDM baseline proportional forestry rate (constant during a crediting period); ha ha^{-1} yr^{-1}
t	Years elapsed since the start of the project; *0 .... n*, yrs
$R_{G,tree}$	Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1); t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1} $)^{-1}$

8.1. Calculation of tCERs and lCERs

Calculation of tCERs and lCERs shall be performed using the equations provided by the CDM Executive Board (EB22 Meeting Report, Annex 15). The following quantities estimated from annually-integrated data provided by this methodology shall be used in the calculation:

- Carbon stocks for the A/R project at the time of verification, $C_P(t_v)$; t CO_2-e
- Carbon stocks for the baseline scenario at the time of verification $C_B(t_v)$; t CO_2-e
- Project emissions for year *t*, PE_t; t CO_2-e
- Leakage emissions for year *t*, LE_t; t CO_2-e
- Year of verification, t_v; yr
- Time span between two verifications, κ; yrs

9. Data Needed for Ex ante Estimation

A list of the data required for *ex ante* estimation is given in Annex A1.

10. Other Information

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

It is recommended that project participants 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. If measured data are not available, or resources do not permit development of a sufficiently large dataset to obtain accurate mean data, these values should be based on:

- Data from well-referenced peer-reviewed literature or other well-established published sources[32]; 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 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)—plus inclusion of a 1-page summary CV for each expert consulted, included in an annex.

SECTION III: MONITORING METHODOLOGY DESCRIPTION

1. Monitoring of Project Implementation

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

(i) The geographic position of the project boundary is accurately and precisely recorded for all parcels, and the location of strata are established; and

(ii) All applicability conditions of the methodology are met; and

(iii) The implementation of forest planting and management activities are in accordance with the project plan used as the basis for making *ex ante* estimates of net GHG removals by sinks; and

(iv) Commonly accepted principles of forest inventory are implemented; and

(v) Any increased risk of erosion having a significant effect on soil carbon stocks has been mitigated; and

(vi) Monitoring plans have been developed to provide a record of the effect of project activities or natural events on project emissions and removals, and measures are in place to ensure all data and information are archived.

Information sufficient to confirm the requirements above may comprise, *inter alia:*

(i) To confirm the project and strata boundaries:

  - Establish the geographic coordinates of the designed project boundary such that the area of the project is accurately established. 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).
  - Once project activities are at a point that the physical limits of the boundary are evident, check that all land areas are within the designed boundary according to procedures in Section II.1. Exclude all areas outside the designed boundary.

---

[32] 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.

- Record and archive the geographic coordinates of the final project boundary, and strata boundaries—including any re-stratification *ex post* in response to post-inventory analysis of biomass spatial distribution, disturbance, or change in the non-CDM baseline forestry stratum.
- It recommended that, whenever possible, monitoring of the project and strata boundaries, and project activities, include use of georeferenced remote sensing imagery or photography—which if acquired in a timely manner has the advantage of providing transparent and readily archived evidence of project activities that is also easily amenable to digital analysis in a GIS (e.g., to determine the area of the project and strata).

(ii) To confirm applicability conditions:

- Information in peer-reviewed publications or official reports can be used to justify that the applicability conditions are valid; or
- Time sequential historical photographs, satellite images, maps, or other digital datasets can be used to provide evidence that applicability conditions are valid—including quantifying the degradation state of lands (if any), the rates of decline or regeneration in (or the static nature of) vegetation cover and/or extent bare ground, and that there is no significant natural forest regeneration; or
- Time sequential photographs from the time the project commences may be used to prove applicability conditions are valid—for example, by showing that erosion has not been increased by project implementation; or
- Documented interviews with local people can be used to justify applicability conditions, for example to establish that project lands will continue to provide the same amount of goods and services after the project commences; or
- Applicability conditions not able to be proven by one of the above approaches must be justified by provision of other transparent and credible evidence that is recorded in the CDM-AR-PDD.

(iii) To confirm forest planting and management activities:

- Record in the CDM-AR-PDD the forest planting and management plan used as the basis for *ex ante* estimates of net GHG removals by sinks, together with a record of the plan as actually implemented during the project.
- Develop standard operating procedures (SOPs) for actions likely to minimise soil erosion in those circumstances in which site preparation or planting involves soil disturbance likely to increase rates of soil erosion above baseline rates.

(iv) To confirm commonly accepted principles of forest inventory are implemented.

(v) Develop, and document in the CDM-AR-PDD, SOPs and quality control/quality assurance (QA/QC) procedures. Use or adaptation of standard procedures in published handbooks, or from the GPG-LULUCF, is recommended:

- Ensure training courses are completed by all staff unfamiliar with these procedures, and document the training provided.

2. Sampling Design

2.1. Stratification

If the project activity or area is not homogeneous, stratification of the project area should be carried out to improve the accuracy and precision of *ex post* biomass estimates. Stratification may make use of remote sensing data, if available. Stratification *ex post* may also be required if post-inventory analysis indicates strata should be combined or split, or to delineate areas of disturbance that may require installation of additional sampling plots. Strata may be defined by one or more of:

(i) Procedures to stratify lands for A/R project activities under the clean development mechanism as approved by the CDM Executive Board, as applicable.

(ii) The methodology provided in Section II.3, if estimating baseline removals in the project scenario *ex post* (though this is not mandatory), or if re-stratification is required to determine the non-CDM baseline forestry stratum, and the non-CDM baseline annual proportional forestry rate, at the start of a future crediting period.

(iii) For estimation of net GHG removals by sinks—according to the project planting plan; that is, by forest species, age class (planting date), and possibly management regime. Further subdivision of the project strata to represent spatial variation in the distribution of biomass/removals is not usually warranted unless methods used for *ex post* estimates explicitly include variables for which spatial data also exist.

(iv) By any other stratification approach that can be shown in the CDM-AR-PDD to allow estimation of *ex post* project biomass stocks in each stratum to the targeted precision level of ±10% of the mean at a 95% confidence level.

2.2. Sampling plots

Permanent sampling plots are strongly recommended for monitoring changes in carbon stocks of above- and below-ground biomass. Permanent plots are generally more statistically efficient than temporary sampling plots in estimating changes in carbon stocks over time, because there is typically a high covariance between observations at successive sampling dates. However, it should be ensured that the plots are treated in the same way as other lands within the project boundary—e.g., during site preparation, weeding, fertilization, irrigation, thinning, etc—and should not be destroyed over the monitoring interval. Ideally, staff involved in management activities should not be aware of the location of permanent sample plots. Where local markers are used, these should not be obvious. Use of a buried metal rod, that is later located using a metal detector, is suggested—together with recording of GPS coordinates to assist with locating the rods in future. If there is any modification of the stratification during the project to improve homogeneity within each stratum, the existing permanent sample plots in the affected strata shall be retained, and new plots added as necessary.

2.3. Determining sample size

To determine the sample size, this methodology uses the latest version of the tool for the "*Calculation of the number of sample plots for measurements within A/R CDM project activities*", approved by the CDM Executive Board[33]. The targeted precision level for biomass estimation within each stratum is ±10% of the mean at a 95% confidence level.

---

[33] CDM Executive Board Meeting Report EB31, Annex 15: *Calculation of the number of sample plots for measurements within A/R CDM project activities.*

2.4. Randomly locating sampling plots

To avoid subjective choice of plot locations (location of plot centres, plot reference points, or movement of plot centres to more "convenient" positions), permanent sample plots shall be located randomly, which is considered good practice [GPG-LULUCF (IPCC 2003)]. The geographical position (preferably, GPS coordinates), administrative location, and stratum series number of each plot shall be recorded and archived.

Sample plots must be distributed across the entire project area. For example, if one stratum is spread across multiple parcels, then the number of sample plots estimated to be required to meet the designed sampling precision should be spread among the parcels according to the percentage area that each parcel contributes to the stratum. For example, consider a single stratum spread across 3 parcels, with the parcels contributing 10%, 30% and 60% of the stratum area respectively. In this case, the 3 parcels should also contain 10%, 30% and 60%, respectively, of the total sample plots for that stratum.

Locating the plots randomly within a parcel can be achieved using either of the following two methods:

(i) Use a random position for the first plot, and thereafter locate plots sequentially at a fixed distance and direction from the last plot. The arrangement of the plots should take account of the total number of plots required to fit into the stratum area, without going outside of the stratum

(ii) Sample plot locations can be selected using available spatial data (i.e. GIS polygons, or georeferenced remote sensing imagery) that shows parcel and stratum boundaries. The stratum area in a parcel is divided into cells equal to the sample plot dimensions, and a random number between 1 and the total cell number are assigned to each cell. Sample plots are then assigned to those cells with sequential numbers that lie entirely within the stratum boundary—until the required number of sample plots has been assigned to the stratum area in the current parcel. Further information can be found in Stolbovoy et al. (2005).

2.5. Sample plot size and shape

The size of sample plots depends on the density of trees—in general between 100 m^2 for dense stands and 1000 m^2 for open stands, and sufficiently large to include at least 10 trees. Sample plots may be circular, square, or rectangular in shape—although circular plots are recommended because they are usually the simplest to implement and they also reduce the chance of bias in selection of corner positions in systematically planted plantations. However, if square or rectangular plots are used, the sides of each plot shall be placed parallel to the rows of planted trees, and each corner of the plot shall be set at a point which is at a distance as near as possible equal from surrounding trees. This may mean that the plots are of slightly varying sizes, and in which case plot dimensions must be carefully noted and checked.

2.6. Treatment of sample plots containing trees existing at the start of the project

Sample plots located for determining biomass of planted trees may sometimes also include within the plot perimeter trees existing at the time the project commences, if these were not removed during site preparation. The presence of such trees should be carefully noted so that their biomass contribution is excluded from estimates of net GHG removals by sinks.

2.7. Monitoring interval

The monitoring interval depends on the rate and variability of carbon accumulation; that is, on the magnitude and variation of growth rates within the project boundary. Although verification and certification shall be carried out every five years after the first verification until the end of the crediting period[34], the monitoring interval may be less than five years if desired. However, to reduce the monitoring cost, the monitoring intervals should coincide with verification times as far as possible; that is, a monitoring interval of five years. Logically, one monitoring and verification event will take place close to the end of the first commitment period (e.g., in the second half of 2012). Project participants shall determine the first monitoring time taking into account:

- The growth rate of trees and the financial resources of the project activity: the later the date of the first verification, the higher will be the amount of net anthropogenic GHG removals by sinks but the lower the financial net present value of a CER.
- Harvesting events and rotation length: The time of monitoring and subsequent verification and certification shall not coincide with peaks in carbon stocks[35]

3. Determination of *Ex post* Baseline Net GHG Removals by Sinks

3.1 Determination of project baseline removals *ex post*

Although not mandatory in this methodology, project participants may optionally determine baseline net GHG removals by sinks *ex post* by making plot-based or destructive measurements of biomass and biomass increment for vegetation that existed inside the project boundary at the time the project commenced (see Sections III.5.1.1 and III.5.2 below for further details on direct and indirect methods of biomass measurement). Alternatively, control sample plots may be established outside the project boundary for determining baseline net GHG removals by sinks *ex post*. The location of control plots should be chosen carefully to ensure environmental and other conditions are as similar as possible those within the project boundary: that is, they should be located in that part of the non-CDM baseline forestry stratum located outside, but adjacent to, the project boundary.

If biomass or biomass increment is to be determined using sample plots[36], their size should be sufficient to include 10-15 trees, with at least 5 plots spread across the spatial extent of each stratum. A large difference in the carbon stock change between the baseline scenario and project scenario is normally expected. If trees existing in the project area at the start of the project are very sparse, fewer than 5 plots could be used provided 10–15 trees are measured in each, as the accuracy of the estimate of baseline removals will in this case have only a limited effect on the accuracy of estimation net anthropogenic GHG removals by sinks. However, if the project is being carried out in a host country that has adopted a high value for the crown cover threshold as part of its forest definition, and trees exist in the project area close to that threshold at the time the project commences, then inventory of baseline biomass/removals by trees should attempt to meet a similar precision to that for the project (i.e. an estimate of biomass stocks in each stratum to a targeted precision level of ±10% of the mean at a 95% confidence level).

The *ex post* biomass and/or biomass increment data are used to estimate baseline net GHG removals by sinks using equations (B1) to (B11) in Section II.5.

3.2. Confirmation of the baseline scenario at renewal of the crediting period

If project participants choose a renewable crediting period, information necessary for determining whether the original baseline scenario is still valid shall be collected and archived. At the time of crediting period renewal, this information shall be examined to determine whether the baseline scenario,

---

[34] Paragraph 32 of Decision 19/CP.9.

[35] Paragraph 12 of Appendix B in Decision 19/CP.9.

[36] Nested sample plots should be used in strata with mixed vegetation types, with shrub and/or herbaceous biomass determined in sub-plots located as far as possible randomly within the main sample plot.

or baseline net GHG removals by sinks, need to be updated. For this methodology, the information to be collected shall extend to that required to evaluate whether the non-CDM baseline forestry scenario—and the annual non-CDM baseline proportional forestry rate—also require revision. However, no revision of the baseline methodology, *per se*, shall be allowed in either the project scenario or the non-CDM baseline forestry scenario: only revision of the value estimated for baseline removals by sinks is permitted.

Possible reasons for revision and updating of the baseline scenario, and of the estimates of baseline removals by sinks may, *inter alia*, include:

- Changes in national, local and sectoral policies or regulations that influence land use in the absence of the proposed A/R CDM project activity—excluding any increases in the area of non-CDM baseline forestry created by in response to national and/or sectoral policies, or regulations, that have been implemented since 11 November 2001.
- Technical progress that may change the accuracy of data available for the baseline approach and scenario.
- Climate conditions and other environmental factors that may alter successional and disturbance processes, change species composition, or resulting in enhanced potential for regeneration—making, for example, natural regeneration possible, when it was not possible for the current baseline scenario.
- Significant changes in political, social or economic circumstances, to an extent sufficient to make the current baseline approach inaccurate.
- Removal of existing barriers, for example:
    - Removal of investment barriers: finance becomes readily available at acceptable rates to landholders or communities that have formerly been unable to obtain commercial loans for forestry activities.
    - Removal of technological barriers: landholders or communities gain sufficient knowledge, training and skills to greatly increase seedling survival rates; or develop more successful tree planting procedures for harsh environments; or new and economically-viable practices to control fire, pests or diseases are invented.
    - Removal of institutional barriers: development of well-organized institutional arrangements to integrate separate households and address technological and financial barriers to establishing forestry projects.

4. Data to be Collected and Archived for Determination of *Ex post* Baseline Net GHG Removals by Sinks

A list of the data to be collected and archived for *ex post* estimation of baseline net GHG removals by sinks is given in Annex A2.

5. Calculation of *Ex post* Actual Net GHG Removals by Sinks

The actual net GHG removals by sinks are the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in GHG emissions—measured in CO_2 equivalents—by sources within the project boundary and attributable to the A/R CDM project activity:

$$\Delta C_{ACTUAL,\,t} = \sum_{i=1}^{n_{st}} \sum_{j=1}^{n_{sp}} \Delta C_{i,j,\,\mathrm{t}} - PE_{\mathrm{t}} \qquad \textbf{(M1)}$$

where:

$\Delta C_{ACTUAL,t}$	Annual actual net GHG removals by sinks, for year *t*; t CO_2-e yr^{-1}
$\Delta C_{i,j,\mathrm{t}}$	Annual carbon stock change in biomass of tree species *j* in stratum *i* for year *t*; t CO_2 yr^{-1}
PE_t	Total annual GHG emissions by sources within the project boundary from implementation of the A/R project activity, in year *t* ; t CO_2-e yr^{-1}
i	Number of strata; $1 \ldots n_{st}$
j	Number of tree species; $1 \ldots n_{sp}$
t	Time elapsed since the start of the project; *0 ... n*, yrs

In choosing key parameters and making critical assumptions when estimating actual net GHG removals by sinks, project participants should retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that is least likely to lead to over-estimation of actual net GHG removals by sinks should be applied.

5.1. Verifiable changes in carbon stocks in the carbon pools

Since carbon stock changes in pools of soil organic matter, litter and dead wood are conservatively neglected in this methodology, the verifiable changes in carbon stocks are equal to the carbon stock changes in above- and below-ground live tree biomass resulting from the A/R activity within the project boundary. These are calculated[37], on an averaged annual basis, as:

$$\Delta C_{i,j,\,t} = (\Delta C_{AB,i,j,\,t} + \Delta C_{BB,i,j,\,t}) \ {}^{44}\!\!/_{12} \qquad \textbf{(M2)}$$

$$\Delta C_{AB,\,i,j,\,t} = (C_{AB,i,j,m2} - C_{AB,i,j,\,m1}) \,\big/\, T \qquad \textbf{(M3)}$$

$$\Delta C_{BB,\,i,j,\,t} = (C_{BB,\,i,j,\,m2} - C_{BB,\,i,j,\,m1}) \,\big/\, T \qquad \textbf{(M4)}$$

where:

$\Delta C_{i,j,t}$	Annual carbon stock change in biomass of tree species *j* in stratum *i* for year *t*; t CO_2 yr^{-1}
$\Delta C_{AB,\,i,j,\,t}$	Annual change in carbon stock in above-ground biomass of species *j* in stratum *i* for year *t*; t C yr^{-1}
$\Delta C_{BB,\,i,j,\,t}$	Annual change in carbon stock in below-ground biomass of species *j* in stratum *i* for year *t*; t C yr^{-1}
$C_{AB,\,i,j,\,m2}$	Carbon stock in above-ground biomass of species *j* in stratum *i*, at monitoring time *m2*; t C
$C_{AB,\,i,j,\,m1}$	Carbon stock in above-ground biomass of species *j* in stratum *i*, at monitoring time *m1*; t C
$C_{BB,\,i,j,\,m2}$	Carbon stock in below-ground biomass of species *j* in stratum *i*, at monitoring time *m2*; t C
$C_{BB,\,i,j,\,m1}$	Carbon stock in below-ground biomass of species *j* in stratum *i*, at monitoring time *m1*; t C
T	Number of years between monitoring times *m2* and *m1* (usually 5)

---

[37] Refers to GPG-LULUCF Equation 3.2.3.

i	Number of strata; $1 \dots n_{st}$
j	Number of tree species; $1 \dots n_{sp}$
t	Time elapsed since the start of the project; $0 \dots n$, yrs
$\frac{44}{12}$	Ratio of molecular weights of carbon and CO_2; g mol^{-1} (g mol^{-1})$^{-1}$

The total carbon stock in living biomass for each stratum, at each monitoring time *m*, is calculated from the area of each stratum and the mean carbon stock per unit area in above- and below-ground biomass resulting from the A/R activity, given by:

$$C_{AB,\ i,j,\ m} = A_i\ MC_{AB,\ i,j,\ m} \qquad \textbf{(M5)}$$

$$C_{BB,\ i,j,\ m} = A_i\ MC_{BB,\ i,j,\ m} \qquad \textbf{(M6)}$$

where:

$C_{AB,\ i,j,\ m}$	Carbon stock in above-ground biomass of species *j* in stratum *i* at monitoring time *m*; t C
$C_{BB,\ i,j,\ m}$	Carbon stock in below-ground biomass of species *j* in stratum *i* at monitoring time *m*; t C
A_i	Area of stratum *i* comprising species *j*; ha
$MC_{AB,\ i,j,\ m}$	Mean carbon stock in above-ground biomass of species *j* in stratum *i* at monitoring time *m*; t C ha^{-1}
$MC_{BB,\ i,j,\ m}$	Mean carbon stock in below-ground biomass of species *j* in stratum *i* at monitoring time *m*; t C ha^{-1}
i	Number of strata; $1 \dots n_{st}$
j	Number of tree species; $1 \dots n_{sp}$
t	Time elapsed since the start of the project; $0 \dots n$, yrs

The mean carbon stock per unit area in above- and below-ground biomass resulting from the A/R activity is estimated from field measurements at permanent sample plots—being careful to exclude from measurements any trees that existed at the time the project commenced and that fall within the sample plot perimeter. Plot-based sampling will inherently include the effect of losses due to disturbance or mortality, and gains due to replanting—and so such activities need not be explicitly considered. However, disturbance may require re-stratification of the project area and installation of extra permanent sampling plots to adequately monitor losses and recovery, and/or the effects of replanting, as disturbance is likely to result in areas with very heterogeneous biomass.

5.1.1. Estimating A/R carbon stocks

The mean carbon stock resulting from the A/R activity can be estimated using one of two methods: the Biomass Expansion Factors (BEF) method, or the Allometric Equations method.

BEF Method

Step 1. Measure the diameter at breast height (DBH; at 1.3 m above ground), and also preferably height, of all the trees above some minimum DBH in the permanent sample plots that result from the A/R 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 (IPCC 2003).

Step 2. Estimate the volume of the commercial (merchantable) component of trees based on locally derived equations, expressed as volume per unit area (e.g., m^3/ha). It is possible to combine steps 1 and 2 if there are field instruments (e.g., a relascope) that measure the volume of each tree directly.

Step 3. Choose a BEF, and root-shoot ratio (R): these parameters vary with local environmental conditions, tree species and age, and the volume of the commercial component of trees. Values for the BEF and R can be determined by developing local regression equations through destructive harvest. Alternatively, values can be selecting from national inventory, from Table 3A.1.10 of Annex 3A.1 of the GPG-LULUCF, or from other reliable published sources—see Sections II.5.1.3, II.10 and III.10 for guidance on selection of data from published information.

If suitable values are not available from published sources, and significant effort is required to develop project-specific BEF and R values—involving, for instance, harvest of trees—then it is recommended to instead use the resources to develop local allometric equations (see the *Allometric Methods* section below; and also Chapter 4.3 in the GPG-LULUCF. If that is not possible either, national species-specific defaults for the BEF and R can be used. Since both BEF and R values are age dependent, it is desirable to use age-dependent equations whenever possible. Using an average BEF value may result in significant errors for both young and old stands, as BEFs are usually large for young stands and rather small for old stands. It is therefore preferable to use allometric equations, if the equations are available or can be developed, and to otherwise use age-dependent BEF and R values.

Step 4. Convert the volume of the commercial component of each tree species in each stratum into carbon stock in above- and below-ground biomass using wood density, the selected values for BEF and R, and the average carbon fraction for trees:

$$MC_{AB} = V \cdot D_v \cdot BEF_2 \cdot CF \tag{M7}$$

$$MC_{BB} = MC_{AB} \cdot R_2 \tag{M8}$$

where:

MC_{AB}	Mean carbon stock in above-ground biomass; t C ha^{-1}
MC_{BB}	Mean carbon stock in below-ground biomass; t C ha^{-1}
V	Merchantable volume; m^3 ha^{-1}
D_v	Merchantable volume-weighted average wood density; t d.m. m^{-3} merchantable volume
BEF_2	Biomass expansion factor for conversion of merchantable biomass to above-ground biomass; t d.m. (t d.m.)$^{-1}$
CF	Average carbon fraction of above-ground biomass; t C (t d.m)$^{-1}$, IPCC default value = 0.5
R_2	Root-shoot ratio appropriate for above-ground biomass stock; t d.m. (t d.m)$^{-1}$

Step 5. **C**alculate the total carbon stock due to implementation of the A/R project activity as the sum of above- and below-ground carbon stocks.

Allometric method

Step 1. As with Step 1 in the BEF Method, the diameter and preferably height of all trees above some minimum diameter is measured.

Step 2. Choose or establish an appropriate allometric equation.

$$B_{AB} = f(DBH, H) \tag{M9}$$

where:

B_{AB} above-ground biomass; t d.m ha^{-1}

$f(DBH,H)$ an allometric equation linking above-ground biomass (d.m. tree^{-1}) to tree diameter at breast height (DBH), and possibly also to tree height (H).

The allometric equations used should preferably be locally-derived and species-specific. When more generic allometric equations are selected from biome-wide databases—such as those in Annex 4A.2, and in Tables 4.A.1 and 4.A.2 of the GPG-LULUCF—it is necessary to verify their applicability by destructive harvesting. This is carried out within the project area but outside the sample plots, for a few trees of quite different sizes, and the measured biomass is compared to that predicted by the selected generic equation. If the biomass of the harvested trees is within about ±10% of that predicted by the selected generic equation, and is not biased—or if biased is wrong on the conservative side (i.e., the equation tends to under- rather than over-estimate project removals)—the generic equation may be used. If this is not the case, it is recommended that local allometric equations be developed for project use. For this, a sample of trees, representing different size classes, is destructively harvested, and total biomass per tree determined. The number of trees to be destructively harvested and measured depends on the range of size classes and number of species—the greater the heterogeneity the more trees are required. An allometric equation is then constructed by a regression analysis that relates the measured biomass to values of easily measured variables, such as the DBH and total height (see the guidance provided in Chapter 4.3, GPG-LULUCF).

Step 3. Estimate carbon stock in above-ground biomass using selected or developed allometric equations applied to the tree measurements made in Step 1.

$$MC_{AB} = B_{AB} \ CF \tag{M10}$$

where:

B_{AB} Above-ground biomass; t d.m ha^{-1}

CF Average carbon fraction of above-ground biomass; t C (t d.m)$^{-1}$, IPCC default value = 0.5

Step 4. Estimate the carbon stock in below-ground biomass using root-shoot ratios, and applying equation **(M8).**

Step 5. **C**alculate the total carbon stock due to implementation of the A/R project activity as the sum of above- and below-ground stocks.

5.2. GHG emissions by sources

Implementation of the A/R project activity may result in GHG emissions within the project boundary. The emission of CO_2, CH_4 and N_2O from the following sources, also listed in Table B in Section II.3, shall be considered:

- Decrease in carbon stocks in living biomass of vegetation that existed at the time the project commenced, caused either by site preparation or competition from planted trees.
- Emissions of non-CO_2 GHG from biomass burning during slash-and-burn site preparation;
- Emissions of GHG from combustion of fossil fuels for site preparation, thinning and logging.
- Direct N_2O emissions caused by nitrogen fertilization application.

The total GHG emissions that result from implementation of the proposed A/R project activity within the project boundary are thus given by:

$$PE_t = E_{biomassloss,t} + E_{Non-CO2,BiomassBurn,t} + E_{FuelBurn,t} + E_{N-fertiliser,t} \qquad \textbf{(M11)}$$

where:

PE_t	Total annual GHG emissions by sources within the project boundary from implementation of the A/R project activity, in year *t*; t CO_2-e yr^{-1}
$E_{biomassloss,\ t}$	Annual CO_2 emissions from a decrease in carbon stock in vegetation biomass, for year *t*; t CO_2 yr^{-1}
$E_{Non\text{-}CO2,\ BiomassBurn,\ t}$	Annual emissions from biomass burning, if this occurs, for year *t*; t CO_2-e yr^{-1}
$E_{FuelBurn,\ t}$	Annual emissions from combustion of fossil fuels, for year *t*; t CO_2-e yr^{-1}
$E_{N\text{-}fertiliser,\ t}$	Annual emissions from application of nitrogenous fertiliser, for year *t*; t CO_2-e yr^{-1}
t	Time elapsed since the start of the project; *0 ... n*, yrs

5.2.1. Calculation of CO_2 emissions from a decrease in biomass of existing vegetation. An increase in emissions of CO_2 may occur as a result of clearance of existing vegetation during site preparation (including by slash-and-burn practices), and/or from decay of un-cleared existing vegetation that subsequently dies as a result of competition from forest established as part of the A/R project activity. As a conservative assumption, it is assumed that existing vegetation affected by either site preparation or forest establishment is instantaneously oxidised at the time the project commences.

In general, existing vegetation within the project boundary may comprise trees, shrubs and herbaceous vegetation (see Table 1). In this methodology it is assumed for *ex post* estimates that all existing shrub and herbaceous vegetation is oxidised as a result of site preparation and/or forest establishment—wherever such activities occur. Whether existing trees are also affected will depend on site preparation procedures and the degree of competition from planted forest. Emissions of CO_2 from loss of biomass from existing living trees shall be accounted as an instant oxidation at the time the project starts unless transparent and verifiable evidence is provided in the CDM-AR-PDD that such trees remain alive after site preparation, and do not die because of forest establishment.

The decrease in carbon stocks of vegetation that existed at the time the project started can be estimated from *ex ante* data, or from *ex post* measurements if these are performed. Note that CO_2 emissions associated with loss of biomass created as part of the project A/R activity will always be determined as an integral part of plot-based inventory (Section III.5.1, above), and to avoid double-counting must not be included in estimates made in this Section.

Step 1. Estimate above- and below-ground biomass of existing herbaceous vegetation, either from *ex ante* estimates, or by determination of biomass *ex post*. The biomass of herbaceous vegetation can be determined by simple harvesting techniques. A small frame of known area (either circular or square), usually encompassing about 0.1–0.25 m^2, is used in this task. The material inside the frame is cut to ground level and weighed. The roots are dug up, washed to remove soil, and also weighed. Well-mixed samples are then taken from the above- and below-ground biomass components, and oven-dried to determine dry mass and moisture content. The moisture content is then used to convert the above- and below-ground wet biomass components to equivalent oven-dry mass. Dividing by the frame area gives dry mass per unit area, and the ratio of below- to above-ground biomass gives the root-shoot ratio.

Step 2. Estimate above- and below-ground biomass of existing shrubs, either from *ex ante* estimates, or by determination of biomass *ex post*. Destructive harvesting techniques similar to those used for herbaceous vegetation can also be used to measure the living above- and below-ground biomass in shrubs, if the shrubs are small. An alternative approach, if the shrubs are larger, is to develop local allometric equations based on variables such as crown area and height, or diameter at the base of the plant, or some other relevant variable (e.g., number of stems in multi-stemmed shrubs). The equations are derived by regressing (usually log-transformed) biomass versus some logical combination of the independent variables. The independent variable or variables are then measured in temporary sample plots of diameter sufficient to include about 10–15 shrubs (for further detail see Chapter 4.3, GPG-LULUCF). If harvesting to establish allometric equations involves only above-ground biomass, a root-shoot ratio obtained from existing information will be required in order to estimate below-ground biomass (see Sections II.5.1.3, II.10 and III.10 for guidance on selection of data from published information).

Step 3. Estimate above- and below-ground biomass of existing trees, if required, either from *ex ante* estimates or by determination of biomass *ex post*. The biomass of existing trees can be determined using the plot-based inventory methodology described in Section III.5.1.1, with above- and below-ground biomass calculated using equations (M7) and (M8) in that section.

Step 4. Estimate for each stratum, by major vegetation category (i.e. trees, shrubs, and herbaceous species), the value of f_{SP}—the fraction of each stratum subject to site preparation, or planting of forest, whichever is greater. This can be determined by field survey, or by use of remote sensing imagery of adequate spatial/spectral resolution. If suitable data are not available, conservatively assume all existing vegetation is removed from all strata (i.e. $f_{SP} = 1$).

Step 5. Estimate the CO_2 emissions from the decrease in biomass of existing vegetation using equations (B14) to (B17) in Section II.6.2.1

5.2.2. Calculation of GHG emissions from biomass burning

Emissions of non-CO_2 gases may occur due to biomass burning within the project boundary, as a result of:

- Site preparation—non-CO_2 emissions will occur if slash-and-burn practices are used, resulting in burning of above-ground biomass in vegetation existing at the time the project commences.
- Wildfire after the project commences—non-CO_2 emissions will occur if the project area is subject to wildfire. Emissions only from trees established as part of A/R project activities are accounted. That is, it is assumed that emissions from any remaining vegetation that existed at the time the project commenced would have also occurred in the absence of the project, and so do not represent an increase compared to baseline emissions[38].

---

[38] This is equivalent to assuming the frequency of wildfire is not significantly increased by implementation of the project.

Step 1. For site preparation, estimate the mean above-ground biomass in trees, shrubs and herbaceous vegetation that existed at the time the project commenced. This will be available from either *ex ante* or *ex post* estimates (Sections II.5.1.1, or III.5.2, respectively).

Step 2. For wildfire after the project commences, estimate the above-ground biomass stock resulting from the A/R activity. This will have been determined as part of Section III.5.1 above if at least one cycle of monitoring has been completed, or if not can be obtained from *ex ante* estimates.

Step 3. Estimate for each stratum the value of f_{Burn}—the fraction of each stratum subject to biomass burning—for either site preparation or wildfire, as applicable. This can be obtained by field survey, or by use of remote sensing imagery of adequate spatial/spectral resolution. If suitable data are not available, assume conservatively that all areas are burned.

Step 4. Estimate combustion efficiencies and emission factors. Combustion efficiencies may be chosen from Table 3.A.1.14 of the GPG-LULUCF (IPCC 2003). Average values shall be estimated for each of trees, shrubs and herbaceous species within the areas burned. If no appropriate combustion efficiency is applicable to the project circumstances, the IPCC default of 0.5 should be used. The nitrogen-carbon ratio (N/C ratio) is approximated as 0.01 [GPG-LULUCF (IPCC 2003)]. This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available.

Step 5. Estimate non-CO_2 GHG emissions from biomass burning using equations (B18) to (B24) of Section II.6.2.2.

5.2.3. Calculation of GHG emissions from combustion of fossil fuels

Annual emissions from combustion of fossil fuels within the project boundary for year t, $E_{FuelBurn,t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[39]

5.2.4. Calculation of GHG emissions application of nitrogenous fertiliser

Annual emissions from application of nitrogenous fertiliser within the project boundary, $E_{N\text{-}fertiliser,t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of direct nitrous oxide emissions from nitrogen fertilisation*[40]

6. Data to be Collected and Achieved for Ex post Actual Net GHG Removals by Sinks

A list of the data to be collected for calculation of *ex post* actual net GHG removals by sinks is given in Annex A3.

7. Leakage

In choosing key parameters and making critical assumptions about leakage, project participants should retain a conservative approach, i.e. if different values for a parameter are equally plausible, a value that is least likely to lead to over-estimation of leakage emissions should be applied.

---

[39] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

[40] CDM Executive Board Meeting Report EB33, Annex 16: *Estimation of direct nitrous oxide emission from nitrogen fertilisation.*

Under the applicability conditions for the methodology, the only potential leakage emissions attributable to the proposed A/R project activity are those from vehicle fossil fuel combustion during transportation of seedlings, labor, materials and harvest products to and/or from project sites (while avoiding double-counting of emissions accounted for in $E_{FuelBurn,t}$ above). Thus:

$$LE_t = LE_{FuelBurn,\ t} \qquad \textbf{(M12)}$$

where:

LE_t	Total annual GHG emissions due to leakage activities for year t; t CO_2-e yr^{-1}
$LE_{FuelBurn,\ t}$	Annual leakage emissions from combustion of fossil fuels, for year t; t CO_2 yr^{-1}

Annual emissions from combustion of fossil fuels outside the project boundary but attributable to project activities, $LE_{FuelBurn,t}$, are estimated using the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[41]

8. Data to be Collected and Achieved for Leakage

A list of the data to be collected for calculation of leakage is given in Annex A4.

9. Ex post Net Anthropogenic GHG Removals by Sinks

Annual net anthropogenic GHG removals by sinks are calculated as actual net GHG removals by sinks, minus the baseline net GHG removals by sinks, minus leakage:

$$C_{AR\_CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LE_t \qquad \textbf{(M13)}$$

where:

$C_{AR\_CDM,\ t}$	Annual net anthropogenic GHG removals by sinks for year t; t CO_2-e yr^{-1}
$\Delta C_{ACTUAL,\ t}$	Annual actual net GHG removals by sinks for year t; t CO_2-e yr^{-1}
$\Delta C_{BSL,\ t}$	Total annual baseline net GHG removals by sinks for year t; t CO_2-e yr^{-1}
LE_t	Total annual GHG emissions due to leakage activities for year t; t CO_2-e yr^{-1}
t	Years elapsed since the start of the project; $0 \ldots n$, yrs

The term $\Delta C_{BSL,\ t}$ in eqn. (M13) includes removals terms due both to the project scenario and to A/R in the baseline scenario, as given in eqn. (B1) and further described in eqn. (B11). Substituting for these terms in eqn. (M13) gives a general expression for annual net anthropogenic removals by sinks that accounts for baseline removals both in the project scenario and due to A/R in the baseline scenario:

$$C_{AR\_CDM,t} = \left(\Delta C_{ACTUAL,t} - \Delta C_{BSL-project,t} - LE_{\text{t}}\right)\left(1 - PFR_{non-CDM}\ \text{t}\ R_{G,tree}\right) \qquad \textbf{(M14)}$$

where:

$C_{AR\_CDM,\ t}$	Annual net anthropogenic GHG removals by sinks for year t; t CO_2-e yr^{-1}

---

[41] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

$\Delta C_{ACTUAL,\,t}$	Annual actual net GHG removals by sinks for year t; t CO_2-e yr^{-1}
$\Delta C_{BSL\text{-}project,\,t}$	Annual baseline net GHG removals by sinks within the project boundary, for year t; t CO_2-e yr^{-1}
LE_t	Total annual GHG emissions due to leakage activities for year t; t CO_2-e yr^{-1}
$PFR_{non\text{-}CDM}$	The average annual non-CDM baseline proportional forestry rate (constant during a crediting period); ha ha^{-1} yr^{-1}
t	Years elapsed since the start of the project; 0 .... n, yrs
$R_{G,\,tree}$	Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1); t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1} $)^{-1}$

9.1. Calculation of tCERs and lCERs

Calculation of tCERs and lCERs shall be performed using the equations provided by the CDM Executive Board (EB22 Meeting Report, Annex 15). The following quantities estimated from annually-integrated data provided by this methodology shall be used in the calculation:

- Carbon stocks for the A/R project at the time of verification, $C_P(t_v)$; t CO_2-e
- Carbon stocks for the baseline scenario at the time of verification $C_B(t_v)$; t CO_2-e
- Project emissions for year t, PE_t; t CO_2-e
- Leakage emissions for year t, LE_t; t CO_2-e
- Year of verification, t_v; yr
- Time span between two verifications, κ; yrs

10. Conservative Approach and Uncertainties

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

It is recommended that project participants 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[42]; or

---

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

- National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; or
- In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value should be briefly noted in the CDM-AR-PDD. For any data provided by experts, the CDM-AR-PDD shall also record the experts name, affiliation, and principal qualification as an expert (e.g., that they are a member of a country's national forest inventory technical advisory group)—plus inclusion of a 1-page summary CV for each expert consulted, included in an annex.

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

11. Other Information

No other information is provided for this methodology.

SECTION IV: LISTS OF VARIABLES, ACRONYMS AND REFERENCES

Lists of variables, acronyms and references used in this methodology are given in Annex A5.

Annex A1

Data needed for *ex ante* estimation

Notes:

1. In using as part of this methodology those Methodological Tools approved by the CDM Executive Board, please ensure that the documentation describing the Tools is consulted to determine extra data/parameters that are required for *ex ante* estimation.
2. If preferred data sources noted in the last column of the Table below do not exist, data for *ex ante* estimation may be obtained from: IPCC literature (IPCC 2000, IPCC 2004, IPCC 2006), national and regional forestry inventory, peer-reviewed publications and reports, or by expert opinion. Guidelines on selection of appropriate data sources are given in Sections II.5.1.3, II.10 and III.10 of this methodology.

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
Current land cover/use data and maps	–	For demonstrating eligibility of land, stratifying land area, and determining the baseline scenario	As close as possible to the start of the project, and not earlier than 2 years before the start	Official publications; national or regional resource mapping or forest inventory agencies; local government and resource management agencies; landholder interviews. Typically better than 1:50,000 scale required.
Current remote sensing data	–	For demonstrating eligibility of land, stratifying land area, and determining the baseline scenario. Also for determining the project area *ex post*	As close as possible to the start of the project, and not earlier than 2 years before the start; or for verifying the project as at a date after the project start when young forest can be detected in the imagery	National or regional mapping or forest inventory agencies; satellite imagery providers. Typically 30 m or better equivalent ground resolution required (e.g., Landsat TM)

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
Historical land use/cover data and maps	–	For demonstrating eligibility of land, stratifying land area, and determining the baseline scenario	At a range of dates relevant to: detection of forest and non-forest land on 31 Dec 1989, determination of rates of A/R in the baseline scenario; determination of regeneration potential	Official publications; national or regional resource mapping or forest inventory agencies; local government and resource management agencies; landholder interviews. Typically better than 1:50,000 scale required.
Historical remote sensing data	–	For demonstrating eligibility of land, stratifying land area, and determining the baseline scenario	At a range of dates relevant to: detection of forest and non-forest land on 31 Dec 1989, determination of rates of A/R in the baseline scenario; determination of regeneration potential	National or regional mapping or forest inventory agencies; satellite imagery providers. Typically 30 m or better equivalent ground resolution required (e.g., Landsat TM).
Climate data	–	Stratifying land area	Current and recent	National or regional meteorology agencies
Soil map	–	Stratifying land area	Most recent	Official publications; national or regional resource mapping or forest inventory agencies; local government and resource management agencies

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
Landform map	–	Stratifying land area	Most recent	Official publications; national or regional resource mapping or forest inventory agencies; local government and resource management agencies
Digital Elevation Model (DEM)	–	Stratifying land area	Most recent	Official publications; national or regional topographic mapping or forest inventory agencies; satellite image providers (e.g., SRTM dataset)
National and sectoral policies	–	Additionality considerations; stratifying land area	All relevant dates	National or regional government departments or policy agencies
UNFCCC decisions	–		Up until the present	UNFCCC website
IRR, NPV cost benefit ratio, or unit cost of service	–	Indicators of return on investment	Current date	Standard text books, World Bank web site
Investment costs	–	For example, rental, purchase or construction of (as applicable): land, machinery and equipment, buildings, fences, site and soil preparation seedlings, planting, weeding, pesticides, fertilisers, training, and technical consultation associated with project implementation	Current date; but also taking into account market risk	Local, regional or national statistics; published data and/or surveys; other similar projects
Operations and maintenance costs	–	For example, costs of replanting, fuel, transportation, repairs, fire and disease control, patrolling, administration associated with project operations	Current date; but also taking into account market risk	Local, regional or national statistics; published data and/or surveys; other similar projects

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
Transaction costs	–	Including costs of project preparation, validation, registration, monitoring, etc	Current date	Local, regional or national statistics; published data and/or surveys; other similar projects
Revenues	–	Those with and without CER revenues	Current date; but also taking into account market risk	Published data on current and projected carbon prices; PointCarbon web site; other carbon trading web sites; other similar projects
$B_{AB,C,i,j_{shrub}}$	t d.m. ha^{-1}	Climax above ground biomass stock of shrub species *j,* in an area with similar growing conditions to project baseline stratum *i*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$B_{AB,C,i,j_{tree}}$	t d.m. ha^{-1}	Climax above ground biomass stock of tree species *j,* in an area with similar growing conditions to project baseline stratum *i*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$B_{AB,j,t}$	t d.m. ha^{-1} yr^{-1}	Above-ground biomass stock of tree species *j,* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$B_{AB,i,j_{herb},t}$	t d.m. ha^{-1}	Above-ground biomass stock of herbaceous species *j* in stratum *i*, for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$B_{AB,i,j_{shrub},t}$	t d.m. ha^{-1}	Above-ground biomass stock of shrub species *j* in stratum *i*, for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$B_{AB,i,j_{tree},t}$	t d.m. ha^{-1}	Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
$BEF_{1, j, t}$	t d.m. yr^{-1} (m^3 yr^{-1})$^{-1}$	Biomass expansion factor for conversion of annual increment in merchantable volume to above-ground biomass increment for tree species *j* for year *t*	Current or recent date	Species- and age-specific data from regional/national inventory preferred
$BEF_{2, j, t}$	t d.m. m^{-3}	Biomass expansion factor for conversion of merchantable volume to above-ground biomass for tree species *j* for year t	Current or recent date	Species- and age-specific data from regional/regional inventory preferred
. □$C_{G, i, shrub, t}$	t CO_2 yr^{-1}	Annual increase in carbon stock due to growth of shrubs in stratum *i,* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
. □$C_{G, i, tree, t}$	t CO_2 yr^{-1}	Annual increase in carbon stock due to growth of trees in stratum *i,* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
CE_{herb}	t d.m. burned (t d.m.)$^{-1}$	Average combustion efficiency for herbaceous species;	Any date	Average data for herbaceous species from regional/national inventory are satisfactory
CE_{shrub}	t d.m. burned (t. d.m.)$^{-1}$	Average combustion efficiency for shrubs	Any date	Average data for shrubs from regional/national inventory are satisfactory
CE_{Tree}	t d.m. burned (t. d.m.)$^{-1}$	Average combustion efficiency for trees	Any date	Average data for trees from regional/national inventory are satisfactory
CF_{herb}	t C (t d.m.)$^{-1}$	Average carbon fraction for biomass of herbaceous species	Any date	Data from IPCC literature should be used; scale not important
CF_{shrub}	t C (t d.m.)$^{-1}$	Average carbon fraction of biomass for shrubs	Any date	Data from IPCC literature should be used; scale not important

Data / Parameter	**Unit**	**Description**	**Vintage**	**Data sources and geographical scale**
CF_{tree}	t C (t d.m.)$^{-1}$	Average carbon fraction of biomass for trees	Any date	Data from IPCC literature should be used; scale not important
D_j	t d.m. m$^{-\square}$	Wood density of tree species *j*	Any date	Species- and age-specific data from regional/regional inventory preferred
$G_{w,i,j_{shrub},t}$	t d.m. ha^{-1} yr^{-1}	Annual above-ground biomass increment of shrub species *j* in stratum *i,* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$G_{w,i,j_{tree},t}$	t d.m. ha^{-1} yr^{-1}	Annual average above-ground biomass increment of tree species *j* in stratum *i,* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$G_{w,j,t}$	t d.m. ha^{-1} yr^{-1}	Annual above-ground biomass increment for tree species *j* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred
$I_{V,j,t}$	m^3 ha^{-1} yr^{-1}	Annual increment in merchantable volume for tree species *j* for year *t*	Current or recent date	Species- and age-specific data from local/regional inventory preferred
$R_{G,tree}$	t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1})$^{-1}$	Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1)	Current or recent date	Species-specific data from local/regional inventory preferred
$R_{1,j_{shrub}}$	t d.m. (t d.m.)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass increment for shrub species *j*	Any date	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data

Data / Parameter	Unit	Description	Vintage	Data sources and geographical scale
$R_{1,\ j_{tree}}$	t d.m. (t d.m.)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass increment for tree species *j*	Any date	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data
$R_{2,\ j_{herb}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of herbaceous species *j*	Any date	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data
$R_{2,\ j_{shrub}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of shrub species *j*	Any date	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data
$R_{2,\ j_{tree}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of tree species *j*	Any date	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data
$t_{cv\text{-}c,i,\ j_{shrub}}$	yrs	Time estimated for the above ground biomass stock of shrub species *j* in stratum *i* and year *t* to reach the climax above ground biomass stock $B_{AB,C,i,\ j_{shrub}}$	Any date	Species- specific data from local/ regional inventory preferred
$t_{cv\text{-}c,i,\ j_{tree}}$	yrs	Time estimated for the above ground biomass stock of tree species *j* in stratum *i* and year *t* to reach the climax above ground biomass stock $B_{AB,C,i,\ j_{tree}}$	Any date	Species- specific data from local/ regional inventory preferred
$V_{j,\ t}$	$m^3\ ha^{-1}$	Merchantable volume for tree species *j* for year *t*	Current or recent date	Species- and age-specific data or growth models from local/ regional inventory preferred

Annex A2

Data to be collected and archived for calculation of *ex post* baseline net GHG removals by sinks

Notes:

1. In using as part of this methodology those Methodological Tools approved by the CDM Executive Board, please ensure that the documentation describing the Tools is consulted to determine extra data to be collected and archived for calculation of baseline net GHG removals by sinks. For this methodology, the following Tools shall be considered: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[43]*;* and *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[44]
2. Entries 1.01–1.04 in the table below must be determined at the start of the first crediting period, and at all subsequent renewals of the crediting period. Other entries are determined once *ex post*, and used with equations in Section II.5. of the methodology to determine *ex post* baseline removals by sinks.
3. All other data required to be collected and archived for *ex post* determination of baseline removals by sinks, or estimated using equations in Sections III.5 and II.5, is described in Annex A3.
4. If preferred data sources noted in the fourth column of the Table below do not exist or cannot reasonably be obtained, data for *ex post* estimation may be obtained from: IPCC literature (IPCC 2000, IPCC 2004, IPCC 2006), national and regional forestry inventory, peer-reviewed publications and reports, or by expert opinion. Guidelines on selection of appropriate data sources are given in Sections II.5.1.3 , II.10 and III.10 of this methodology.

ID number	Data Variable	Data Unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
1.01	National, local and sectoral policies that may influence land use in the absence of the proposed AR CDM project activity	Various	Official regional/national government publications	–	Start of the project, and at the start of each re-crediting period	–	Obtain as complete information as possible

---

[43] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

[44] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

ID number	Data Variable	Data Unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
1.02	Natural and anthropogenic factors influencing land use, land cover and natural regeneration	Various	Official publications; regional or national resource management agencies	–	Start of the project, and at the start of each re-crediting period	–	Obtain as complete information as possible
1.03	Non-CDM forestry baseline stratum	Map or digital dataset	Current land cover/use data and maps; current remote sensing data	–	Start of the project, and at the start of each re-crediting period	Entire stratum	Re-evaluate stratification scheme used to determine A/R in the baseline scenario. Use data from publications; national or regional resource mapping or forest inventory agencies; local government and resource management agencies; or landholder interviews. Typically better than 1:50,000 scale maps required, or 30 m or better ground resolution imagery
1.04	$PFR_{non\text{-}CDM}$ — The average annual non-CDM baseline proportional forestry rate (constant during a crediting period)	ha ha^{-1} yr^{-1}	Analysis of current and historical land cover maps and/or remotely-sensed imagery	*M*	Start of the project, and at the start of each re-crediting period	Entire stratum	

ID number	Data Variable	Data Unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
1.05	$B_{AB,C,i,j_{shrub}}$ — Climax above ground biomass stock of shrub species *j,* in an area with similar growing conditions to project baseline stratum *i*	t d.m. ha^{-1}	Plot-based sampling preferred; or regional/ national forest inventory as an alternative	*M*, or *C*	At the start of the project	One-time estimate only	
	$B_{AB,C,i,j_{tree}}$ — Climax above ground biomass stock of tree species *j,* in an area with similar growing conditions to project baseline stratum *i*	t d.m. ha^{-1}	Plot-based sampling preferred; or regional/ national forest inventory as an alternative	*M*, or *C*	At the start of the project	One-time estimate only	
1.06	$t_{cv\text{-}c,i,j_{shrub}}$ — Time estimated for the above-ground biomass stock of shrub species *j* in stratum *i* and year *t* to reach the climax above-ground biomass stock $B_{AB,C,i,j_{shrub}}$	yrs	Plot-based sampling of age in current and climax stands preferred; alternatively either field-based or photo-based estimates of age based on surrogates	*M*, or *C*	At the start of the project	One-time estimate only	Suitable surrogates for age are shrub volume, shrub height, or stem basal diameter
1.07	$t_{cv\text{-}c,i,j_{tree}}$ — Time estimated for the above-ground biomass stock of tree species *j* in stratum *i* and year *t* to reach the climax above-ground biomass stock $B_{AB,C,i,j_{tree}}$	yrs	Plot-based sampling of age in current and climax stands preferred; alternatively either field-based or photo-based estimates of age based on surrogates	*M*, or *C*	At the start of the project	One-time estimate only	Suitable surrogates for age are tree height, or diameter at breast height

Annex A3

Data to be collected for calculation of *ex post* actual net GHG removals by sinks

Note: in using as part of this methodology those Methodological Tools approved by the CDM Executive Board, please ensure that the documentation describing the Tools is consulted to determine extra data to be collected for calculation of *ex post* actual net GHG removals by sinks. For this methodology, the following Tools shall be considered: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[45]*;* and *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[46]

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.01	Stratum ID	Alphanumeric code	Stratification map	–	Before the start of the project	Entire project area	
2.02	Sample plot ID	Alphanumeric code	Project and plot map	–	Before the start of the project	Entire project area	Assigned to each permanent or temporary sample plot
2.03	Sample plot location	Alphanumeric code	Project and plot map; GPS coordinates	*M*	5 years	Entire project area	Preferably do not mark locations visibly in the field—use buried iron rod at plot centre (find using metal detector), or use witness trees and distance/bearing measurements to plot centre. Record a GPS coordinate of the plot centre if possible at the start of the project, and use for future navigation

---

[45] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

[46] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.04	Sample plot size	m^2, or ha	Project inventory	*M*	5 years	Entire project area	
2.05	Sub-plot size	m^2	Project inventory	*M*	5 years	Entire project area	
2.06	Frame size	m^2	Project inventory	*M*	5 years	Entire project area	
2.07	Tree species name	Alphanumeric code	Project inventory	–	5 years	All sample plots	
2.08	Shrub species name	Alphanumeric code	Project inventory	–	5 years	All sample plots	
2.09	Herbaceous species name	Alphanumeric code	Project inventory	–	5 years	All sample plots	
2.10	Number of trees of the same species in a sample plot	Number	Project inventory	*M*	5 years	All sample plots	
2.11	Number of shrubs of the same species in a sample plot	Number	Project inventory	*M*	5 years	All sample plots	
2.12	Number of herbaceous species of the same type in a sample plot	Number	Project inventory	*M*	5 years	All sample plots	
2.13	Age of plantation	Years	Project inventory	*M*	5 years	All sample plots	Time zero is the time of planting
2.14	A_i — Area of stratum *i*	ha	Project inventory	*M*	5 years	All strata	
2.15	$B_{AB,j,t}$ — Above-ground biomass stock of tree species *j*, for year *t*	t d.m. ha^{-1} yr^{-1}	Project inventory	*M*, or *E*	5 years	All sample plots	

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.16	$B_{AB,i,j_{herb},t}$ — Above-ground biomass stock of herbaceous species *j* in stratum *i*, for year *t*	t d.m. ha^{-1}	Project inventory	*M,* or *E*	5 years	All sample plots	
2.17	$B_{AB,i,j_{shrub},t}$ — Above-ground biomass stock of shrub species *j* in stratum *i*, for year *t*	t d.m. ha^{-1}	Project inventory	*M,* or *E*	5 years	All sample plots	
2.18	$B_{AB,i,j_{tree},t}$ — Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*	t d.m. ha^{-1}	Project inventory	*M,* or *E*	5 years	All sample plots	
2.19	BEF_2 — Biomass expansion factor for conversion of merchantable biomass to above-ground biomass	t d.m. (t d.m.)$^{-1}$	Destructive harvest if Species- specific data from local/ regional inventory preferred	*M,* or *E*	Start of project	None	
2.20	$BEF_{2,j}$ — Biomass expansion factor for conversion of merchantable volume to above-ground biomass for tree species *j*	t d.m. m^{-3}	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project-specific ratios may also be performed, if well-sampled datasets are used
2.21	CE_{shrub} — Average combustion efficiency for shrubs	t d.m. burned (t d.m.)$^{-1}$	Species- specific data from local/ regional inventory preferred	*M,* or *E*	Start of project	None	

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.22	CE_{Tree} — Average combustion efficiency for trees	t d.m. burned (t d.m.)$^{-1}$	Species- specific data from local/ regional inventory preferred	*M,* or *E*	Start of project	None	
2.23	CF — Average carbon fraction of above-ground biomass; IPCC default value = 0.5	t C (t d.m)$^{-1}$	Data from IPCC literature should be used	*M,* or *E*	Start of project	None	
2.24	CF_{herb} — Average carbon fraction for biomass of herbaceous species	t C (t d.m.)$^{-1}$	Data from IPCC literature should be used	*M,* or *E*	Start of project	None	
2.25	CF_{shrub} — Average carbon fraction for biomass of shrubs	t C (t d.m.)$^{-1}$	Data from IPCC literature should be used	*M,* or *E*	Start of project	None	
2.26	CF_{tree} — Average carbon fraction for biomass of trees	t C (t d.m.)$^{-1}$	Data from IPCC literature should be used	*M,* or *E*	Start of project	None	
2.27	D_v — Merchantable volume-weighted average wood density	t d.m. m^{-3}	Species- specific data from local/ regional inventory preferred	*M,* or *E*	Start of project	None	
2.28	ER_{CH4} — Emission ratio for CH_4; IPCC default: 0.012	mol CH_4 (mol C)$^{-1}$	IPCC default	–	Start of project	None	
2.29	ER_{N2O} — Emission ratio for N_2O; IPCC default: 0.007	mol N_20 (mol N_2)$^{-1}$	IPCC default	–	Start of project	None	

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.30	$f(DBH,H)$ — An allometric equation linking above-ground biomass (d.m. tree^{-1}) to tree diameter at breast height (DBH), and possibly also to tree height (H).	–	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M*, or *E*	Start of project	None	Applicability of IPCC default equations must be proven. Development of project-specific allometric equations may also be performed, if well-sampled datasets are used
2.31	$f_{Burn,i,t}$ — Fraction of stratum *i* subject to biomass burning, for year *t*	Dimensionless	Project inventory	*M*	At time of site preparation, or wildfire	All strata	
2.32	$f_{SP,i,t}$ — Fraction of stratum *i* cleared during site preparation for year *t*, or planted at any time as part of project activities, whichever is greater	Dimensionless	Project inventory	*M*	At time of site preparation, or wildfire	All strata	
2.33	*i* — Number of strata; $1 \ldots n_{st}$	Dimensionless	Project inventory	*M*	As required	Project area	
2.34	*j* — Number of tree, shrub, or herbaceous species, as appropriate; $1 \ldots n_{sp}$	Dimensionless	Project inventory	*M*	5 years	All sample plots	
2.35	*K* — Time span between two verifications	yrs	Known	–	5 years	–	

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.36	$L_{BiomassBurn,\ i,\ C_{AB\text{-}herb},\ t}$ — Loss of carbon stock in the stratum *i* due to burning of herbaceous above-ground biomass, for year *t*	$t\ C\ yr^{-1}$	Project inventory	*E*	At time of site preparation	All sample plots	
2.37	$L_{BiomassBurn,\ i,\ C_{AB\text{-}shrub},\ t}$ — Loss of carbon stock in the stratum *i* due to burning of shrub above-ground biomass, for year t^{-1}	t C yr	Project inventory	*E*	At time of site preparation	All sample plots	
2.38	$L_{BiomassBurn,\ i,\ C_{AB\text{-}tree},\ t}$ — Loss of carbon stock in the stratum *i* due to burning of tree above-ground biomass, for year *t*	$t\ C\ yr^{-1}$	Project inventory	*E*	At time of site preparation	All sample plots	
2.39	$^{N}\!/_{C}\ ratio$ — Average nitrogen-carbon ratio for burned biomass; IPCC default: 0.01	$kg\ kg^{-1}$	IPCC default, or species- specific data from local/ regional inventory	–	Start of project	None	
2.40	$R_{1,\ j_{shrub}}$ — Root-shoot ratio appropriate for above-ground biomass increment for shrub species *j*	$t\ d.m.\ (t\ d.m.)^{-1}$	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify default data used, or otherwise use conservative values. Development of project-specific ratios may also be performed, if well-sampled datasets are used

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.41	$R_{1,j_{tree}}$ — Root-shoot ratio appropriate for above-ground biomass increment for tree species *j*	t d.m. (t d.m.)$^{-1}$	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project
2.42	R_2 — Root-shoot ratio appropriate for above-ground biomass stock	t d.m. (t d.m)$^{-1}$	Data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project
2.43	$R_{2,j_{herb}}$ — Root-shoot ratio appropriate for above-ground biomass stock of herbaceous species *j*	t d.m. (t d.m)$^{-1}$	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project
2.44	$R_{2,j_{shrub}}$ — Root-shoot ratio appropriate for above-ground biomass stock of shrub species *j*	t d.m. (t d.m)$^{-1}$	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M,* or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project

ID number	Data Variable	Data unit	Data source	Measured, calculated or estimated (M, C or E)	Recording frequency	Proportion of data monitored	Comment
2.45	$R_{2,j_{tree}}$ — Root-shoot ratio appropriate for above-ground biomass stock of tree species *j*	t d.m. (t d.m)$^{-1}$	Species-specific data from local/regional inventory preferred if well-sampled data exist, otherwise use IPCC data	*M*, or *E*	Start of project	None	If feasible verify any default data used, or otherwise use conservative values. Development of project-specific ratios may also be performed, if well-sampled datasets are used
2.46	$R_{G,\ tree}$ — Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1)	t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1})$^{-1}$	Project inventory; and species-specific data from local/regional inventory preferred for trees in the baseline stratum	*M*, or *E*	Start of project	None	
2.47	*T* — Time elapsed since the start of the project; *0 … n*	yrs	Known	*M*	As required	–	
2.48	*T* — Number of years between monitoring times *m2* and *m1* (usually 5)	yrs	Known	–	5 years	–	
2.49	t_v — Year of verification	yr	Known	–	As required	–	
2.50	*V* — Merchantable volume	m^3 ha^{-1}	Project inventory	*M*, or *C*	5 years	All sample plots	
2.51	$V_{j,\ t}$ — Merchantable volume for tree species *j* for year *t*	m^3 ha^{-1}	Project inventory	*M*, or *C*	5 years	All sample plots	

Annex A4

Data to be collected for calculation of leakage

Notes:

1. In using as part of this methodology those Methodological Tools approved by the CDM Executive Board, please ensure that the documentation describing the Tools is consulted to determine extra data to be collected for calculation leakage.
2. In this methodology the only data required are those described in the latest version of the following methodological tool approved by the CDM Executive Board: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[47].

---

[47] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

Annex A5

1. Lists of variables, acronyms and references

Note: in using as part of this methodology those Methodological Tools approved by the CDM Executive Board, please ensure that the documentation describing the Tools is consulted to obtain definitions for extra variables and acronyms, and also any references. For this methodology, the following Tools shall be considered: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[48]*;* and *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities*[49]

Variable	SI Unit	Description
$^{16}/_{12}$	$g\ mol^{-1}\ (g\ mol^{-1})^{-1}$	Ratio of molecular weights of CH_4 and carbon
$^{44}/_{12}$	$g\ mol^{-1}\ (g\ mol^{-1})^{-1}$	Ratio of molecular weights of CO_2 and carbon
$^{44}/_{28}$	$g\ mol^{-1}\ (g\ mol^{-1})^{-1}$	Ratio of molecular weights of N_2O and nitrogen
A_i	ha	Area of stratum *i*
B_{AB}	$t\ d.m\ ha^{-1}$	Above-ground biomass
$B_{AB,C,i,j_{shrub}}$	$t\ d.m.\ ha^{-1}$	Climax above ground biomass stock of shrub species *j,* in an area with similar growing conditions to project baseline stratum *i*
$B_{AB,C,i,j_{tree}}$	$t\ d.m.\ ha^{-1}$	Climax above ground biomass stock of tree species *j,* in an area with similar growing conditions to project baseline stratum *i*
$B_{AB,j,t}$	$t\ d.m.\ ha^{-1}\ yr^{-1}$	Above-ground biomass stock of tree species *j,* for year *t*
$B_{AB,i,j_{herb},t}$	$t\ d.m.\ ha^{-1}$	Above-ground biomass stock of herbaceous species *j* in stratum *i*, for year *t*

---

[48] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

[49] CDM Executive Board Meeting Report EB33, Annex 14: *Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.*

Variable	SI Unit	Description
$B_{AB,\ i,\ j_{shrub},\ t}$	t d.m. ha^{-1}	Above-ground biomass stock of shrub species *j* in stratum *i*, for year *t*
$B_{AB,i,\ j_{tree},\ t}$	t d.m. ha^{-1}	Above-ground biomass stock of tree species *j* in stratum *i*, for year *t*
$BEF_{1,\ j,\ t}$	t d.m. yr^{-1} $(m^3\ yr^{-1})^{-1}$	Biomass expansion factor for conversion of annual increment in merchantable volume to above-ground biomass increment for tree species *j* for year *t*
BEF_2	t d.m. m^{-3}	Biomass expansion factor for conversion of merchantable volume to above-ground biomass
$BEF_{2,\ j,\ t}$	t d.m. m^{-3}	Biomass expansion factor for conversion of merchantable volume to above-ground biomass for tree species *j* for year t
$\Delta C_{ACTUAL,t}$	t CO_2-e yr^{-1}	Annual actual net GHG removals by sinks, for year *t*
$\Delta C_{AB,\ i,j,\ t}$	t C yr^{-1}	Annual change in carbon stock in above-ground biomass of species *j* in stratum *i* for year *t*
$\Delta C_{BB,\ i,j,\ t}$	t C yr^{-1}	Annual change in carbon stock in below-ground biomass of species *j* in stratum *i* for year *t*
$\Delta C_{BSL,\ t}$	t CO_2-e yr^{-1}	Total equivalent annual baseline net GHG removals by sinks, for year *t*
$\Delta C_{BSL-A/R,t}$	t CO_2-e yr^{-1}	Equivalent annual baseline net GHG removals by sinks due to A/R in the baseline scenario, for year *t*
$\Delta C_{BSL-project,t}$	t CO_2-e yr^{-1}	Annual baseline net GHG removals by sinks within the project boundary, for year *t*
$\Delta C_{BSL-project,i,\ t}$	t CO_2-e yr^{-1}	Annual baseline net GHG removals by sinks within the project boundary for stratum *i*, for year *t*
$\Delta C_{i,\ t}$	t CO_2 yr^{-1}	Annual carbon stock change in biomass of woody species in stratum *i,* for year *t*
$\Delta C_{i,j,t}$	t CO_2 yr^{-1}	Annual carbon stock change in biomass of tree species *j* in stratum *i* , for year *t*

Variable	SI Unit	Description
$\Delta C_{G,\,i,\,t}$	t CO_2 yr^{-1}	Annual increase in carbon stock due to growth of woody species in stratum *i,* for year *t*
$\Delta C_{G,\,i,\,shrub,\,t}$	t CO_2 yr^{-1}	Annual increase in carbon stock due to growth of shrubs in stratum *i,* for year *t*
$\Delta C_{G,\,i,\,tree,\,t}$	t CO_2 yr^{-1}	Annual increase in carbon stock due to growth of trees in stratum *i,* for year *t*
$\Delta C_{L,\,i,\,t}$	t CO_2 yr^{-1}	Annual decrease in carbon stock due to loss of biomass in woody species in stratum *i,* for year *t*
$C_{AB,\,i,j,\,m}$	t C	Carbon stock in above-ground biomass of species *j* in stratum *i* at monitoring time *m*
$C_{AB,\,i,j,\,m1}$	t C	Carbon stock in above-ground biomass of species *j* in stratum *i*, at monitoring time *m1*
$C_{AB,\,i,j,\,m2}$	t C	Carbon stock in above-ground biomass of species *j* in stratum *i*, at monitoring time *m2*
CAR_CDM, t	t CO_2-e yr^{-1}	Annual net anthropogenic GHG removals by sinks for year *t*
$C_B(t_v)$	t CO_2	Carbon stocks for the baseline scenario at the time of verification
$C_{BB,\,i,j,\,m}$	t C	Carbon stock in below-ground biomass of species *j* in stratum *i* at monitoring time *m*
$C_{BB,\,i,j,\,m1}$	t C	Carbon stock in below-ground biomass of species *j* in stratum *i*, at monitoring time *m1*
$C_{BB,\,i,j,\,m2}$	t C	Carbon stock in below-ground biomass of species *j* in stratum *i*, at monitoring time *m2*
CE_{herb}	t d.m. burned (t d.m.)$^{-1}$	Average combustion efficiency for herbaceous species
CE_{shrub}	t d.m. burned (t. d.m.)$^{-1}$	Average combustion efficiency for shrubs
CE_{Tree}	t d.m. burned (t. d.m.)$^{-1}$	Average combustion efficiency for trees
CF	t C (t d.m)$^{-1}$	Average carbon fraction of above-ground biomass; IPCC default value = 0.5
CF_{herb}	t C (t d.m.)$^{-1}$	Average carbon fraction for biomass of herbaceous species

Variable	SI Unit	Description
CF_{shrub}	$t\ C\ (t\ d.m.)^{-1}$	Average carbon fraction for biomass of shrubs
CF_{tree}	$t\ C\ (t\ d.m.)^{-1}$	Average carbon fraction for biomass of trees
$C_P(t_v)$	$t\ CO_2$	Carbon stocks for the A/R project at the time of verification
D_j	$t\ d.m.\ m^{-3}$	Wood density of tree species *j*
D_v	$t\ d.m.\ m^{-3}$	Merchantable volume-weighted average wood density
$E_{BiomassBurn,\ CH4,\ i,\ t}$	$t\ CO_2\text{-e}\ yr^{-1}$	Annual CH_4 emissions from biomass burning in stratum *i*, for year *t*
$E_{BiomassBurn,\ N2O,\ i,\ t}$	$t\ CO_2\text{-e}\ yr^{-1}$	Annual N_2O emissions from biomass burning in stratum *i*, for year *t*
$E_{biomassloss,\ t}$	$t\ CO_2\ yr^{-1}$	Annual CO_2 emissions from a decrease in carbon stock in vegetation biomass for year *t*
$E_{biomassloss,\ i,\ herb,\ t}$	$t\ CO_2\ yr^{-1}$	Annual CO_2 emissions in stratum *i* from a decrease in carbon stock in herbaceous biomass, for year *t*
$E_{biomassloss,\ i,\ shrub,\ t}$	$t\ CO_2\ yr^{-1}$	Annual CO_2 emissions in stratum *i* from a decrease in carbon stock in shrub biomass, for year *t*
$E_{biomassloss,\ i,\ tree,\ t}$	$t\ CO_2\ yr^{-1}$	Annual CO_2 emissions in stratum *i* from a decrease in carbon stock in tree biomass, for year *t*
$E_{FuelBurn,\ t}$	$t\ CO_2\text{-e}\ yr^{-1}$	Annual emissions from combustion of fossil fuels, for year *t*
$E_{N\text{-}fertiliser,\ t}$	$t\ CO_2\text{-e}\ yr^{-1}$	Annual emissions from application of nitrogenous fertiliser, for year *t*
$E_{Non\text{-}CO2,\ BiomassBurn,\ t}$	$t\ CO_2\text{-e}\ yr^{-1}$	Annual emissions from biomass burning, if this is used, for year *t*
ER_{CH4}	$mol\ CH_4\ (mol\ C)^{-1}$	Emission ratio for CH_4; IPCC default: 0.012
ER_{N2O}	$mol\ N_20\ (mol\ N_2)^{-1}$	Emission ratio for N_2O; IPCC default: 0.007

Variable	SI Unit	Description
$f(DBH,H)$	–	An allometric equation linking above-ground biomass (d.m. $tree^{-1}$) to tree diameter at breast height (DBH), and possibly also to tree height (H).
$f_{Burn,i,t}$	Dimensionless	Fraction of stratum *i* subject to biomass burning, for year *t*
$f_{SP,i,t}$	Dimensionless	Fraction of stratum *i* cleared during site preparation for year *t*, or planted at any time as part of project activities, whichever is greater
$G_{w,i,j_{shrub},t}$	t d.m. ha^{-1} yr^{-1}	Annual above-ground biomass increment of shrub species *j* in stratum *i*, for year *t*
$G_{w,i,j_{tree},t}$	t d.m. ha^{-1} yr^{-1}	Annual average above-ground biomass increment of tree species *j* in stratum *i*, for year *t*
$G_{w,j,t}$	t d.m. ha^{-1} yr^{-1}	Annual above-ground biomass increment for tree species *j* for year *t*
GWP_{CH4}	kg CO_2-e (kg CH_4)$^{-1}$	Global Warming Potential for CH_4; IPCC default = 21, valid for the first commitment period
GWP_{N2O}	kg CO_2-e (kg N_2O)$^{-1}$	Global Warming Potential for N_2O; IPCC default = 310, valid for the first commitment period
i	Dimensionless	Number of strata; $1 \ldots n_{st}$
$I_{V,j,t}$	m^3 ha^{-1} yr^{-1}	Annual increment in merchantable volume for tree species *j* for year *t*
j	Dimensionless	Number of tree, shrub, or herbaceous species, as appropriate; $1 \ldots n_{sp}$
κ	yrs	Time span between two verifications
$L_{BiomassBurn,i,C_{AB},t}$	t C yr^{-1}	Annual carbon loss in above-ground biomass in stratum *i* due to biomass burning, for year *t*
$L_{BiomassBurn,i,C_{AB\text{-}herb},t}$	t C yr^{-1}	Loss of carbon stock in the stratum *i* due to burning of herbaceous above-ground biomass, for year *t*
$L_{BiomassBurn,i,C_{AB\text{-}shrub},t}$	t C yr	Loss of carbon stock in the stratum *i* due to burning of shrub above-ground biomass, for year t^{-1}

Variable	SI Unit	Description
$L_{BiomassBurn,\ i,\ C_{AB\text{-}tree},\ t}$	t C yr^{-1}	Loss of carbon stock in the stratum *i* due to burning of tree above-ground biomass, for year *t*
$LE_{FuelBurn,\ t}$	t CO$_2$-e	Annual leakage emissions from combustion of fossil fuels, for year *t* yr^{-1}
LE_t	t CO$_2$-e yr^{-1}	Total annual GHG emissions due to leakage activities for year *t*
MC_{AB}	t C ha^{-1}	Mean carbon stock in above-ground biomass
$MC_{AB,\ i,j,\ m}$	t C ha^{-1}	Mean carbon stock in above-ground biomass of species *j* in stratum *i* at monitoring time *m*
MC_{BB}	t C ha^{-1}	Mean carbon stock in below-ground biomass
$MC_{BB,\ i,j,\ m}$	t C ha^{-1}	Mean carbon stock in below-ground biomass of species *j* in stratum *i* at monitoring time *m*
${}^{N}\!/_{C}\ ratio$	kg kg^{-1}	Average nitrogen-carbon ratio for burned biomass; IPCC default: 0.01
PE_t	t CO$_2$-e yr^{-1}	Total annual GHG emissions by sources within the project boundary from implementation of the A/R project activity, in year *t*
$PFR_{non\text{-}CDM}$	ha ha^{-1} yr^{-1}	The average annual non-CDM baseline proportional forestry rate (constant during a crediting period)
$R_{1,\ j_{shrub}}$	t d.m. (t d.m.)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass increment for shrub species *j*
$R_{1,\ j_{tree}}$	t d.m. (t d.m.)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass increment for tree species *j*
R_2	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock
$R_{2,\ j_{herb}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of herbaceous species *j*

Variable	SI Unit	Description
$R_{2,\,j_{shrub}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of shrub species *j*
$R_{2,\,j_{tree}}$	t d.m. (t d.m)$^{-1}$	Root-shoot ratio appropriate for above-ground biomass stock of tree species *j*
$R_{G,\ tree}$	t d.m.ha^{-1} yr^{-1} (t d.m.ha^{-1} yr^{-1})$^{-1}$	Ratio of mean annual increment of above-ground biomass of tree species used for non-CDM forest in the baseline scenario, to the mean annual increment of above-ground biomass of the tree species used for A/R in the project (default = 1)
t	yrs	Time elapsed since the start of the project; *0 … n*
T	yrs	Number of years between monitoring times *m2* and *m1* (usually 5)
$t_{cv\text{-}c,i,\,j_{shrub}}$	yrs	Time estimated for the above ground biomass stock of shrub species *j* in stratum *i* and year *t* to reach the climax above ground biomass stock $B_{AB,C,i,\,j_{shrub}}$
$t_{cv\text{-}c,i,\,j_{tree}}$	yrs	Time estimated for the above ground biomass stock of tree species *j* in stratum *i* and year *t* to reach the climax above ground biomass stock $B_{AB,C,i,\,j_{tree}}$
t_v	yr	Year of verification
V	m^3 ha^{-1}	Merchantable volume
$V_{j,\,t}$	m^3 ha^{-1}	Merchantable volume for tree species *j* for year *t*

2. List of acronyms used in the methodologies

Acronym	**Description**
A/R	Afforestation or reforestation
C	Carbon
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
COP	Conference of the Parties
d.m.	Dry matter
DBH	Diameter at Breast Height
EB	Executive Board (of the CDM)
GHG	Greenhouse gases
GIS	Geographic Information System
GPG-2000	Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000)
GPG-LULUCF	Good Practice Guidance for Land Use, Land-use Change and Forestry (IPCC 2004)
GPS	Global Positioning Satellite
IPCC	Intergovernmental Panel on Climate Change
IPCC 1996 Revised Guidelines	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996 Revised Guidelines)
IPCC 2006 Guidelines	IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006)
N_2O	Nitrous oxide

Acronym	Description
PDD	Project Design Document

3. References

IPCC 1996 Revised Guidelines. Revised 1996 Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environment Strategies, Kanagawa, Japan.

IPCC 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environment Strategies, Kanagawa, Japan.

IPCC 2004. Good Practice Guidance for Land Use and Land-use Change and Forestry Activities. Intergovernmental Panel on Climate Change, IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environment Strategies, Kanagawa, Japan.

IPCC 2006. Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environment Strategies, Kanagawa, Japan.

Stolbovoy, V., Montanarella, L., Filippi, N., Selvaradjou, S., Panagos, P. and Gallego, J. (2005) Soil sampling protocol to certify the changes of organic carbon stock in mineral soils of European Union. EUR 21576 EN, 12. Office for Official Publications of the European Communities, Luxembourg.

- - - - -

History of the document

Version	Date	Nature of revision
01	EB35, Annex 15 19 October 2007	Initial adoption