



Approved afforestation and reforestation baseline methodology AR-AM0005

“Afforestation and reforestation project activities implemented for industrial and/or commercial uses”

(Version 03)

Source

This methodology is based on the draft CDM-AR-PDD “Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil” whose baseline study, monitoring and verification plan and project design document were prepared by Plantar S/A - Belo Horizonte, Brazil; World Bank - Carbon Finance Business, Washington DC, US. For more information regarding the proposal and its consideration by the Executive Board please refer to case ARNM0015-rev: “Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil” at:

<http://cdm.unfccc.int/methodologies/ARmethodologies/publicview.html?OpenRound=7&OpenNM=ARNM0015&cases=B#ARNM0015>.

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

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

- Afforestation or reforestation activities undertaken to meet commercial or industrial needs on grasslands, with low soil carbon content (compared to the expected soil carbon content under the project activity) because of soil degradation, or because climato-edaphic conditions naturally lead to thin, infertile soils with low carbon content.

This methodology anticipates two possible baseline scenarios:

1. Maintenance of the present land uses as grassland;
2. Afforestation or reforestation activity undertaken intermittently in small amounts in the periods prior to the A/R CDM project activity.

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

- Land cover within the project boundary is in steady state as grassland;
- Natural regeneration is not expected to occur in the project area because of the absence of seed sources or because land use practices do not permit the establishment of tree vegetation;
- Carbon stocks in soil organic matter, litter and deadwood can be expected to decrease more or increase less in the absence of the project activity during the time frame that coincides with the crediting period of the project activity, relative to the baseline scenario. Lower soil carbon under grassland compared to plantations or secondary forests can be expected under tropical conditions,¹ it cannot necessarily be expected under non-tropical conditions;²

¹ Desjardins T, Andreux F, Vokoff B, Cerri CC (1994): Organic carbon and 13 C contents in soils and soil size-fractions, and their changes due to deforestation and pasture installation in eastern Amazonia. Geoderma 61,

evidence has to be provided that the exclusion of soil organic carbon is conservative for the project case through, e.g. representative scientific literature;

- Flooding irrigation is not permitted;
- Soil drainage and disturbance are insignificant, so that non CO₂-greenhouse gas emissions from these types of activities can be neglected;
- The amount of nitrogen-fixing species (NFS) used in the A/R CDM project activity is not significant, so that greenhouse gas emissions from denitrification can be neglected in the estimation of actual net greenhouse gas removals by sinks.

3. Selected carbon pools

Table I.1: Selection and justification of carbon pools

Carbon Pools	Selected (answer with yes or no)	Justification / Explanation
Above-ground	Yes	Major carbon pool subjected to the project activity
Below-ground	Yes	Major carbon pool subjected to the project activity
Dead wood	No	Conservative approach under applicability condition
Litter	No	Conservative approach under applicability condition
Soil organic carbon	No	Conservative approach under applicability condition

4. Summary of baseline and monitoring methodologies

This baseline methodology outlines transparent and conservative methods to estimate the net anthropogenic GHG removals by sinks resulting from A/R CDM project activities implemented to meet the demand for wood for industrial use (e.g., charcoal production for industrial uses etc.) and/or commercial use (e.g., furniture making, construction materials etc.). The methodology can be used as stand-alone or in conjunction with other methodologies that have provisions to account for the end-uses of the biomass from A/R CDM project activities that are proposed to reduce GHG emissions.

This methodology provides for the estimation of changes in carbon stock in selected carbon pools of A/R CDM project activities implemented on grasslands. It accounts for carbon stock changes in the living biomass (above- and below-ground biomass) in the estimation of baseline net GHG removals by sinks and actual net GHG removals by sinks. The exclusion of deadwood, litter, and soil organic carbon is conservative considering that net increases in the carbon accumulated in these pools is expected over the crediting period, relative to the baseline scenario.

It conservatively draws the baseline scenario(s) from amongst the plausible scenarios, and presents methods to transparently estimate the carbon stock changes expected from the most likely land use(s) prior to the start of the A/R CDM project activity.

103-118. Detwiler RP (1986): Land use change and the global carbon cycle: the role of tropical soils. *Biogeochemistry* 2, 67-93 Fearnside PM, Barbosa RI (1998): Soil carbon changes from conservation of forest to pasture in Brazilian Amazonia. *Forest Ecology and Management* 108, 147-166.

² Guo LB, Gifford R, M, (2002): Soil carbon stocks and land use change: a meta analysis. *Global Change Biology* 8, 345-360.



The methodology adopts 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”, taking into account national, sector, and local policies influencing the land use prior to the start of the A/R CDM project activity, the scope of project alternatives relative to the baseline; and barriers to implement the A/R CDM project activity.

This methodology anticipates two possible baseline scenarios: (1) maintenance of the present land uses as grassland, and (2) afforestation or reforestation activity undertaken intermittently in small amounts in the periods prior to the A/R CDM project activity.

It uses the latest version of the “Tool for the Demonstration and Assessment of Additionality for Afforestation and Reforestation CDM Project Activities”.³

The monitoring methodology outlines methods to monitor carbon stock changes in the living biomass of A/R CDM project activities and increases in the GHG emissions that result from the implementation of the A/R CDM project activity. It outlines methods and procedures that complement the provisions of the baseline methodology. It assumes that the A/R CDM project activities are implemented on grassland.

As per this methodology, the baseline scenario is identified and quantified *ex ante* at the beginning of the A/R CDM project activity and will hold throughout the crediting period and does not require monitoring. The methodology outlines methods for assessing and accounting leakage from , displacement of fuelwood collection outside the project boundary and displacement of grazing activities attributable to the A/R CDM project activity.

The methodology recommends the use of field-based inventory methods and, depending on availability, remotely sensed data to monitor the implementation of the A/R CDM project activity. The methodology stratifies the project area based on climate, vegetation, and tree species and/or years of planting with the aid of land use/cover maps, remote sensing imagery, and/or field survey data. The methodology uses permanent sample plots to monitor the carbon stock changes in the living biomass in order to achieve the accuracy of $\pm 10\%$ of the mean at the 95% confidence level. The plots shall be laid out in a way that facilitates easy location and ensures consistent monitoring over time, but are physically invisible to avoid preferential treatment.

The methodology specifies a monitoring frequency of 5-year intervals. In addition to monitoring the living biomass at successive monitoring intervals, it supports the recording of disturbances, if any. It recommends the adoption of standard operating procedures for monitoring, data collection, and archival, in order to maintain the integrity of the data collected in the monitoring process.

³ Available at <<http://cdm.unfccc.int/Reference/tools>>.



Baseline methodology steps

The baseline methodology is structured into the following steps:

- *Delineation of project boundary*: The land parcels included in the A/R project shall be delineated with a clearly traceable project boundary; and land eligibility shall be demonstrated;
- *Selection of carbon pools*: The methodology provides for estimation of carbon stock changes in the living (above- and below-ground) biomass pools of A/R CDM project activities implemented on grasslands. The exclusion of deadwood, litter, and soil organic carbon is conservative considering the net increase in carbon accumulated in these pools over the crediting period, in comparison to the baseline scenario;
- *Stratification*: Stratification of the A/R CDM project area is undertaken based on data and information collected from the most recent land-use/land-cover maps, soil maps, vegetation maps and supplementary information on the baseline land-use/land-cover determined for each stratum. For the *ex ante* stratification of the project area, variables related to site quality, species and their silvicultural characteristics, year of planting and stand level management criteria are taken into account;
- *Assessment of baseline scenario*: The methodology outlines procedures to select the baseline from amongst the plausible scenarios and evaluates land-use/land-cover of the baseline strata in order to estimate carbon stock changes expected under the most likely land-use at the time the project starts. The methodology anticipates two possible scenarios in the baseline: (1) land use as grassland; and (2) afforestation or reforestation activity undertaken as in small amounts in the period preceding the A/R CDM project;

The methodology adopts the 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*” taking into account national, sector, and local policies influencing the land-use prior to the start of the A/R CDM project and plausible land-use alternatives and barriers to implementation of the project activity;

- *Estimation of the baseline net GHG removals by sinks*: For grassland strata with herbaceous and non-woody vegetation, the methodology assumes the carbon stock in the baseline to remain constant in a low steady state, i.e., the baseline net GHG removals by sinks is zero. For strata with isolated trees and shrub vegetation, changes in carbon stocks of living biomass pools are estimated using the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (GPG/LULUCF) (IPCC 2003);
- *Demonstration of Additionality*: The latest version of the “*Tool for the Demonstration and Assessment of Additionality for Afforestation and Reforestation CDM Project Activities*”⁴ approved by the CDM Executive Board is used to test the additionality of the project;
- *Ex ante estimation of the actual net GHG removals by sinks*: The *ex ante* actual net GHG removals by sinks of stands established under the A/R CDM project activity are estimated using locally available allometric equations or yield models, taking into account the silvicultural management of the species included in the project. The increase in project emissions from fossil fuel consumption in the plantation activities, site preparation, and natural or anthropogenic biomass burning, are estimated following the guidance outlined in GPG/LULUCF (IPCC 2003);

⁴ Available at <<http://cdm.unfccc.int/Reference/tools>>.



- *Leakage*: The increase in GHG emissions outside the project boundary, which is associated with emissions from displacement of grazing activities that leads to loss of vegetation and collection of fuelwood to areas outside the project's boundary is accounted;
- *Ex ante estimation of the net anthropogenic GHG removals by sinks*: The methodology estimates the net anthropogenic GHG removals by sinks according to the relevant provisions in the modalities and procedures for A/R CDM projects. The methodology can be used stand alone or in conjunction with other methodologies that provide provisions for the end-use of the products from an A/R CDM project activity that result in greenhouse gas (GHG) emission reductions. To avoid double-counting of emission sources in a project activity, which has both A/R and non-A/R components, "emissions associated with A/R activities should be accounted for in the A/R project activity. In general all project activities using biomass for energy should account for emissions associated with production of biomass. However, in the case that it can be demonstrated that for a project activity using biomass for energy, which uses biomass originating from a registered A/R project activity (i.e. through contractual agreement for procurement of biomass) it need not account for emission related to biomass production" (EB 25 meeting report, para. 38).

Monitoring methodology steps

The monitoring methodology is structured into the following steps:

- *Monitoring of the project boundary and forest establishment*: This methodology outlines procedures to identify land parcels included in the project using field surveys and GPS methods and recording information on the project boundary. The methodology requests the use of field-based inventory methods and GPS data to verify consistency of the delineated project boundary of the parcels included in the project. The monitoring procedures cover information related to site preparation, species to be planted, and layout of planting adopted as per the management plan. The variables that influence the establishment of forest and the actual net GHG removals by sinks of the CDM A/R project activity are taken into account as part of the procedures for monitoring of the forest establishment;
- *Ex post stratification of project area for monitoring*: The *ex post* stratification considers monitoring of the project strata to verify the applicability of the *ex ante* stratification, and variables that influence the strata and establishment of the forest stands. The sample frame of the methodology specifies the number of permanent sample plots to be selected to monitor the carbon stock changes in living biomass in order to achieve an accuracy of $\pm 10\%$ in the mean at 95% confidence level. The *ex post* stratification procedures facilitate cost-effective, consistent and accurate monitoring of carbon stock changes of the project during the crediting period;
- *Absence of baseline monitoring*: The methodology prescribes validity of the baseline identified *ex ante* at the start of the A/R CDM project activity for the crediting period, thereby avoids the need for monitoring of the baseline over the crediting period, and achieves savings in the costs associated with baseline monitoring;
- *Calculation of the actual net GHG removals by sinks*: The methodology provides for calculation of the actual net GHG removals by sinks from the project, using data on carbon stocks changes from the permanent sample plots, and the data on emissions from fossil fuel consumption, site preparation, and burning of biomass in the project. The methods from Good Practice Guidance for Land use, Land Use Change and Forestry (GPG/LULUCF) (IPCC 2003) and the latest EB guidance are used in calculating the actual net GHG removals by sinks;

- *Monitoring leakage*: Emissions related to displacement of activities from the project boundary to areas outside it, such as grazing and collection of fuelwood, are monitored and accounted in order to calculate the net anthropogenic GHG removals by sinks;
- *Quality Assurance (QA)/Quality Control (QC)*: The QA/QC guidelines proposed as part of the monitoring plan verify the accuracy and consistency of field measurements and ensure the integrity of data collection, management of project databases and the database archival during the crediting period.

Section II. Baseline methodology description

1. Project boundary

Project participants shall define the project boundary at the beginning of a proposed A/R CDM project activity and shall provide the geographical coordinates of lands to be afforested or reforested, so as to allow clear identification for the purpose of verification. The remotely sensed data⁵ with adequate spatial resolution, officially certified topographic maps, land administration and tenure records, and/or other official documentation that facilitates the clear delineation of the project boundary can be used. The data shall be geo-referenced, and preferably provided in digital format. In the absence of requisite data and documentation, field surveys shall be undertaken to delineate the project boundary.

Table II.1: Gaseous emissions from sources other than those resulting from changes in carbon pools

Source	Gas	Included/ excluded	Justification / Explanation
Combustion of fossil fuels, e.g., on-site use of machinery/vehicles (but excluding transportation)	CO ₂	Included	
	CH ₄	Excluded	Potential emission is negligibly small
	N ₂ O	Excluded	Potential emission is negligibly small
Biomass burning (Fires)	CO ₂	Included	
	CH ₄	Included	
	N ₂ O	Included	
Removal of pre-existing non-tree vegetation	CO ₂	Included	
	CH ₄	Excluded	Not applicable
	N ₂ O	Excluded	Not applicable

The definition of the project boundary is an iterative process and depends on the result of further elements of the baseline methodology, e.g. on the test of eligibility of lands in Section II.2.

The emissions sources included in or excluded from the project boundary are shown in Table II.1. Any one of these sources can be neglected, i.e. accounted as zero, if the application of the most recent version of the “Tool for testing significance of GHG emissions in A/R CDM project activities” leads to the conclusion that the emission source is insignificant.

⁵ Remotely sensed data includes data acquired from earth observation satellites or aerial photographs.



2. Eligibility of land

It shall be demonstrated that each discrete area of land to be included in the boundary is eligible for an A/R CDM project activity. Project participants shall apply the latest version of the Procedures to Demonstrate the Eligibility of Lands for Afforestation and Reforestation CDM Project Activities as approved by the Executive Board.

3. *Ex ante* stratification

This methodology recommends a hierarchical approach to stratification. The factors relevant at the regional scale, such as climate, topography or geographical conditions, should be considered on priority followed by the next level of variables in the hierarchy for the purpose of identifying the strata. The minimum contiguous area for stratum or a part of it that represents more than one discontinuous parcel should be equal to the minimum area defined for a forest by the DNA of the Host country. The steps to be followed in the *ex ante* stratification are outlined below.

Step 1: Stratification taking into account pre-existing conditions

The baseline strata should be identified using the following criteria that consider the pre-existing conditions and expected evolution of baseline scenario:

- The variables influencing carbon stock changes in above- and below-ground biomass pools shall be identified. Such variables could include climate, soil, topography, vegetation type, anthropogenic pressure etc. It is preferable to rank the variables so that stratification takes into account the variables that are specific to the baseline land use of the grasslands included in the project;
- The baseline information reflecting the status of grassland shall be collected from the most recent land use/cover maps, satellite images, soil and vegetation maps, and site information from published literature or local studies in order to identify most relevant stratification criteria;
- Data on pre-existing conditions of the grassland in terms of its vegetation and composition shall be collected in order to demonstrate the maintenance of grassland in its state in the absence of implementation of the A/R CDM project;
- Information on pre-project status of grassland shall be collected from the official data sources, land-use maps and field surveys. The project entity shall demonstrate the status of grassland by providing relevant information on the land-use;
- Data on the pre-existing conditions of grassland and on the pre-project use of grassland shall be used to identify characteristic features that can be used in identifying the preliminary strata of the grassland;
- The specific features of the stratum levels should be identified in order to complement the information on the strata identified under preliminary stratification. Such characteristics could include;
 - The type of grassland vegetation, herbaceous vegetation, categories of shrub species and their growth characteristics such as diameter at the base (DBS) and height, and presence of isolated tree species, if any, and the characteristics of such vegetation;
 - Information on land tenure that reflects the nature of past management of grassland;
 - Nature and extent of past changes in the grassland vegetation in order to demonstrate the maintenance of grassland in its state or evidence demonstrating the steady state or the propensity to reach steady state in the near future;



- Site characteristics that influence the evolution of the grassland, such as slope, gradient, soil type, soil depth, etc.;
- Differences in the strata demonstrating the occurrence of grassland areas in steady state and/or under extensive management and/or in a degraded state and/or with isolated vegetation that is expected to remain in such states in the future;
- If the analysis of preliminary strata reflects significant variation within the strata, taking into account specific characteristics of the stratum levels, further stratification should be undertaken based on more specific criteria in order to improve their distinctness. For highly variable landscapes, it is recommended to carry out systematic sampling in order to determine the percentage of project area with specific type of land use in each stratum;
- Based on the stratification criteria, strata are identified and their respective areas are estimated. Furthermore, dominant species of grassland vegetation should be considered as the basis to estimate the carbon stock changes under the baseline.

Step 2: Criteria of stratification to be considered in the proposed A/R CDM project activity

- (i) The species and stand level characteristics of the project should be specified taking into account the following criteria:
 - Species or species types that represent mix of species to be planted on a site within the same planting year shall be considered to represent a stand;
 - The growth characteristics of species or species types representing mix of species with similar characteristics shall be specified.
- (ii) Silvicultural regime of species, such as planting, tending, thinning, harvesting, coppicing, and replanting cycle, shall be taken into account by specifying:
 - The age class at which the management activities are proposed to be implemented;
 - The volume of wood that is proposed to be thinned or harvested;
 - The rotation cycle or the coppicing cycle adopted.
- (iii) The temporal and spatial information on the plantation establishment shall be specified by adopting:
 - The planting date;
 - The area to be planted (ha);
 - The geographical location of the plantation site and stands proposed to be raised on the site should be identified and represented as the coordinates of polygons.
- (iv) The factors affecting actual net GHG removals by sinks should be reflected in the stratification. In order to maintain the optimal number of strata, the lands with similar stocking levels and similar growth patterns could be included in a stratum and management factors such as thinning, harvesting and replanting, that may not warrant separate stratum levels could be kept out of the stratification criteria.



Step 3: Ex ante stratification of A/R CDM project activity taking into account the stratification criteria and land use within the project boundary

As part of the *ex ante* stratification, the boundary of each stratum should be delineated using land-use maps or geo-referenced data. As per the availability, data from remote sensing and global positioning systems should also be included. The project boundary shall be consistent with the parcels identified under the project.

Step 4: Preparation of ex ante stratification map

A stratification map showing different strata and their characteristic features should be prepared. The stratification should also include information pertaining to the sub-strata. If GIS systems are available it is good practice to present the overlays of GIS information on the *ex ante* stratification map.

Step 5: The changes to the A/R project after the adoption of ex ante stratification shall be recorded

The relevant changes that occur to the project activity implementation after the *ex ante* stratification shall be recorded so that these could be taken into account during the *ex post* stratification at the monitoring stage of the project. The use of GIS overlays on the stratification maps facilitate the representation of changes to the *ex ante* stratification during the *ex post* stratification and spatial represented on the stratification map.

4. Procedure for selection of most plausible baseline scenario

The baseline scenario shall be determined through a sequence of steps, which reflect the changes in carbon stocks in above-ground biomass from the most likely land use at the time the project starts, in a transparent and conservative manner. The following steps shall be followed in selecting the baseline scenario:

Step 1: Demonstration of the most likely land use at the time the project starts

Demonstrate that as per the land eligibility established in Section II.2, the scenario anticipated for lands proposed under the project would remain under the existing grassland use that is expected to continue in the absence of the project activity. This can be done in one of the following ways:

- **Generally:** By demonstrating that similar lands, in the vicinity, are under similar use and are not expected to be used for alternative land uses. The financial and/or other barriers, which prevent alternative land uses can be identified;
- **Specifically for a forest as alternative land use:** Apply Step 2 (investment analysis) or Step 3 (barrier analysis) of the A/R “Tool for the demonstration and assessment of additionality”, to demonstrate that this land use, in absence of the CDM, is unattractive, and that land pressures prevent the possibility of land being reverted to natural forest regrowth;
- **Specifically, for other alternative land uses:** Use Step 2 (investment analysis) or Step 3 (barrier analysis) of the A/R “Tool for the demonstration and assessment of additionality” to demonstrate that alternative agricultural land uses would not occur in the absence of project activities.

This analysis should use relevant sources of data, e.g. archives, maps and/or satellite images of land use/cover around 1990 and before the start of the proposed A/R CDM project activity, supplementary field investigation, landowner interviews, or collection of data from other sources.

***Step 2: Assessment of national and sector policies and legislation***

In order to adequately reflect the impacts of prevailing policies, project participants shall make an assessment of the relevant national or sector policies.

(a) Policies related to the creation of wood sources

National or sector policies that have a direct influence on land use in the context of the A/R CDM project activity must be considered. Project participants must analyze the applicable policy incentives and constraints. “As a general principle, national and/or sectoral policies and circumstances are to be taken into account on the establishment of a baseline scenario, without creating perverse incentives that may impact Host Parties” contributions to the ultimate objective of the Convention. National and/or sectoral land-use policies or regulations, which give comparative advantages to afforestation/reforestation activities and that have been implemented since the adoption by the COP of the CDM M&P (decision 17/CP.7, 11 November 2001), need not be taken into account in developing a baseline scenario (i.e. the baseline scenario could refer to a hypothetical situation without the national and/or sectoral policies or regulations being in place)” (EB 23, Annex 19). Special attention shall be devoted to historical and/or prevailing land use and industrial policies, including incentives, subsidies, taxes and other fiscal and policy measures that influence the land use and the end use of the biomass from the afforestation /reforestation activities.

In case the A/R activity is affected by the policies in the competing industries or commercial end-uses, the policy analysis should evaluate the backward and forward linkages among the relevant sectors in order to demonstrate the additionality. The project participants shall identify and analyze specific policy contexts that had implications for A/R activities in the past or expected to have in the future.

(b) Legislation related to the requirements of A/R activities and land use

Project participants shall make an assessment of the impacts of prevailing legislation (federal, state, local) on the A/R activities, including the mandatory requirements on the land uses. The role of regulation and its enforcement is particularly relevant as the lack of effective regulation on the use of natural forests as biomass sources will effectively limit the incentives for implementing the A/R activities. In cases where widespread non-compliance is observed, evidence on the non-compliance shall be presented.

An analysis of the national policies and regulations related to natural forests and A/R activities, and their implications in terms of demand and supply of forest products and the impacts on the existing and future land uses shall be presented.

Step 3: Assessment of demand and supply of wood resources for industrial and commercial purposes

A brief description of demand and supply balance of wood sources for industrial and commercial purposes shall be prepared, taking into account the factors influencing the A/R activities (e.g. end-uses of wood from the plantations). The impact of incentives and constraints in the land use for plantation activity shall be taken into account.

It is good practice to use long-term data to identify the land use and plantation establishment trends, in order to demonstrate, if needed, the demand-supply balance/imbalance, i.e. supply shortages or constraints in the sustainability of wood production and supply.

***Step 4: Assessment of management practices and prevailing land uses in the project region***

Project participants shall make an assessment of the previous land uses in the region and the project area, and the management practices that are likely to impact the carbon stocks of the prevailing land uses now and in the future. The impact of policies and regulations shall be assessed to guide the choice of the most likely land uses. If applicable, project participants should explain how the incentives and constraints identified in Step 2, impact on land uses within the project area.

In case of the pre-project A/R activities that occurred in the absence of the proposed A/R CDM project activity, project participants must provide an estimate of the average regional and project entity-specific annual rates of A/R activities in the absence of the proposed A/R CDM project activity, so that it is considered within the listing of plausible land-use alternatives in Step 5. If the past policies resulted in an impact in terms of the implementation of the pre-project A/R in the region of the project area, the A/R activities attributable to these policies shall be considered as part of the baseline via the historical rate of afforestation/reforestation.

The determination of such an average regional and project-entity specific annual pre-project A/R rates must be established by means of historical data taking into account EB guidance on the consideration of national and sectoral policies (e.g. EB 23, Annex 19) in accordance with the relevant incentives or constraints applicable to the pre-project A/R activities in the region of the project area and applicable to the project entity (e.g. impact of major policies identified in Step 2 such as the regulatory framework, suspension of previously applicable incentives, etc.). The region considered for the determination of the average regional annual pre-project A/R rate should contain the area with the same biophysical and socio-economic preconditions as the project area, including the project area. If regional data is not available or not reflecting sectoral conditions, average annual rate of pre-project A/R undertaken at the national level should be selected.

The analysis shall focus on the rate of A/R activities that is likely to occur in the absence of the A/R CDM project activity; the determination of such an average annual A/R rate must be established by means of verifiable data and supported by the reasons for the trends in the land uses. To provide conservative estimates, the average regional and project-entity specific annual pre-project A/R rates shall be compared and the higher one shall be selected as the baseline A/R rate.

Step 5: Identification of plausible and credible land-use alternatives

The identification of plausible and credible land-use alternatives shall be based on the scope of maintaining current land use, including the possibility of undertaking A/R as per the applicable trends shall be considered. If there are no specific geographic trends in the pre-project A/R activities, they are assumed to be applicable to all strata in proportion to the area of a stratum. Therefore, the proportion of project parcels of each stratum that are likely to be affected by the policies adopted prior to November 11, 2001 shall be assessed. In doing so, e.g. land records, field surveys, data and feedback from stakeholders, or other appropriate sources shall be used.

Step 6: Identification of the most likely land-use

The most likely land-use from among the alternatives listed in the project boundary at the start of the A/R CDM project shall be identified as the baseline scenario. Accordingly, the steps outlined for the determination of the baseline net GHG removals by sinks in Section II.5 could be adopted consistent with the baseline approach 22(c).

For each baseline stratum the most likely land-use alternative at the time the project starts from among the plausible land-use alternatives shall be identified. Furthermore, it should be demonstrated that in absence of the proposed CDM A/R project activity, the most likely land-use would correspond to a plausible scenario that represents the grassland.

5. Estimation of baseline net GHG removals by sinks

This methodology outlines methods to estimate the changes in carbon stocks in the living biomass of grassland, and the evolution of these changes in the absence of the A/R CDM project activity. The methods and algorithms used in assessing the baseline are outlined below.

If more than one category of land is anticipated in the baseline scenario (e.g., part of the land within the project scenario is expected to be under the existing land use, whereas other parts of the land uses are subjected to afforestation/reforestation at a pre-project rate, the project participants shall stratify the lands under the baseline as per the likely land use or combinations of lands uses in the baseline, as per Step 6 of the Section II.4 above.

This methodology foresees two categories of land uses in the baseline scenario: maintenance of grassland in its present state; and the afforestation/reforestation implemented at a specified pre-project rate. Therefore, the baseline net GHG removals by sinks for the baseline scenario of the maintenance of grassland in its state, and the pre-project A/R activities that are likely to occur during the crediting period are represented as follows:

$$\Delta C_{BSL,t} = \Delta C_{GLB,t} + \Delta C_{ARB,t} \quad (\text{B.1})$$

where:

$\Delta C_{BSL,t}$	Sum of carbon stock changes in living biomass of grassland (above- and below-ground biomass) under the baseline scenario; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{GLB,t}$	Sum of carbon stock changes in the living biomass of grassland (above- and below-ground biomass) under the baseline scenario - maintenance of grassland in its state; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{ARB,t}$	The sum of carbon stock changes in living biomass of trees, under the baseline scenario with A/R activities implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year $t =$ ranges from 1 to length of the crediting period

(1) Maintenance of grassland in its state

The maintenance of grassland occurs in the absence of seed sources within the project boundary or due to current land use practices preventing the regeneration of forests. Further on, the project land areas have low demand from competing land uses. Project participants shall stratify the grasslands by their condition and management regimes to allow a more precise estimation of expected net carbon stock change in the pools considered.

It must be noted that the stock changes in the living biomass occurs primarily in the early 15-20 years of grasslands. After this period, the biomass of grassland tends to achieve a steady state with limited expected changes in the foreseeable future, unless the grasslands are subjected to further changes in their management.

Under the baseline scenario, *maintenance of grassland in its state*, the carbon pools considered in this methodology are assumed to be in steady state. Hence, the sum of the carbon stock changes of the living biomass in the grassland, for any year t , is considered to be zero, as indicated in equation below.

$$\Delta C_{GLB,t} = 0 \quad (\text{B.2})$$

where:

$\Delta C_{GLB,t}$ Sum of carbon stock changes in the living biomass of grassland (above and below-ground biomass) under the baseline scenario - maintenance of grassland in its state; tonnes $\text{CO}_2 \text{ yr}^{-1}$ in year t

For areas with isolated trees, the changes in carbon stocks of the living biomass for isolated trees shall be estimated and the baseline net GHG removals by sinks shall be represented as follows:

$$\Delta C_{GLB,t} = \Delta C_{ijk,t,ETB} \quad (\text{B.3})$$

where:

$\Delta C_{GLB,t}$ Sum of carbon stock changes in the living biomass of grassland (above- and below-ground biomass) under the baseline scenario - maintenance of grassland in its state; tonnes $\text{CO}_2 \text{ yr}^{-1}$ in year t

$\Delta C_{ijk,t,ETB}$ Sum of annual changes in the carbon stocks of living biomass (above- and below-ground) of pre-existing trees in stratum i , substratum j , species k ; $t \text{ CO}_2 \text{ yr}^{-1}$, using methods described in the Step 5 of Section II.5.(2) below

The sum of changes in the living biomass estimated as part of the baseline study prior to the project shall be frozen and adopted as the baseline to represent the scenario in the absence of the project.

(2) A/R implemented during the pre-project period

The changes in carbon stock in the living biomass expected from the annual rate of A/R activities undertaken during the pre-project, which is expected to occur in the future shall be included as part of the baseline before the *ex ante* baseline is adopted under the baseline approach 22(c), and frozen for the crediting period. Accordingly, the following steps shall be adopted:

Step 1: Determine the applicable A/R rate as outlined in Section II.4, Step 4.

Step 2: The project participants shall use the percentage of land area corresponding to the average annual pre-project A/R undertaken for the purpose of industrial/commercial sector at the regional level.

Step 3: To estimate the baseline carbon stock changes from the pre-project A/R activities, the species composition of the pre-project A/R activities shall be evaluated.

Step 4: Estimate the carbon stock changes of pre-project A/R activities undertaken as part of the baseline, as below:

$$\Delta C_{ARB,t} = \sum_{i=1}^I \sum_{j=1}^J \Delta C_{ARB,ij,t} \quad (\text{B.4})$$

where:

$\Delta C_{ARB,t}$	Sum of carbon stock changes in living biomass of trees, under the baseline scenario with A/R activities implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{ARB,ij,t}$	Average annual change in carbon stock in the living biomass of trees for stratum i , species j under the baseline scenario with A/R activities implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)

The following two generic methods are used to estimate the changes in carbon stock in living biomass of trees:

Method 1: Carbon gain-loss method⁶

$$\Delta C_{ARB,ij,t} = \Delta C_{ARB,G,ij,t} - \Delta C_{ARB,L,ij,t} \tag{B.5}$$

where:

$\Delta C_{ARB,ij,t}$	Average annual change in carbon stock in the living biomass of trees for stratum i , species j under the baseline scenario with A/R activities implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{ARB,G,ij,t}$	Average annual increase in carbon stock due to biomass growth of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{ARB,L,ij,t}$	Average annual decrease in carbon stock due to biomass loss of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t

$$\Delta C_{ARB,G,ij,t} = A_{ARB,ij} \cdot G_{ARB,ij,t} \cdot CF_j \cdot \frac{44}{12} \tag{B.6}$$

where:

$\Delta C_{ARB,G,ij,t}$	Average annual increase in carbon stock due to biomass growth of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes CO ₂ yr ⁻¹ in year t
$A_{ARB,ij}$	Area of stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; hectare (ha)
$G_{ARB,ij,t}$	Average annual increment of total dry biomass of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes d.m. ha ⁻¹ yr ⁻¹ in year t
CF_j	Carbon fraction of dry matter for species j ; tonnes C (tonne d.m.) ⁻¹
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

⁶ GPG for LULUCF Equation 3.2.2, Equation 3.2.4 and Equation 3.2.5.

Note: This methodology allows for the conservative assumption that, for any time t , $C_{ARB,L,ij,t} = 0$ for the baseline scenario with A/R activities implemented during the pre-project period.⁷

$$G_{ARB,ij,t} = G_{ARB,w,ij,t} \cdot (1 + R1_j) \quad (\text{B.7})$$

$$G_{ARB,w,ij,t} = I_{ARB,v,ij,t} \cdot D_j \cdot BEF_{1,j} \quad (\text{B.8})$$

where:

$G_{ARB,ij,t}$ Average annual increment of total dry biomass of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; t. d.m. $\text{ha}^{-1} \text{yr}^{-1}$ in year t

$G_{ARB,w,ij,t}$ Average annual above-ground biomass increment of trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; t. d.m. $\text{ha}^{-1} \text{yr}^{-1}$ in year t

$R1_j$ Root-shoot ratio appropriate for biomass increment for species j ; t d.m. $(\text{t d.m.})^{-1}$

Note: Care should be taken that the root-shoot ratio may change as a function of the above-ground biomass present at time t (see IPCC GPG 2003, Annex 3.A1, Table 3A1.8)

$I_{ARB,v,ij,t}$ Average annual increment in merchantable volume for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; $\text{m}^3 \text{ha}^{-1} \text{yr}^{-1}$ in year t

Note: $I_{ARB,v,ij,t}$ for all subsequent rotation cycles, is smaller than that in the first cycle, for two reasons: it is assumed, conservatively, that there is no growth in the below-ground biomass; and the rate of growth decreases at successive cycles

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

$BEF_{1,j}$ Biomass expansion factor for conversion of annual net increment (including bark) in merchantable volume to total above-ground biomass increment for species j ; dimensionless

Method 2: Stock change method ⁸

$$\Delta C_{ARB,ij,t} = \frac{C_{ARB,ij,t_2} - C_{ARB,ij,t_1}}{T} \cdot \frac{44}{12} \quad (\text{B.9})$$

$$C_{ARB,ij} = C_{ARB,AB,ij} + C_{ARB,BB,ij} \quad (\text{B.10})$$

$$C_{ARB,AB,ij} = A_{ARB,ij} \cdot V_{ARB,ij} \cdot D_j \cdot BEF_{2,j} \cdot CF_j \quad (\text{B.11})$$

$$C_{ARB,BB,ij} = C_{ARB,AB,ij} \cdot R_j \quad (\text{B.12})$$

⁷ This is conservative because the proportion of living biomass that dies or gets harvested is not deduced from the estimation of baseline net GHG removals by sinks and takes into account the loss of grass biomass under the pre-project A/R.

⁸ GPG for LULUCF Equation 3.2.3.

where:

$G_{ARB,ij,t}$	Average annual increment of total dry biomass of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes d.m. $\text{ha}^{-1} \text{yr}^{-1}$ in year t
C_{ARB,ij,t_2}	Total carbon stock in living biomass of trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period calculated at time t_2 ; tonnes C
C_{ARB,ij,t_1}	Total carbon stock in living biomass of trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period calculated at time t_1 ; tonnes C
T	Number of years between times t_2 and t_1 ; years
$C_{ARB,AB,ij}$	Carbon stock in above-ground biomass for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes C
$C_{ARB,BB,ij}$	Carbon stock in below-ground biomass for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes C
$A_{ARB,ij}$	Area of stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; hectare (ha)
$V_{ARB,ij}$	Merchantable volume of stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; $\text{m}^3 \text{ha}^{-1}$
D_j	Wood density for species j ; tonnes d.m. m^{-3} merchantable volume
$BEF_{2,j}$	Biomass expansion factor for conversion of merchantable volume to above-ground tree biomass for species j ; dimensionless
CF_j	Carbon fraction of dry matter for species j ; tonnes C (tonne d.m.) $^{-1}$
R_j	Root-shoot ratio appropriate for biomass stock, for species j ; t C (t C)^{-1}

An alternative way of estimating $C_{ARB,AB,ij}$ is to use allometric equations, which is considered good practice by the IPCC.

$$C_{ARB,AB,ij} = A_{ARB,ij} \cdot nTR_{j,i,t} \cdot CF_j \cdot f_j(DBH, H) \quad (\text{B.13})$$

where:

$C_{ARB,AB,ij}$	Carbon stock in above-ground tree biomass of species j in stratum i , at time t ; t C
$A_{ARB,ij}$	Area of baseline stratum i ; ha
$nTR_{j,i,t}$	Tree stand density of species j in stratum i , at time t under the baseline scenario with A/R implemented during the pre-project period; trees ha^{-1}
CF_j	Carbon fraction of dry matter for species j ; t C t^{-1} d.m.



$f_j(DBH, H)$	Allometric equation for species j linking diameter at breast height (DBH) and possibly tree height (H) to above-ground biomass of living trees; t d.m. tree ⁻¹ (Note: if using an average DBH in an allometric equation, the average must be calculated as the square root of the sum of the squares of the individual tree diameters making up the sample divided by their number - i.e. so called “quadratic mean” or “root mean square”)
i	Strata in the baseline scenario
j	Tree species in the baseline scenario
t	1, 2, 3, ... t years elapsed since the start of the A/R CDM project activity

Selection of parameters for estimation of carbon stocks in biomass

The following hierarchical order is recommended to select the respective parameters, tables and equations:

- (1) Locally-derived species-specific information, if sufficiently accurate and comprehensive data are available;
- (2) Species-specific information from regional datasets, or species-specific information extracted from national datasets for sites with similar soil and climatic conditions;
- (3) Species-specific information extracted from nationally-derived datasets avoiding only sites with very different soil and climate conditions;
- (4) Locally-, regionally-, or nationally-derived information for similar species;
- (5) Default values provided by the IPCC (e.g. IPCC 2003, Annex 3A.1, Annex 4A.2) or other scientific sources.

Conservative estimates shall be used for all parameters; the conservativeness of any parameter used to estimate tree biomass shall be substantiated in the PDD.

6. Additionality

This 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.⁹

In addition, based on the paragraph 3 of Annex 19 in the EB 24 report, the assessment of additionality shall include the justification that the increased rate of A/R would not occur in the absence of the project activity and results from direct intervention by project participants.¹⁰

⁹ Available at <<http://cdm.unfccc.int/Reference/tools>>.

¹⁰ <http://cdm.unfccc.int/EB/024/eb24_repan19.pdf>.

7. *Ex ante* actual net GHG removal by sinks

The *ex ante* estimation of actual removals involves (1) estimating the changes in carbon stocks in the living biomass pool; and (2) estimating the increase in emissions of greenhouse gases by the sources that are increased as a result of the implementation of the A/R CDM project activity, i.e.,

$$\Delta C_{ACTUAL,t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K \Delta C_{ijk,t} - GHG_{E,t} \quad (\text{B.14})$$

where:

$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ in year t
$\Delta C_{ijk,t}$	Average annual change in carbon stock in living biomass of trees for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$GHG_{E,t}$	GHG emissions by sources within the project boundary as a result of the implementation of the A/R CDM project activity; tonnes CO ₂ -e yr ⁻¹ in year t
t	Ranges from 1 to end of crediting period; years
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)
k	Substratum k (K = total number of substrata)

(a) *Changes in carbon stocks of living biomass of trees*

For the purpose of this methodology, the annual changes in carbon stock in the living biomass for year t , $\Delta C_{ijk,t}$ are estimated using the equation:

$$\Delta C_{ijk,t} = \Delta C_{AB,ijk,t} + \Delta C_{BB,ijk,t} \quad (\text{B.15})$$

where:

$\Delta C_{ijk,t}$	Average annual change in carbon stock in living biomass of trees for stratum i , species j , sub-stratum (age class) k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{AB,ijk,t}$	Average annual changes in carbon stock in above-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{BB,ijk,t}$	Average annual changes in carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t

The general formulae for estimating the changes in carbon stock in living biomass of trees of the A/R CDM project activity in year t is presented in the equation below. Annual changes in living biomass, at any given year, result from the difference in annual growth and loss. The decreases (or losses) result from the harvests of commercial wood and fuelwood and impacts from disturbance (e.g., fire, pest outbreaks).

For the purpose of *ex ante* estimation of carbon stock changes, the impacts of disturbance need not be considered provided the disturbance is expected to be small and is primarily associated with the natural events such as fire or pest incidence. However, risk allowance shall be made in the estimates of GHG removals to account for natural disturbances.

$$\Delta C_{AB,ijk,t} = \Delta C_{G,AB,ijk,t} - \Delta C_{L,AB,ijk,t} \quad (\text{B.16})$$

$$\Delta C_{BB,ijk,t} = \Delta C_{G,BB,ijk,t} - \Delta C_{L,BB,ijk,t} \quad (\text{B.17})$$

where:

$\Delta C_{AB,ijk,t}$	Average annual changes in carbon stock in above-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{BB,ijk,t}$	Average annual changes in carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{G,AB,ijk,t}$	Average annual increase in carbon in above-ground biomass due to biomass growth of trees for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{L,AB,ijk,t}$	Average annual decrease in carbon in above-ground biomass due to biomass loss in stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{G,BB,ijk,t}$	Average annual increase in carbon in below-ground biomass due to biomass growth of trees for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{L,BB,ijk,t}$	Average annual decrease in carbon in below-ground biomass due to biomass loss in stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t

(a) 1 Gain in the living biomass of trees

The annual increase in living biomass can be estimated using biomass expansion factors. If local or national data on wood density or biomass expansion factors are not available, project participants can use the data from GPG for LULUCF for the land-use category and climatic region. The root-shoot ratio shall be obtained from national sources that closely reflect the conditions of the A/R CDM project activity. If national data are not available, the mean root-to-shoot value in the GPG for LULUCF shall be used.

$$\Delta C_{G,AB,ijk,t} = A_{ijk,t} \cdot I_{ijk,t} \cdot D_j \cdot BEF_{1j} \cdot CF_j \cdot \frac{44}{12} \quad (\text{B.18})$$

$$\Delta C_{G,BB,ijk,t} = \Delta C_{G,AB,ijk,t} \cdot R_j \quad (\text{B.19})$$

where:

$\Delta C_{G,AB,ijk,t}$	Average annual increase in carbon in above-ground biomass due to biomass growth of trees for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{G,BB,ijk,t}$	Average annual increase in carbon in below-ground biomass due to biomass growth of trees for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$A_{ijk,t}$	Area for stratum i , species j , sub-stratum k ; hectares in year t
$I_{ijk,t}$	Average annual increment in merchantable volume for stratum i , species j , sub-stratum k ; m ³ ha ⁻¹ yr ⁻¹ in year t
D_j	Basic wood density for species j ; t d.m. m ⁻³ merchantable volume

BEF_{1j}	Biomass expansion factor for conversion of merchantable volume for species j to above-ground tree biomass for species j ; dimensionless
CF_j	Carbon fraction of dry matter; tonnes C (tonne d. m.) ⁻¹
R_j	Root-shoot ratio appropriate for species j ; dimensionless
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

(a) 2 Losses in the living biomass

The annual decreases or losses of carbon in living biomass of trees result from (i) commercial harvest (ii) fuelwood harvest, and/or (iii) impacts of disturbance (e.g., fire, pest outbreaks), as represented in the equation below:

$$\Delta C_{L,AB,ijk,t} = \left(\Delta C_{L,AB,ijk,Harvest,t} + \Delta C_{L,AB,ijk,Fwood,t} + \Delta C_{L,AB,ijk,Dist,t} \right) \cdot \frac{44}{12} \quad \text{(B.20)}$$

$$\Delta C_{L,BB,ijk,t} = \left(\Delta C_{L,BB,ijk,Harvest,t} + \Delta C_{L,BB,ijk,Fwood,t} + \Delta C_{L,BB,ijk,Dist,t} \right) \cdot \frac{44}{12} \quad \text{(B.21)}$$

where:

$\Delta C_{L,AB,ijk,t}$	Average annual decrease in carbon in above-ground biomass due to biomass loss in stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{L,BB,ijk,t}$	Average annual decrease in carbon in below-ground biomass due to biomass loss in stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
t	Ranges from 1 to end of crediting period; years
$\Delta C_{L,AB,ijk,Harvest,t}$	Average annual decrease in carbon stock of above-ground biomass of trees due to commercial harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
$\Delta C_{L,AB,ijk,Fwood,t}$	Annual decrease in carbon stock of above-ground biomass of trees due to fuel wood collection/harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
$\Delta C_{L,AB,ijk,Dist,t}$	Average annual decrease in carbon stock of above-ground biomass of trees due to disturbance for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
	Note: this can be ignored for small amounts in the <i>ex ante</i> estimation
$\Delta C_{L,BB,ijk,Harvest,t}$	Average annual decrease in carbon stock of below-ground biomass of trees due to commercial harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
$\Delta C_{L,BB,ijk,Fwood,t}$	Annual decrease in carbon stock of below-ground biomass of trees due to fuel wood collection/harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t

$\Delta C_{L,BB,ijk,Dist,t}$ Average annual decrease in carbon stock of below-ground biomass of trees due to disturbance for stratum i , species j , sub-stratum k ; tonnes C yr⁻¹ in year t

$\frac{44}{12}$ Ratio of molecular weights of CO₂ and carbon; dimensionless

(a) 2.1 Loss in above-ground living biomass of trees from commercial harvest

The annual decrease of carbon stock in living biomass of trees (above-and below-ground) from the harvest of merchantable volume is estimated using the equation below.

$$\Delta C_{L,AB,ijk,Harvest,t} = A_{H,ijk,t} \cdot H_{ijk,t} \cdot D_j \cdot BEF_{jk} \cdot CF_j \quad (\text{B.22})$$

$$\Delta C_{L,BB,ijk,Harvest,t} = \Delta C_{L,AB,ijk,Harvest,t} \cdot R_{jk} \quad (\text{B.23})$$

where:

$\Delta C_{L,AB,ijk,Harvest,t}$ Average annual decrease in carbon stock in above-ground biomass of trees due to commercial harvest for stratum i , species j , sub-stratum k ; tonnes C yr⁻¹ in year t

$\Delta C_{L,BB,ijk,Harvest,t}$ Average annual decrease in carbon stock in below-ground biomass of trees due to commercial harvest for stratum i , species j , sub-stratum k ; tonnes C yr⁻¹ in year t

$A_{H,ijk}$ Area of harvest in stratum i , species j , sub-stratum k ; ha yr⁻¹ in year t

$H_{ijk,t}$ Amount of merchantable volume harvested in stratum i , species j , sub-stratum k ; m³ ha⁻¹ in year t

D_j Basic wood density for species j ; tonnes d.m. m⁻³ merchantable volume

BEF_{jk} Biomass expansion factor for conversion of harvested volume of species j , sub-stratum k to above-ground biomass; dimensionless

R_{jk} Root-shoot ratio appropriate for species j sub-stratum k ; dimensionless

CF_j Carbon fraction of dry matter; tonnes C (tonne d. m.)⁻¹

(a) 2.2 Loss in living tree biomass from fuelwood harvest

The annual decrease of carbon stock in living biomass of trees (above-and below-ground) from fuelwood harvest is estimated using the equation below.

$$\Delta C_{L,AB,ijk,Fwood,t} = A_{F,ijk} \cdot FW_{ijk,t} \cdot D_j \cdot BEF_{jk} \cdot CF_j \quad (\text{B.24})$$

$$\Delta C_{L,BB,ijk,Fwood,t} = \Delta C_{L,AB,ijk,Fwood,t} \cdot R_{jk} \quad (\text{B.25})$$

where:

$\Delta C_{L,AB,ijk,Fwood,t}$	Average annual decrease in carbon stock in above-ground biomass of trees due to fuelwood collection/harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
$A_{F,ijk}$	Area of harvest for fuelwood in stratum i , species j , sub-stratum k ; ha yr ⁻¹ in year t
$FW_{ijk,t}$	Amount of fuelwood volume harvested for fuelwood in stratum i , species j , sub-stratum k ; m ³ ha ⁻¹ in year t
D_j	Basic wood density for species j ; tonnes d.m. m ⁻³ merchantable volume
BEF_{jk}	Biomass expansion factor for conversion of harvested volume of species j sub-stratum k to above-ground biomass; dimensionless
R_{jk}	Root-shoot ratio appropriate for species j sub-stratum k ; dimensionless
CF_j	Carbon fraction of dry matter; tonnes C (tonne d. m.) ⁻¹

If no changes in below-ground biomass occur at the rotation harvest (e.g., roots are left on the field for coppicing), then R_{jk} should be set to zero for all age classes $k >$ rotation. In this case, no increase in below-ground biomass is assumed to occur until the below-ground biomass is removed, and new plantations are established. Such an assumption leads to conservative *ex ante* estimates.

(a) 2.3 Loss of biomass due to disturbance

For the purpose of *ex ante* estimation of carbon stock changes, the impacts of disturbance need not be considered provided the disturbance is expected to be small and is primarily associated with natural events such as fire or pest incidence.

(b) Increase in emissions of greenhouse gases

In this methodology increases in emissions of greenhouse gases by sources are assumed to result from fossil fuel combustion, loss of biomass due to conversion of grassland to forests as a result of the A/R CDM activity and burning of biomass. The increase in greenhouse gas emissions is estimated as follows:

$$GHG_{E,t} = E_{FuelBurn,t} + E_{BiomassLoss,t} + E_{Non-CO_2,BiomassBurn,t} \quad (\text{B.26})$$

where:

$GHG_{E,t}$	Annual GHG emissions as a result of the implementation of the A/R CDM project activity within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{FuelBurn,t}$	CO ₂ emissions from combustion of fossil fuels within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{BiomassLoss,t}$	GHG emissions from the loss of biomass in site preparation and conversion to A/R within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Non-CO_2,BiomassBurn,t}$	Non-CO ₂ emission as a result of biomass burning within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t

If the implementation of the A/R CDM project activity does not result in the burning of biomass (e.g. for site preparation), the non-CO₂ greenhouse gas emissions need not be estimated.

(b) 1 Calculation of CO₂ emissions from burning fossil fuels

Emissions from fossil fuel combustion occur from the use of machinery in nursery, site preparation, thinning, harvesting, etc (but excluding transportation). The IPCC 1996 Guidelines can be used to estimate the CO₂ emissions from the combustion of fossil fuels:

$$E_{FuelBurn,t} = (CSP_{diesel,t} \cdot EF_{diesel} + CSP_{gasoline,t} \cdot EF_{gasoline}) \cdot 0.001 \quad (\text{B.27})$$

where:

$E_{FuelBurn,t}$	CO ₂ emissions from combustion of fossil fuels within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$CSP_{diesel,t}$	Volume of diesel consumption; litre (l) yr ⁻¹ in year t
$CSP_{gasoline,t}$	Volume of gasoline consumption; litre (l) yr ⁻¹ in year t
EF_{diesel}	Emission factor for diesel; kg CO ₂ l ⁻¹
$EF_{gasoline}$	Emission factor for gasoline; kg CO ₂ l ⁻¹
0.001	Conversion from kg to tonnes of CO ₂

Project participants should use national CO₂ emission factors. If these are not available they may use default emission factors as provided in the 1996 Revised IPCC Guidelines.

(b) 2 Emissions from biomass loss due to conversion of grassland to forests

The annual loss of grassland living biomass due to the removal of grassland vegetation and other pre-existing vegetation to afforest or reforest the area is estimated using the equation below.

$$E_{BiomassLoss,t} = \sum_{i=1}^I A_{ijk,Conv,t} \cdot B_{w,i} \cdot (1 + R_G) \cdot CF \cdot \frac{44}{12} \quad (\text{B.28})$$

where:

$E_{BiomassLoss,t}$	Average annual decrease in grassland biomass due to conversion of grassland to forests in stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t
$A_{ijk,Conv,t}$	Annual area converted to forest in stratum i , species j , sub-stratum k ; ha yr ⁻¹ in year t
$B_{w,i}$	Peak (maximum) above-ground biomass of grassland in stratum i ; t. d.m. ha ⁻¹
R_G	Root-shoot ratio appropriate for grassland; dimensionless
CF	Carbon fraction of dry matter; tonnes C (tonne d. m.) ⁻¹
i	Stratum i (I = total number of strata)
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

Note that the loss of biomass due to the removal of grass and other pre-existing vegetation occurs only when the area $A_{ijk,Conv,t}$ is converted from grassland to forest through afforestation/reforestation. The

estimates of $B_{w,i}$ and R_G shall be provided from national publications. In case these data are not available, project participants shall rely on default data provided in the GPG for LULUCF (Table 3.4.2 and Table 3A.1.8).

(b) 3 Emissions from biomass burning

Emissions from biomass burning (fires) include not only CO₂ but also other greenhouse gases (in particular methane and a negligible amount of nitrous oxide). These non-CO₂ emissions result from incomplete combustion of biomass. Such emissions can occur e.g. during the burning of pre-existing vegetation¹¹ for site preparation or from forest fires.

The CO₂ emissions from biomass burning (fires) do not have to be accounted for since changes in carbon stock in the grassland in the living biomass are already included in the calculation of the decrease in carbon stocks in living biomass from removal of grassland to afforest or reforest. However, if biomass burning occurs during the site preparation before planting and/or replanting, this results in non-CO₂ emissions.

$$E_{Non-CO_2, Biomass Burn, t} = E_{Biomass Burn, CH_4, t} \tag{B.29}$$

$$E_{Biomass Burn, CH_4, t} = E_{Biomass Burn, C, t} \cdot EF_{CH_4} \cdot GWP_{CH_4} \cdot \frac{16}{12} \tag{B.30}$$

where:

$E_{Non-CO_2, Biomass Burn, t}$	Non-CO ₂ emission as a result of biomass burning within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Biomass Burn, CH_4, t}$	CH ₄ emission from biomass burning; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Biomass Burn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t
EF_{CH_4}	IPCC default emission ratio for CH ₄ (IPCC default: 0.0012); tC as CH ₄ (tC burned) ⁻¹
GWP_{CH_4}	Global warming potential for CH ₄ (IPCC default for the first commitment period: 21); t CO ₂ -e (t CH ₄) ⁻¹
$\frac{16}{12}$	Ratio of molecular weights of CH ₄ and carbon; dimensionless

$$E_{Biomass Burn, C, t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K A_{burn,ijk,t} \cdot B_{ijk,t} \cdot CE \cdot CF \tag{B.31}$$

where:

$E_{Biomass Burn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t
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¹¹ In accordance with guidance contained in paragraph 35 of EB 42 meeting report, GHG emissions due to removal (loss) of herbaceous vegetation as a component of non-tree biomass are neglected in this methodology. Hence, all references to GHG emission from removal of non-tree/ pre-existing vegetation (biomass) do not include GHG emissions from removal of herbaceous vegetation.

$A_{burn,ijk,t}$	Annual area affected by biomass burning in stratum i , species j , sub-stratum k ; ha yr ⁻¹
$B_{ijk,t}$	Average above-ground biomass before burning for stratum i , species j , sub-stratum k ; tonnes d.m. ha ⁻¹ <u>Notes:</u> if the burning occurs during site preparation, $B_{ijk,t}$ indicates the above-ground biomass on grassland before burning. Otherwise it indicates the above-ground biomass of trees in year t
CE	Combustion efficiency; dimensionless (IPCC default = 0.5)
CF	Carbon fraction of dry matter; tonnes C (tonne d.m.) ⁻¹
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)
k	Substratum k (K = total number of substrata)

The combustion efficiencies may be chosen from Table 3.A.14 of GPG for LULUCF. If no appropriate combustion efficiency can be used, the IPCC default of 0.5 should be used, see Section 3.2.1.4.2.2 in GPG for LULUCF.

8. Leakage

Leakage is assumed to occur as a result of increased emissions from displacement of fuelwood collection ($LK_{Fuelwood,t}$) and the displacement of grazing activities to areas outside the project that lead to deforestation and land use change to grazing lands ($LK_{Displacement_grazing,t}$). As the land use in the absence of the project activity is grazing/pasture land the consideration of leakage due to displacement of agricultural activities is not applicable.

$$LK_t = LK_{Displacement_grazing,t} + LK_{Fuelwood,t} \quad (\text{B.32})$$

where:

LK_t	Increase of GHG emissions outside the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$LK_{Displacement_grazing,t}$	Increase in GHG emissions outside the project boundary resulting from displacement of grazing activities; tonnes CO ₂ -e yr ⁻¹ in year t
$LK_{Fuelwood,t}$	Increase in GHG emissions outside the project boundary resulting from displacement of fuelwood collection; tonnes CO ₂ -e yr ⁻¹ in year t

(a) Determination of leakage due to displacement of grazing activities

Estimation of leakage due to displacement of grazing shall be done using the latest version of the tool for “Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity” where leakage due to conversion of land to grazing land ($LK_{Displacement_grazing,t}$) is estimated as the parameter $LK_{Displacement,t}/1\text{year}$ (Leakage due to the displacement of animals in year t) as provided by the tool.

The management practices implemented by PPs may require at least temporary displacement of fuelwood collection.¹² If part the fuelwood gathered outside the project boundary does not obey the

¹² In this context, fuelwood refers both to fuelwood collection for direct use and for charcoal production.



most recent definition of renewable biomass as approved by the EB¹³ then leakage due to displacement of fuelwood collection ($LK_{Fuelwood}$) shall be estimated.

If application of the most recent version of the “Tool for testing significance of GHG emissions in A/R CDM project activities” leads to a conclusion that $LK_{Fuelwood}$ (as calculated using the Equation B.35 below) is insignificant then it can be neglected, i.e. accounted for as zero.

To calculate $LK_{fuelwood}$, first the volume of fuelwood gathered outside the project area will be estimated as follows:

$$FG_{outside,t} = FG_{BL} - FG_{AR,t} - FG_{Conv,t} \quad (B.33)$$

where:

$FG_{outside,t}$	Volume of fuelwood gathering displaced outside the project area at year t ; $m^3 yr^{-1}$
FG_{BL}	Average annual pre-project volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
$FG_{AR,t}$	Average annual volume of fuelwood collected in the project area under the proposed A/R CDM project activity; $m^3 yr^{-1}$
$FG_{Conv,t}$	Average annual volume of fuelwood collected during conversion of land to grazing land; $m^3 yr^{-1}$
t	1, 2, 3, ... t years elapsed since the start of the A/R CDM project activity

Leakage due to displacement of fuelwood collection can be set as zero ($LK_{Fuelwood} = 0$) under the following condition:

$$FG_{BL} \leq FG_{AR,t} + FG_{Conv,t}$$

$$FG_{BL} = \frac{sFG_{BL}}{SFR_{PAfw}} \quad (B.34)$$

where:

FG_{BL}	Average pre-project annual volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
sFG_{BL}	Sampled average pre-project annual volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
SFR_{PAfw}	Fraction of total plots or households in the project area sampled; dimensionless

In all other cases, leakage due to displacement of fuelwood collection shall be estimated as follows (IPCC GPG-LULUCF 2003 - Equation. 3.2.8):

$$LK_{Fuelwood,t} = FG_{outside,t} \cdot (1 - FRF) \cdot D_{DS} \cdot BEF_{2,DS} \cdot CF_{DS} \cdot \frac{44}{12} \quad (B.35)$$

¹³ See Glossary of CDM terms available at: <http://cdm.unfccc.int/Reference/Guidclarif/>.

where:

$LK_{Fuelwood}$	Leakage due to displacement of fuelwood collection at year t ; t CO ₂ -e yr ⁻¹
$FG_{outside,t}$	Volume of fuelwood gathering displaced outside the project area at year t ; m ³ yr ⁻¹
FRF	Fraction of fuelwood collected outside the project boundary that obeys the definition of renewable biomass; dimensionless
D_{DS}	Basic wood density of dominant species DS collected as fuelwood; t d.m. m ⁻³ (see IPCC GPG-LULUCF 2003, Table 3A.1.9)
$BEF_{2,DS}$	Biomass expansion factor for conversion of volumes of extracted roundwood to total above-ground tree biomass for dominant species DS collected as fuelwood; dimensionless
CF_{DS}	Carbon fraction of dry matter for dominant species DS collected as fuelwood; t C t ⁻¹ d.m.

9. Ex ante net anthropogenic GHG removal by sinks

The estimation of the net anthropogenic greenhouse gas removals by sinks follows the generic formulation:

$$C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t \quad (\text{B.36})$$

where:

$C_{AR-CDM,t}$	Net anthropogenic greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
$\Delta C_{BSL,t}$	Baseline net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
LK_t	Leakage; tonnes CO ₂ -e yr ⁻¹ for year t

The calculation of ICER's and tCER's should follow and be performed in accordance with the guidance from EB 22, Annex 15.

10. Uncertainties

The approach provided in Section III.10 below should be applied.

11. Data needed for ex ante estimations

The data requirements in this methodology can be met from the following major sources – international data; national level data; project level data, and published data and expert judgment. It is recommended that key parameters, such as average wood volume, basic wood density, biomass expansion factors, root-to-shoot ratio be investigated by sound research if data is unavailable from scientifically referenced publications. The data to calculate the project area shall have been acquired prior to the submission of the proposed A/R CDM project activity.

The auxiliary data to guide the stratification of the project area, such as soil map, previous land uses, shall be the latest developed by the national, regional or local authorities and institutions.



Precipitation data, if used, shall cover a time series of at least the five years prior to submission of the proposed A/R CDM project activity.

National data on peak carbon stock in above-ground biomass of grassland, maximum carbon stock in above-ground biomass in afforested or reforested areas, average annual increase in carbon stock in above-ground biomass in afforested or reforested areas, root-to-shoot ratio shall be those published in reliable sources or national reports. There is no restriction regarding the vintage of these data; however, it is recommendable that they are not older than 10 years.

IPCC data: the IPCC default emission factors, and other data (annual increases in carbon stock in above-ground biomass, peak carbon stock in above-ground biomass in grassland and afforested or reforested areas, root-to-shoot ratios) shall be those in the GPG 2000, GPG for LULUCF and IPCC 2006 Guidelines to be published. Data from the 1996 Guidelines shall be used if no updated data are provided in the GPG reports or 2006 Guidelines.

Project participants shall ensure that the spatial resolution of the data is adequate for the specific conditions of the proposed A/R CDM project activity. Some areas within the project boundary may have a spatial configuration that imposes restrictions on the spatial resolution of the data to be used. Auxiliary data (such as soil maps, land use/land-cover maps etc.) shall also be compatible with the spatial resolution of the remotely sensed data, to allow integration of the data into a Geographic Information System.

Table II.2: Data/parameter, their vintage, geographical scale and possible data sources

Data parameter	Description	Vintage	Geographical scale	Data sources
Historical land use/cover data	Determining baseline approach and demonstrating land eligibility	Earliest possible up to current	Local	Publications, forestry inventory, local government, interviews
Land use/cover map	Demonstrating land eligibility and stratification	Around 1990 & most recent	Local	Forest inventory
Satellite imagery	Demonstrating land eligibility and stratification	1989/1990 & most recent	Local	E.g. Landsat imagery
Landform map	Stratification of area	Most recent	Local	Local government
Soil map	Stratification of area	Most recent	Local	Local government regional agencies
National and sector policies	Additionality consideration	Most recent	National	Official publications
UNFCCC decisions		1997 up to now	Global	UNFCCC website
Forest thresholds (height, crown cover, minimum area)	Land eligibility criteria	Most updated	National	Designated national authority UNFCCC records
Incentives and barriers to A/R for industrial/commercial use	Baseline consideration	Compliant with sector policies & local practices	Local	National or local documentation
Demand and supply of wood resources for industrial/	Baseline consideration	Compliant with sector policies & local practices	Local / National	National or local publications; data on wood imports



Data parameter /	Description	Vintage	Geographical scale	Data sources
commercial use				
A/R Tool for the assessment and demonstration of additionality	Additionality consideration	Most updated	Global	UNFCCC website; Additionality Tool (EB 21, Annex 16)
Investment cost	Land purchase, rental, machinery, equipment, buildings, fences, site preparation, nursery, planting, weeding, pesticides, fertilization, consultation, etc. That occur during establishment period	Most recent data, taking into account market risk	Project	Local/national statistics, published /survey data
Operations and maintenance costs	Costs of thinning, pruning, harvesting, replanting, fuel, transportation, repairs, fire and disease control, patrol, administration	Most recent date, taking into account market risk	Local	Local statistics, published data / survey
Transaction costs	Including costs of project preparation, validation, registration, monitoring etc	Most updated	Local	Project data
Revenues	Those from timber, fuelwood, non-wood products, with and without cers revenues etc	Most recent	Local	Project data/ local published data / survey
Barrier analysis	Additionality consideration	Most recent considering Risks	Local/ national /regional	Local/national official publications/ project data
0.001	Conversion from kg to tonnes of CO ₂	Constant	Global default	Official publications
$\frac{44}{28}$	Ratio of molecular weights of N ₂ O and nitrogen; dimensionless	Constant	Global default	Official publications
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless	Constant	Global default	Official publications
$A_{ijk,t}$	Area for stratum i , species j , sub-stratum k ; hectares in year t	Most updated	Project	Calculated
$A_{ijk,Conv,t}$	Annual area converted to forest in stratum i , species j , sub-stratum k ; ha yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$A_{ARB,ij}$	Area of stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; hectare (ha)	Most updated	Project	Calculated
$A_{burn,ijk,t}$	Annual area affected by biomass burning in stratum i , species j , sub-stratum k ; ha yr ⁻¹	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$A_{F,ijk}$	Area of harvest for fuelwood in stratum i , species j , sub-stratum k ; ha yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>



Data parameter /	Description	Vintage	Geographical scale	Data sources
$A_{H,ijk}$	Area of harvest in stratum i , species j sub-stratum k ; ha yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$B_{ijk,t}$	Average above-ground biomass before burning for stratum i , species j , sub-stratum k ; tonnes d.m. ha ⁻¹	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$B_{w,i}$	Peak (maximum) above-ground biomass of grassland in stratum i ; t. d.m. ha ⁻¹	Most updated	Local/national / global	Local/national GPG for LULUCF/ official publications
BEF_{1j}	Biomass expansion factor for conversion of annual net increment (including bark) in merchantable volume to total above-ground biomass increment for species j ; dimensionless	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
$BEF_{2,DS}$	Biomass expansion factor for conversion of volumes of extracted roundwood to total above-ground tree biomass for dominant species DS collected as fuelwood; dimensionless	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
$BEF_{2,j}$	Biomass expansion factor for conversion of merchantable volume to above-ground tree biomass for species j ; dimensionless	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
BEF_{jk}	Biomass expansion factor for conversion of harvested volume of species j , sub-stratum k to above-ground biomass; dimensionless	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
$\Delta C_{AB,ijk,t}$	Average annual changes in carbon stock in above-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{BB,ijk,t}$	Average annual changes in carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{ijk,t,ETB}$	Sum of annual changes in the carbon stocks of living biomass (above- and below-ground) of	Most updated	Project	Calculated



Data parameter /	Description	Vintage	Geographical scale	Data sources
	pre-existing trees in stratum i , substratum j , species k ; t CO ₂ yr ⁻¹			
$\Delta C_{ijk,t}$	Average annual change in carbon stock in living biomass of trees for stratum i , species j , substratum k ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{ARB,ij,t}$	Average annual change in carbon stock in the living biomass of trees for stratum i , species j under the baseline scenario with <i>A/R activities implemented during the pre-project period</i> ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{ARB,G,ij,t}$	Average annual increase in carbon stock due to biomass growth of living trees for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{ARB,L,ij,t}$	Average annual decrease in carbon stock due to biomass loss of living trees for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{ARB,t}$	Sum of carbon stock changes in living biomass of trees, under the baseline scenario with <i>A/R activities implemented during the pre-project period</i> ; tonnes CO ₂ yr ⁻¹ in year t	Most updated	Project	Calculated



$\Delta C_{BSL,t}$	Sum of the carbon stock changes in living biomass of grassland (above and below-ground biomass) under the baseline scenario; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Calculated
$\Delta C_{G,AB,ijk,t}$	Average annual increase in carbon in above-ground biomass due to biomass growth of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{L,AB,ijk,t}$	Average annual decrease in carbon in above-ground biomass due to biomass loss in stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{G,BB,ijk,t}$	Average annual increase in carbon in below-ground biomass due to biomass growth of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Calculated
$\Delta C_{GLB,t}$	Sum of the carbon stock changes in the living biomass of grassland (above and below-ground biomass) under the baseline scenario - <i>maintenance of grassland in its state</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Calculated
$\Delta C_{L,BB,ijk,t}$	Average annual decrease in carbon in below-ground biomass due to biomass loss in stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>	Most updated	Project	Calculated
$\Delta C_{L,AB,ijk,Dist,t}$	Average annual decrease in carbon stock of above-ground biomass of trees due to disturbance for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes C yr ⁻¹ in year <i>t</i>	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{L,AB,ijk,Harvest,t}$	Average annual decrease in carbon stock of above-ground biomass of trees due to commercial harvest for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes C yr ⁻¹ in year <i>t</i>	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>



$\Delta C_{L,BB,ijk,Harvest,t}$	Average annual decrease in carbon stock of below-ground biomass of trees due to commercial harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{L,AB,ijk,Fwood,t}$	Average annual decrease in carbon stock in above-ground biomass of trees due to fuelwood	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$\Delta C_{L,BB,ijk,Fwood,t}$	Annual decrease in carbon stock of below-ground biomass of trees due to fuel wood collection/harvest for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t	Most updated	Project	Calculated
$\Delta C_{L,BB,ijk,Dist,t}$	Average annual decrease in carbon stock of below-ground biomass of trees due to disturbance for stratum i , species j , sub-stratum k ; tonnes C yr ⁻¹ in year t	Most updated	Project	Calculated
C_{ARB,ij,t_2}	Total carbon stock in living biomass of trees for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> calculated at time t_2 ; tonnes C	Most updated	Project	Calculated
C_{ARB,ij,t_1}	Total carbon stock in living biomass of trees for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> calculated at time t_1 ; tonnes C	Most updated	Project	Calculated
$C_{ARB,AB,ij}$	Carbon stock in above-ground biomass for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> ; tonnes C	Most updated	Project	Calculated
$C_{ARB,BB,ij}$	Carbon stock in below-ground biomass for stratum i , species j under the baseline scenario with <i>A/R implemented during the pre-project period</i> ; tonnes C	Most updated	Project	Calculated
$C_{AR-CDM,t}$	Net anthropogenic greenhouse gas removals by sinks; tonnes CO ₂ -e for year t	Most updated	Project	Estimated <i>ex -ante</i> & measured <i>ex post</i>



CE	Combustion efficiency; dimensionless (IPCC default =0.5)	Default	Global	IPCC
CF	Carbon fraction of dry matter; tonnes C (tonne d.m.) ⁻¹	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
CF_{DS}	Carbon fraction of dry matter for dominant species DS collected as fuelwood; t C t ⁻¹ d.m.	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
CF_j	Carbon fraction of dry matter for species j ; tonnes C (tonne d.m.) ⁻¹	Most updated	Local/national /global default	Local/national GPG for LULUCF/ official publications
$CSP_{diesel,t}$	Volume of diesel consumption; litre (l) yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$CSP_{gasoline,t}$	Volume of gasoline consumption; litre (l) yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
D_j	Basic wood density for species j ; tonnes d.m. m ⁻³	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
D_{DS}	Basic wood density of dominant species DS collected as fuelwood; t d.m. m ⁻³	Most updated	Local/national /global default	Local/national/ GPG for LULUCF/ publications
$E_{FuelBurn,t}$	CO ₂ emissions from combustion of fossil fuels within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$E_{BiomassLoss,t}$	GHG emissions from the loss of biomass in site preparation and conversion to A/R within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$E_{Non-CO_2,BiomassBurn,t}$	Non-CO ₂ emission as a result of biomass burning within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$E_{BiomassBurn,CH_4,t}$	CH ₄ emission from biomass burning; tonnes CO ₂ -e yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$E_{BiomassBurn,C,t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>



$f_j(DBH, H)$	Allometric equation for species j linking diameter at breast height (DBH) and possibly tree height (H) to above-ground biomass of living trees; t d.m. tree ⁻¹ (Note: if using an average DBH in an allometric equation, the average must be calculated as the square root of the sum of the squares of the individual tree diameters making up the sample divided by their number - i.e. so called “quadratic mean” or “root mean square”)	Most updated	Local/national /global	Local/national GPG for LULUCF/ official publications
FG_{BL}	Average pre-project annual volume of fuelwood gathering in the project area; m ³ yr ⁻¹	Most updated	Average data based on at least 3 and no more than 10 years time period preceding the starting date of the A/R CDM project activity	Estimated based on interviews and/or Participatory Rural Appraisal (PRA) or Others sources of information, such as local studies on fuelwood consumption or charcoal production may also be used
FRF	Fraction of fuelwood collected outside the project boundary that obeys the definition of renewable biomass; dimensionless	Most updated	Project	If available, verifiable local or national estimates will be used. Otherwise a default value of 60% will be used
$FG_{AR,t}$	Average annual volume of fuelwood collected in the project area under the proposed A/R CDM project; m ³ yr ⁻¹	Most updated	Project	Estimated <i>ex ante</i> , monitored <i>ex post</i> . Project Management plan or field sampling For each verification period, estimate the fuelwood collected in the project area. Besides volume, also determine what the dominant species is that is collected as fuelwood



$FG_{Conv,t}$	Average annual volume of fuelwood collected during conversion of land to grazing land; $m^3 yr^{-1}$	Most updated	Project	Estimated <i>ex ante</i> , monitored <i>ex post</i> . For each verification period, estimate the fuelwood collected in the project area. Besides volume, also determine what the dominant species is that is collected as fuelwood
$FG_{outside,t}$	Volume of fuelwood gathering displaced outside the project area at year t ; $m^3 yr^{-1}$	Most updated	Project	Estimated <i>ex ante</i> , monitored <i>ex post</i>
$FW_{ijk,t}$	Amount of fuelwood volume harvested for fuelwood in stratum i , species j , sub-stratum k ; $m^3 ha^{-1}$ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$G_{ARB,ij,t}$	Average annual increment of total dry biomass of living trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes d.m. $ha^{-1} yr^{-1}$ in year t	Most updated	Project	Calculated
$G_{ARB,w,ij,t}$	Average annual above-ground biomass increment of trees for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; tonnes d.m. $ha^{-1} yr^{-1}$ in year t	Most updated	Project	Calculated
$GHG_{E,t}$	GHG emissions by sources within the project boundary as a result of the implementation of the A/R CDM project activity; tonnes $CO_2-e yr^{-1}$ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
GWP_{CH_4}	Global warming potential for CH_4 (IPCC default for the first commitment period: 21); $kg CO_2 (kg CH_4)^{-1}$	Default	Global	IPCC
GWP_{N_2O}	Global warming potential for N_2O (IPCC default for the first commitment period: 310); $kg CO_2 (kg N_2O)^{-1}$	Default	Global	IPCC
$H_{ijk,t}$	Amount of merchantable volume harvested in stratum i , species j , sub-stratum k ; $m^3 ha^{-1}$ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>



$I_{ARB,v,t}$	Average annual increment in merchantable volume for stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; $m^3 ha^{-1} yr^{-1}$ in year t	Most updated	Local to Global default	Estimate/ Calculated
$I_{ijk,t}$	Average annual increment in merchantable volume for stratum i , species j , sub-stratum k ; $m^3 ha^{-1} yr^{-1}$ in year t	Most updated	Project	Calculated
$k_{vf,t}$	Kilometers traveled by each of vehicle type v with fuel type f ; km in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
LK_t	Increase of GHG emissions outside the project boundary; tonnes $CO_2-e yr^{-1}$ in year t	Most updated	Project	Calculated
$LK_{Displacement_grazing}$	Increase in GHG emissions outside the project boundary resulting from displacement of grazing activities; tonnes $CO_2-e yr^{-1}$ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$LK_{Fuelwood,t}$	Increase in GHG emissions outside the project boundary resulting from displacement of fuelwood collection; tonnes $CO_2-e yr^{-1}$ in year t	Most updated	Project	Estimated <i>ex ante</i> & measured <i>ex post</i>
$nTR_{j,i,t}$	Tree stand density of species j in stratum i , at time t under the baseline scenario with A/R implemented during the pre-project period; trees ha^{-1}	Most updated	Project	Calculated
$R1_j$	Root-shoot ratio appropriate for biomass increment for species j ; $t d.m. t^{-1} d.m$	Most updated	Local/national /global default	Local/national GPG for LULUCF/ official publications
R_j	Root-shoot ratio appropriate for biomass stock, for species j ; $t C (t C)^{-1}$	Most updated	Local/national /global default	Local/national GPG for LULUCF/ official publications
R_{jk}	Root-shoot ratio appropriate for species j sub-stratum k ; $t C (t C)^{-1}$	Most updated	Local/national /global default	Local/national GPG for LULUCF/ official publications
R_G	Root-shoot ratio appropriate for pre-existing non-tree vegetation; dimensionless	Most updated	Local/national /global	Local/national GPG for LULUCF/ official publications



sFG_{BL}	Sampled average pre-project annual volume of fuelwood gathering in the project area; $m^3 yr^{-1}$	Most updated		
SFR_{PAfw}	Fraction of total plots or households in the project area sampled; dimensionless	Most updated		
T	Number of years between times t_2 and t_1 ; years	Most updated	Project	Calculated
t	Ranges from 1 to length of the crediting period	Most updated	Project	Calculated
$V_{ARB,ij}$	Merchantable volume of stratum i , species j under the baseline scenario with A/R implemented during the pre-project period; $m^3 ha^{-1}$	Most updated	Project	Calculated
v	Vehicle type	Most updated	Project	Calculated

12. Other information

Void.



Section III: Monitoring methodology description

1. Monitoring project boundary and project implementation

(a) Monitoring of the project boundary

The project boundary delineates the A/R CDM project activity as a distinct land use in relation to the land uses in the adjoining area. During the crediting period, a combination of field surveys and/or remote sensing methods shall be used to monitor the proposed A/R CDM activity within the project boundary.

The project boundary shall be verified using field-based methods and/or GPS systems. The methods used in monitoring of the project boundary shall be subjected to quality assurance/quality control procedures. The project participants shall be trained on the quality control/quality assurance procedures associated with the monitoring of the project boundary.

Project participants shall follow the steps outlined below in order to monitor the area planted under the A/R CDM project activity in each stratum:

- Field surveys shall be undertaken to verify that the delineated project boundary is congruent with the description presented in the AR-CDM-PDD;
- The spatial extent and location of the species planted under the A/R project activity, in each stratum, shall be recorded;
- As per the availability of remote sensing data of adequate resolution, project participants can assess the area planted and compare the changes observed in the planted area using remote sensing data and the data from ground checks, field monitoring, and from planting records;
- Any discrepancies between the area reported and the area estimated under the proposed A/R CDM project activity in any part of the strata or sub-strata along with the species planted, including the areas of mortality due to natural factors (e.g. fire and pests) and anthropogenic factors shall be recorded and reported.

(b) Monitoring of the forest establishment

In order to ensure that the planting quality and forest establishment conforms to the prescribed silvicultural practices relevant to the region, the CDM-AR-PDD shall provide the information on the monitoring activities implemented during the early stage of the forest establishment covering the 3-5 year period of the planting activity.

- Activities related to site preparation and vegetation affected as part of site preparation shall be recorded;
- Information on the number of species planted, area of stratum, and planting layout as per the management plan shall be prepared;
- Any deviation in the implementation in relation to the management or silvicultural plan and the information on such deviation shall be recorded and the justification shall be presented in the monitoring report;
- Survival rates of A/R areas in various sub-strata and strata of the project during the initial months of the project shall be recorded;
- The planted areas affected by natural and anthropogenic disturbances and seedlings planted by species as part of the gap planting during the year 2 and year 3 shall be recorded as during the assessment.



(c) Monitoring of the forest management activities

As part of monitoring of the forest management activities, inputs (e.g. fertilizer application) and outputs (e.g., harvests) of the A/R CDM project activities, which reflect in the GHG removals by sinks of the proposed A/R CDM project shall be recorded. The following categories of operations shall be recorded in the project database and reported to the DOE at the time of verification:

- Species-wise thinning and harvest regimes prescribed and followed, and the biomass removed from the operations, including the damage (if any occurred as part of thinning and harvesting);
- Schedule of replanting, coppicing and other management implemented to ensure the land use in its intended purpose;
- Quantity of fossil fuels used in the forest management and operations during each year of the project;
- Natural or anthropogenic disturbances (including the fire or other catastrophic events) by date, location, species, volume of biomass lost or affected, and the preventive or curative measures, if any implemented;
- Biomass burning practices, if any, carried out during the monitoring interval and the reasons for the activity;
- Information on the forest protection practices such as fire breaks, control burning, and closure to prevent anthropogenic activities that impact the standing biomass.

2. Stratification and sampling design for *ex post* calculations

The strata of the project in terms of their numbers and boundaries may change after the implementation of the project as described under the *ex ante stratification* outlined in Section II.3. For this reason, strata should be monitored at regular intervals. If a change in the number and area of the project strata occurs, the sample frame should be adjusted accordingly. Furthermore, *ex post* stratification also holds significance for merging the strata that have close similarities in terms of stocking levels or other criteria that lead to greater similarities in the carbon stock changes identified during *ex ante* stratification. The procedures for monitoring project strata and for implementing sampling frame are outlined below.

(a) Ex post stratification of project area

The *ex post* stratification shall consider monitoring of the project strata and their boundaries in order to account for the changes occurring in the strata due to disturbances and management activities in the period subsequent to *ex ante* stratification. Monitoring of strata shall be done using a Geographical Information System (GIS), which allows for integrating data from different sources (including data from GPS and remote sensing methods). The monitoring of strata and stand boundaries is critical to the verification of the area of stratum *i*, sub-stratum *k*, which reflects in the actual net GHG removals by sinks. The need for *ex post* stratification shall be evaluated at each monitoring event and changes in strata should be reported to the DOE for verification. The stratification map should be of adequate scale and should reflect the variables considered under the *ex post* monitoring.

**(a) 1 Factors to be considered in the *ex post* stratification**

The stratum reflects the characteristics of proposed A/R activity, stand type, age class, and planting year, and other characteristics that are specific to it. The maps of suitable scale should be used to delineate a sub-stratum and stratum levels. The potential anthropogenic and natural influences should be taken into account in *ex post* stratification for the purpose of evaluating variables influencing actual GHG removals by sinks. The factors to be considered in the *ex post* stratification are outlined below.

- Catastrophic disturbances such as fire, pest, or disease outbreaks that modify the homogeneous character of a stratum;
- The influence of grassland vegetation on stand development, for example, level of competition or shrub and herb weed growth that has changed during the period subsequent to *ex ante* stratification and could impact the growth of young stands should be taken into account;
- Management and silvicultural activities such as planting, thinning, harvesting, coppicing, replanting etc. implemented at different intervals and locations than those proposed at the start of the project;
- Changes in local factors that lead to different planting regimes than those planned at the time of *ex ante* stratification leading to differences in the composition of strata and the carbon stocks associated with them;
- Information on land use, tenure and institutional issues that were either not available at the time of *ex ante* stratification or were not taken into account at the earlier stage of stratification should be taken into account in the *ex post* stratification;
- Additional information on site characteristics or other variables not considered during the *ex ante* stratification of grassland should be considered during *ex post* stratification.

The *ex post* stratification implemented taking into account above factors and any other additional information is expected form the basis for the sampling frame required for monitoring of the stands. The procedures of sampling frame are outlined below.

(b) Sampling frame

The monitoring of the stratum $A_{ijk,t}$ (area of stratum i , species j and (if needed) at sub-stratum k (age class) level data permits transparent and accurate calculation of the net anthropogenic GHG removals by sinks. The sampling framework specifies the sample size, plot size, and plot location in order make an unbiased assessment of carbon stock changes under the project.

(b) 1 Sample size

Permanent sampling plots should be used for sampling to monitor changes in carbon stocks over the crediting period as they take into account the high covariance between observations at successive sampling events. The plots should be treated in the same way as other lands within the project boundary (e.g., during site and soil preparation, weeding, fertilization, irrigation, thinning, etc.).

The number of permanent plots needed for monitoring depends on the accuracy desired, variability of the carbon stock, composition of the species and costs associated with sampling. This methodology adopts a maximum permissible error of $\pm 10\%$ of the mean, at the 95% confidence level. The samples size (n) can be estimated as per the Neyman criterion of fixed levels of costs and accuracy. The number of plots in each stratum/sub-stratum shall be calculated using the following equation.

$$n = \left(\frac{t_{\alpha}}{E} \right)^2 \cdot \left(\sum_{i=1}^I W_i \cdot s_i \cdot \sqrt{C_i} \right) \cdot \left(\sum_{i=1}^I W_i \cdot \frac{s_i}{\sqrt{C_i}} \right) \quad \text{(M.1)}$$

where:

n	Sample size (number of sample plots required for monitoring)
t_{α}	t value for a significance level of α (0.05) or confidence level of 95%
N_i	Number of sample units for stratum i , calculated by dividing the area of stratum i by the area of each plot
N	Total number of sample units of all stratum levels, $N = \sum N_i$
s_i	Standard deviation of stratum i
E	Allowable error ($\pm 10\%$ of the mean)
C_i	Cost to select a plot of the stratum i
i	Stratum i (total number of strata I)
$W_i = \frac{N_i}{N}$	

The number of plots shall be allocated among the strata as per the equation below.

$$n_i = n \cdot \frac{W_i \cdot \frac{s_i}{\sqrt{C_i}}}{\sum_{i=1}^I W_i \cdot \frac{s_i}{\sqrt{C_i}}} \quad \text{(M.2)}$$

where:

n_i	Number of sample units (permanent sample plots) per stratum, that are allocated proportional to $W_i \cdot \frac{s_i}{\sqrt{C_i}}$
C_i	Cost to select a plot of the stratum i
n	Sample size (number of sample plots required for monitoring)
s_i	Standard deviation of stratum i
i	Stratum i (total number of strata I)
$W_i = N_i/N$	



(b) 2 Sample plot size

The plot size depends on the density of stands and spatial heterogeneity of the sub-stratum levels. As the size is related to number of trees, diameter, and variance of carbon stock among the plots, it is difficult to set a standard common size. Large sized plots will be useful in achieving desired accuracy. The permanent sample plots could be square, rectangular or circular in shape.

The plot area has major influence on sampling intensity, time, and resources spent in the measurements. Increasing the plot area decreases the variability between two samples. Thus, by increasing the sample plot area, variation among plots can be reduced permitting the use of small sample size at the same accuracy. Therefore, the size of plots could range between 100 m² for dense stands and 1000 m² for open stands.

(b) 3 Location of sample plots

The location of sample plots should be done using plot centres as reference points. The geographical position, administrative location, stratum, stand, and series number of plots and their location within the sub-strata and strata should be recorded, represented on the map and archived. The plots should be systematically located with a random start in each stratum or sub-stratum and could be accomplished with the help of GPS or by adopting standard field operating procedures of forest inventory. In situations where GPS is not readily available, the plot description should follow the standard forest survey and inventory practices.

The total stratum area is divided by the number of plots to estimate the average area represented by one sample plot. Each sub-stratum or site is divided by the average area per plot to obtain the number of plots rounded to the nearest integer.

(b) 4 Treatment of sample plots

All plots within a stratum/sub-stratum are managed in the same way and their layout and treatment should not lead to a differentiated treatment. Any changes occurring in the sample plots and the type of management practices and disturbance observed in the sample plots should be recorded and considered in evaluating carbon stock changes.

(b) 5 Management of sample plot data

The geo-referenced spatial data base shall be updated periodically taking into account the influence of the *ex post* stratification. The quality assurance and quality control measures should be applied in order to maintain the consistency of the monitoring data over the crediting period.

(c) Monitoring interval

Monitoring interval depends on the growth rate and variability observed in the above-ground carbon stock. The verification and certification events should not coincide with peaks in carbon stocks. As per the paragraph 12 of Appendix B in decision 19/CP.9, the time of thinning, harvest and other silvicultural activities shall be taken into account in adopting the monitoring interval. Depending on the rate of carbon accumulation in the living biomass, the first monitoring interval could be 3-5 years, after which the monitoring interval coincides with the verification interval, which is expected to occur at 5-year intervals until the end of the crediting period.

Project participants should determine the monitoring frequency taking into account the growth rate of species in the project activity: Within a 5 year monitoring interval, the fast growing species may allow early verification relative to slow growing species.

Data needed for the monitoring of emission sources and leakage should be collected and analyzed at least annually.

3. Calculation of *ex post* baseline net GHG removals by sinks, if required

The *ex ante* baseline scenario defined prior to the start of the proposed A/R CDM project activity shall be valid for the entire crediting period. Therefore, this methodology does not require the monitoring of baseline scenario during the crediting period and thereby avoids the costs to be incurred on baseline monitoring.

4. Data to be collected and archived for of baseline net GHG removals by sinks

Under this methodology there is no need for collecting data to estimated baseline net GHG removals by sinks.

5. Calculation of *ex post* actual net GHG removal by sinks

(a) Carbon stock changes

As per the provisions of the baseline methodology, carbon stocks in dead wood, litter, and soil pools are not monitored under this methodology. Therefore, changes in carbon stocks equal the carbon stock changes in above- and below-ground biomass within the project boundary. This methodology recommends estimating the changes in the above- and below-ground biomass using either allometric equation or Biomass Expansion Factor (BEF) methods. Allometric equation method should receive precedence over the *BEF* method. However, if allometric equations do not exist, *BEF* method could be used. In case it is impossible to calculate the changes in carbon stock due to absence of allometric equations and the parameters of the *BEF* method, the project specific biomass allometric equations can be established. Considering the cost and time intensiveness of the destructive sampling, it should only be pursued in the absence of local/regional allometric equations and parameters of the *BEF* method.

The changes in the carbon stocks of above- and below-ground biomass are estimated as follows.

$$\Delta C_{ijk,t} = (\Delta C_{AB,ijk,t} + \Delta C_{BB,ijk,t}) \cdot \frac{44}{12} \quad (\text{M.3})$$

$$\Delta C_{AB,ijk,t} = \frac{C_{AB,ijk,m_2} - C_{AB,ijk,m_1}}{T} \quad (\text{M.4})$$

$$\Delta C_{BB,ijk,t} = \frac{C_{BB,ijk,m_2} - C_{BB,ijk,m_1}}{T} \quad (\text{M.5})$$

where:

$\Delta C_{ijk,t}$	Verifiable changes in carbon stock in living biomass of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>
$\Delta C_{AB,ijk,t}$	Changes in carbon stock in above-ground biomass of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>
$\Delta C_{BB,ijk,t}$	Changes in carbon stock in below-ground biomass of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> ; tonnes CO ₂ yr ⁻¹ in year <i>t</i>
C_{AB,ijk,m_2}	Carbon stock in above-ground biomass of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> calculated at monitoring point <i>m</i> ₂ ; tonnes C
C_{AB,ijk,m_1}	Carbon stock in above-ground biomass of trees for stratum <i>i</i> , species <i>j</i> , sub-stratum <i>k</i> calculated at monitoring point <i>m</i> ₁ ; tonnes C

C_{BB,ijk,m_2}	Carbon stock in below-ground biomass of trees for stratum i , species j , sub-stratum k calculated at monitoring point m_2 ; tonnes C
C_{BB,ijk,m_1}	Carbon stock in below-ground biomass of trees for stratum i , species j , sub-stratum k , calculated at monitoring point m_1 ; tonnes C
T	Number of years between monitoring point m_2 and m_1 , which in this methodology is 5 years
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

(a) 1 Use of allometric equations

The tree biomass can be estimated as a relationship between biomass and DBH , or DBH and tree height H to calculate biomass as an intermediate step in the estimation of biomass.

Step 1: For plot level measurements, plots shall be located, their identity verified by comparing the identification in the project database and monitoring plan. The measurements of diameter at breast height (DBH) and tree height (H) shall be collected. For tree height, trees above minimum DBH shall be selected. The minimum DBH may vary from 2.5 cm to 10 cm.

Step 2: Allometric equation relating the diameter at the breast height and tree height is represented as below.

$$TB_{AB,ijk,m} = f(DBH, H) \quad (M.6)$$

where:

$TB_{AB,tree,ijk,m}$ Above-ground biomass of a tree in stratum i , species j , sub-stratum k ; kg tree⁻¹ at monitoring time m

$f(DBH, H)$ An allometric equation for species j linking above-ground tree biomass (kg tree⁻¹) to the diameter at breast height (DBH) and possibly tree height (H) in plots for stratum i , species j , sub-stratum k

The allometric equations used for the *ex post* estimates should preferably be the same as used for the *ex ante* estimates baseline methodology and be selected according to the same hierarchical order of data sources.

Step 3: The carbon stock per tree in above-ground biomass shall be estimated using allometric equations applied to the tree measurements.

$$TC_{AB,ijk,tree,m} = TB_{AB,ijk,tree,m} \cdot CF_j \quad (M.7)$$

where:

$TB_{AB,tree,ijk,m}$ Above-ground biomass of a tree in stratum i , species j , sub-stratum k ; kg tree⁻¹ at monitoring time m

$TC_{AB,ijk,tree,m}$ Carbon stock in above-ground biomass per tree in stratum i , species j , sub-stratum k ; kg C tree⁻¹ at monitoring time m

CF_j Carbon fraction of species j , tonnes C (tonne d.m.)⁻¹; IPCC default = 0.5

Step 4: The carbon stock in living biomass of trees in each plot shall be summed up and extrapolated to a per ha basis by multiplying the carbon stock per plot with the plot expansion factor XF :

$$PC_{AB,ijk,plot,m} = \frac{\sum_{tr=1}^{TR} TC_{AB,ijk,tree,m} \cdot XF}{1000} \quad (\text{M.8})$$

$$XF = \frac{10'000}{AP} \quad (\text{M.9})$$

$$PC_{BB,ijk,plot,m} = PC_{AB,ijk,plot,m} \cdot R_j \quad (\text{M.10})$$

where:

$PC_{AB,ijk,plot,m}$	Plot level carbon stock in above-ground biomass for stratum i , species j , substratum k ; tonnes C ha ⁻¹ at monitoring time m
$TC_{AB,ijk,tree,m}$	Carbon stock in above-ground biomass per tree in stratum i , species j , substratum k ; kg C tree ⁻¹ at monitoring time m
XF	Plot expansion factor from per plot values to per hectare values, ha ⁻¹
AP	Plot area; m ²
$PC_{BB,ijk,plot,m}$	Plot level carbon stock in below-ground biomass for stratum i , species j , substratum k ; tonnes C ha ⁻¹ at monitoring time m
R_j	Root-shoot ratio appropriate to increments for species j ; dimensionless
tr	tree (TR = number of trees in the plot)

Step 5: Mean carbon stock within each stratum shall be calculated by averaging the carbon stock across plots in a stratum.

$$MC_{AB,ijk,m} = \frac{\sum_{P_{ijk}=1}^{P_{ijk}} PC_{AB,ijk,plot,m}}{P_{ijk}} \quad (\text{M.11})$$

$$MC_{BB,ijk,m} = \frac{\sum_{P_{ijk}=1}^{P_{ijk}} PC_{BB,ijk,plot,m}}{P_{ijk}} \quad (\text{M.12})$$

where:

$MC_{AB,ijk,m}$	Mean carbon stock in above-ground biomass for stratum i , species j , substratum k ; tonnes C ha ⁻¹ at monitoring time m
$MC_{BB,ijk,m}$	Mean carbon stock in below-ground biomass for stratum i , species j , substratum k ; tonnes C ha ⁻¹ at monitoring time m
$PC_{AB,ijk,plot,m}$	Plot level carbon stock in above-ground biomass for stratum i , species j , substratum k ; tonnes C ha ⁻¹ at monitoring time m

$PC_{BB,ijk,plot,m}$	Plot level carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes C ha ⁻¹ at monitoring time m
P_{ijk}	Plot in stratum i , species j , sub-stratum k (P_{ijk} = total number of plots in stratum i , species j , sub-stratum k); dimensionless

Step 6: The carbon stock in living biomass is calculated from the area of each stratum i , species j and substratum k at time t and the mean carbon stock in above- and below-ground biomass per unit area, given by:

$$C_{AB,ijk,m} = A_{ijk,m} \cdot MC_{AB,ijk,m} \quad (\text{M.13})$$

$$C_{BB,ijk,m} = A_{ijk,m} \cdot MC_{BB,ijk,m} \quad (\text{M.14})$$

where:

$C_{AB,ijk,m}$	Changes in carbon stock in above-ground biomass for stratum i , species j , sub-stratum k ; tonnes C at monitoring time m
$C_{BB,ijk,m}$	Changes in carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes C at monitoring time m
$A_{ijk,m}$	Area of stratum i , species j , sub-stratum k ; hectare (ha) at monitoring time m
$MC_{AB,ijk,m}$	Mean carbon stock in above-ground biomass for stratum i , species j , sub-stratum k ; tonnes C ha ⁻¹ at monitoring time m
$MC_{BB,ijk,m}$	Mean carbon stock in below-ground biomass for stratum i , species j , sub-stratum k ; tonnes C ha ⁻¹ at monitoring time m

(a) 2 Use of BEF method

The estimation of carbon stock of the above-ground biomass in each stratum shall be carried out using plot level data and available local yield data and expansion factors as follows:

Step 1: Estimation of living biomass of trees using BEF

Measurements of the diameter at breast height (*DBH*) above a minimum diameter of 2.5 to 10 cm and height of trees in the permanent sample plot shall be used to estimate the merchantable volume. The biomass expansion factor (*BEF*) and root-to-shoot ratio (*R*) required for conversion of merchantable volume into above- and below-ground biomass should preferably be the same as used for the *ex ante* estimates baseline methodology and be selected according to the same hierarchical order of data sources.

$$TB_{AB,ijk,tree,m} = V_{ijk,m} \cdot D_j \cdot BEF_{jk} \quad (\text{M.15})$$

$$TB_{BB,ijk,tree,m} = TB_{AB,ijk,tree,m} \cdot R_j \quad (\text{M.16})$$

where:

$TB_{AB,ijk,tree,m}$	Above-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
$TB_{BB,ijk,tree,m}$	Below-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
$V_{ijk,m}$	Merchantable volume per tree (diameter DBH and height H) in stratum i , species j , sub-stratum k (age class); m ³ tree ⁻¹ at monitoring time m
D_j	Basic wood density for species j ; tonnes d.m. m ³ merchantable volume
BEF_{jk}	Biomass expansion factor for conversion of merchantable volume to above- ground tree biomass for species j , sub-stratum k ; dimensionless
R_j	Root-to-shoot ratio appropriate for species j ; dimensionless

The BEF and the root-shoot ratio (R) are age or density-dependent, therefore, it is desirable to use age or density-dependent equations (i.e. volume per ha). Stem wood volume can be small in young stands and BEF can be very large, while for old stands BEF is significantly smaller. Therefore care shall be exercised in using average BEF value as it may show significant variation for both young stands and old stands.

Step 2: Estimation of the carbon stock of living biomass of trees in one permanent sample plot

The living biomass of trees in one single permanent plot is the sum of the living biomass of measured trees within the sample plot and converted to carbon stock by multiplying the carbon fraction of the biomass.

$$PC_{AB,ijk,plot,m} = \sum_{tr=1}^{TR} TB_{AB,ijk,tree,m} \cdot CF_j \quad (\text{M.17})$$

$$PC_{BB,ijk,plot,m} = \sum_{tr=1}^{TR} TB_{BB,ijk,tree,m} \cdot CF_j \quad (\text{M.18})$$

where:

$PC_{AB,ijk,plot,m}$	Plot level carbon stock in above-ground biomass for stratum i , species j , sub- stratum k ; tonnes C ha ⁻¹ at monitoring time m
$PC_{BB,ijk,plot,m}$	Plot level carbon stock in below-ground biomass for stratum i , species j , sub- stratum k ; tonnes C ha ⁻¹ at monitoring time m
$TB_{AB,ijk,tree,m}$	Above-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
$TB_{BB,ijk,tree,m}$	Below-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
CF_j	Carbon fraction of species j , tonnes C (tonne d.m.) ⁻¹ ; IPCC default = 0.5

Step 3: Repeat Step 5 and Step 6 outlined under the allometric method above (Section III.5.a.1) to estimate the carbon stock in living trees

(b) GHG emissions by sources

The A/R project activity can result in the increase of GHG emissions, in particular CO₂, CH₄ and N₂O emissions. This methodology provides guidance for the monitoring of the increases in greenhouse gas emissions from fossil fuel combustion, loss of biomass from the conversion of grassland, non-CO₂ emissions from biomass burning (if practiced to clear the land to afforest or reforest), and estimates the GHGs emissions based on project monitoring data and IPCC emission factors.

The changes in GHG emissions caused by these practices can be calculated from the monitoring data and by selecting appropriate emission factors. The increase in greenhouse gas emissions ($GHG_{E,t}$) by sources is represented as follows:

$$GHG_{E,t} = E_{FuelBurn,t} + E_{BiomassLoss,t} + E_{Non-CO_2,BiomassBurn,t} \quad (M.19)$$

where:

$GHG_{E,t}$	Annual GHG emissions as a result of the implementation of the A/R CDM project activity within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{FuelBurn,t}$	CO ₂ emissions from combustion of fossil fuels within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{BiomassLoss,t}$	GHG emissions from the loss of biomass in site preparation and conversion to A/R within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Non-CO_2,BiomassBurn,t}$	Non-CO ₂ emission as a result of biomass burning within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t

The A/R project activities that result in emissions from the use of fossil fuels, shall be monitored and the emissions be calculated. However, not all A/R project activities burn biomass. If implementation of the A/R project activity results in the burning of biomass, it shall be monitored and the greenhouse gas emissions from biomass burning shall be estimated.

(b) 1 CO₂ emissions from burning of fossil fuels

Emissions from fossil fuel burning occur e.g., from the use of machinery in nursery, site preparation, thinning, and harvest. The data on operations are monitored and the data collected to estimate the emissions from the fossil fuel use as per the steps outlined below.

Step 1: The type and amount of fossil fuels using in project activities such as site preparation, planting, thinning, harvesting (but excluding transportation) shall be monitored and recorded, e.g. from log books, sales records, etc.

Step 2: The project activities that use fossil fuels shall be identified and the parameters of activities such as number of hours of machines operation, fuel consumption per hour of the machines, types of vehicles used, amount of timber thinned or harvested etc. shall be monitored and recorded based on, e.g. from log books, sales records, etc.

Step 3: The emission factors of the fuels used in the project should be chosen. If national/regional emission factors are not readily available, IPCC default emission factors can be used.

Step 4: The operation-wise GHG emissions shall be calculated. The IPCC 1996 Guidelines can be used to estimate the CO₂ emissions from combustion of fossil fuels using the equation below:

$$E_{FuelBurn,t} = (CSP_{diesel,t} \cdot EF_{diesel} + CSP_{gasoline,t} \cdot EF_{gasoline}) \cdot 0.001 \quad (M.20)$$

where:

$E_{FuelBurn,t}$ CO₂ emissions from combustion of fossil fuels within the project boundary; tonnes CO₂-e yr⁻¹ in year t

$CSP_{diesel,t}$ Volume of diesel consumption; litre (l) yr⁻¹ in year t

$CSP_{gasoline,t}$ Volume of gasoline consumption; litre (l) yr⁻¹ in year t

EF_{diesel} Emission factor for diesel; kg CO₂ l⁻¹

$EF_{gasoline}$ Emission factor for gasoline; kg CO₂ l⁻¹

0.001 Conversion from kg to tonnes of CO₂

(b) 2 Emissions from loss of biomass in site preparation and conversion of grassland

The loss of biomass due to the removal of grass and pre-existing non-tree vegetation occurs when the area A_{ijk} is converted from grassland to forest. Some proportion of biomass that disappears during the conversion of grassland to forests and site preparation and other vegetation re-grows even if some biomass is removed during site preparation.

A conservative approach is followed in this methodology by treating the biomass loss as equal to the peak biomass of the pre-existing non-tree vegetation. The amount of biomass loss is monitored based on the area affected, biomass associated with the area, and the carbon fraction of the biomass using the steps outlined below.

Step 1: The peak biomass of pre-existing non-tree¹⁴ vegetation on lands to be afforested/reforested is estimated from the field data or local studies. The estimates of $B_{w,i}$ and R_G provided in the national publications shall be used. In case these data are unavailable, project participants shall rely on default data provided in the GPG for LULUCF or use destructive sampling.

Step 2: The CO₂ emissions from biomass loss are estimated using the following equation.

$$E_{BiomassLoss,t} = \sum_{i=1}^I A_i \cdot B_{w,i} \cdot (1 + R_G) \cdot CF \cdot \frac{44}{12} / 1 \text{ year } \forall t = 1 \quad (M.21)$$

$$E_{BiomassLoss,t} = 0 \quad \forall t > 1 \quad (M.22)$$

¹⁴ In accordance with guidance contained in paragraph 35 of EB 42 meeting report, GHG emissions due to removal (loss) of herbaceous vegetation as a component of non-tree biomass are neglected in this methodology.

where:

$E_{Biomass\ Loss,t}$	Average annual decrease in grassland biomass due to conversion of grassland to forests in stratum i , species j , sub-stratum k ; tonnes CO ₂ yr ⁻¹ in year t
A_i	Area of stratum i ; ha
$B_{w,i}$	Peak (maximum) above-ground biomass of pre-existing non-tree vegetation in stratum i ; t. d.m. ha ⁻¹
R_G	Root-shoot ratio appropriate for pre-existing non-tree vegetation; dimensionless
CF	Carbon fraction of dry biomass in pre-existing non-tree vegetation; tonnes C (tonnes d.m.) ⁻¹
i	Stratum i (total number of strata I)
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

(b) 3 Emissions from biomass burning

Emissions from biomass burning include not only CO₂ but also other greenhouse gases (in particular methane and a negligible amount of nitrous oxide). These non-CO₂ emissions result from incomplete combustion of the biomass, as a consequence of biomass burning for site preparation of forest fires.

The CO₂ emissions from biomass burning (fires) do not have to be accounted for since changes in the loss of carbon stock in the grassland in the living biomass are already included in the calculated part of the emissions from biomass loss. The following steps are used for monitoring and estimating the non-CO₂ emissions from biomass burning.

Step 1: To estimate the biomass per unit area affected in the burning, the average biomass of the area shall be estimated. The above-ground tree and shrub biomass per unit area shall be estimated using available shrub and tree allometric equations. The non-tree biomass shall be estimated by collecting the non-tree biomass in circular/squares frames and the dry to wet ratio of the biomass is estimated using standards non-tree biomass sampling procedures. The total biomass per unit area can thus be estimated adding up all the above-ground biomass.

Step 2: The monitoring data on the area affected by burning shall be collected by surveying the area subjected to burn; this data on affected area is used along with the biomass per unit area to estimate the amount of biomass burnt.

Step 3: The combustion efficiencies shall be chosen from Table 3.A.14 of IPCC GPG for LULUCF. If no relevant combustion efficiency is found, the IPCC default of 0.5 should be used. Emission factors provided in Tables 3.A.15 and 3.A.16 of IPCC GPG for LULUCF shall be referred for additional guidance.

Step 4: The GHG emissions from the biomass burn shall be estimated based on the revised IPCC 1996 Guidelines for LULUCF and IPCC GPG for LULUCF using the equations below.

$$E_{Non-CO_2, Biomass\ Burn,t} = E_{Biomass\ Burn, CH_4,t} \quad (M.23)$$

$$E_{Biomass\ Burn, CH_4,t} = E_{Biomass\ Burn, C,t} \cdot EF_{CH_4} \cdot GWP_{CH_4} \cdot \frac{16}{12} \quad (M.24)$$

where:

$E_{Non-CO_2, Biomass Burn, t}$	Non-CO ₂ emission as a result of biomass burning within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Biomass Burn, CH_4, t}$	CH ₄ emission from biomass burning; tonnes CO ₂ -e yr ⁻¹ in year t
$E_{Biomass Burn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t
EF_{CH_4}	IPCC default emission ratio for CH ₄ of biomass burning (IPCC default: 0.012); t C as CH ₄ (t C burned) ⁻¹
GWP_{CH_4}	Global warming potential for CH ₄ (IPCC default for the first commitment period: 21); t CO ₂ -e (t CH ₄) ⁻¹
$\frac{16}{12}$	Ratio of molecular weights of CH ₄ and carbon; dimensionless

$$E_{Biomass Burn, C, t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K A_{burn,ijk,t} \cdot B_{ijk,t} \cdot PP_{ijk,t} \cdot CE \cdot CF \quad (M.25)$$

where:

$E_{Biomass Burn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t
$A_{burn,ijk,t}$	Annual area affected by biomass burning in stratum i , species j , sub-stratum k ; ha yr ⁻¹ in year t
$B_{ijk,t}$	Average above-ground biomass before burning for stratum i , species j , sub-stratum k ; tonnes d.m. ha ⁻¹ <u>Note:</u> if the burning occurs during site preparation, $B_{ijk,t}$ indicates the above-ground biomass on grassland before burning. Otherwise it indicates the above-ground biomass of established forest in year t
$PP_{ijk,t}$	Proportion of biomass burned, dimensionless
CE	Combustion efficiency; dimensionless (IPCC default =0.5)
CF	Carbon fraction of dry matter; tonnes C (tonne d.m.) ⁻¹
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)
k	Substratum k (K = total number of substrata)

(c) Actual net GHG removals by sinks

The actual net greenhouse gas removals by sinks represent the sum of the changes in the carbon stocks in the carbon pools considered under this methodology minus the sum of all GHG emissions by sources increased due to the implementation of the project activity.

$$\Delta C_{ACTUAL,t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K \Delta C_{ijk,t} - GHG_{E,t} \quad (M.26)$$



where:

$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)
k	Substratum k (K = total number of substrata)
$\Delta C_{ijk,t}$	Average annual change in carbon stock in living biomass of trees for stratum i , species j , sub-stratum (age class) k ; tonnes CO ₂ yr ⁻¹ in year t
$GHG_{E,t}$	Annual GHG emissions as a result of the implementation of the A/R CDM project activity within the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t



6. Data to be collected and archived for Actual net GHG removals by sinks

Table III.1: Data to be collected or used in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary from the proposed A/R CDM project activity, and how this data will be archived:

ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.01	Stratum ID	Stratification map	Alpha-numeric		Before the start of the project	100%	Each stratum has a particular combination of soil type, climate, and possibly tree species
2.1.1.02	Sub-stratum ID	Stratification map	Alpha-numeric		Before the start of the project	100%	Each sub-stratum has a particular year to be planted under each stratum
2.1.1.03	Confidence level		%		Before the start of the project	100%	For the purpose of QA/QC and measuring and monitoring accuracy
2.1.1.04	Accuracy		%		Before the start of the project	100%	For the purpose of QA/QC and measuring and monitoring accuracy
2.1.1.05	Standard deviation of each stratum			e	Before the start of the project	100%	For each stratum and sub-stratum, calculated from 2.1.1.03 – 2.1.1.05
2.1.1.06	Number of sample plots			c	Before the start of the project	100%	Plot ID shall be provided to each permanent sample plot



ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.07	Sample plot ID	Project and plot map	Alpha numeric		Before the start of the project	100%	Numeric series ID will be assigned to each permanent sample plot
2.1.1.08	Plot location	Project and plot map; GPS		m	5 years	100%	Using GPS to locate before start of the project and at time of each field measurement
2.1.1.09	Tree species	Project design map			5 years	100%	Arranged in CDM-AR PDD
2.1.1.10	Age of plantation	Plot measurement	Year	m	5 years	100% sampling plot	Counted since the planted year
2.1.1.11	Number of trees	Plot measurement	Number	m	5 years	100% of trees on plots	Counted in plot measurement
2.1.1.12	Diameter at Breast Height(DBH)	Plot measurement	cm	m	5 year	100% trees on plots	Measured at each monitoring interval
2.1.1.13	Mean DBH	Calculated from 2.1.1.12	cm	c	5 years	100% of sampling plots	Calculated from 2.1.1.11 and 2.1.1.12
2.1.1.14	Tree height	Plot measurement	m	m	5 year	100% trees on plots	Monitoring at each monitoring time per sampling method
2.1.1.15	Mean tree height	Calculated from 2.1.1.14	m	c	5 year	100% trees in plots	Calculated from 2.1.1.11 and 2.1.1.14
2.1.1.16	Merchantable volume	Calculated or plot measurement	m ³ /ha	c/m	5 year	100% of sampling plots	Calculated from 2.1.1.13 and possibly 2.1.1.15 using local-derived equations, or directly measured by field instrument



ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.17	Wood density	Local-derived, national GHG inventory, GPG for LULUCF	t d.m. m ⁻³	e	5 year	100% of plots	Local-derived and species-specific value have the priority
2.1.1.18	Biomass expansion factor (BEF)	Local-derived, national inventory, GPG for LULUCF	Dimensionless	e	5 year	100% of plots	Local-derived and species-specific value have the priority
2.1.1.19	Carbon fraction	Local/national, IPCC	t C. (t d.m) ⁻¹	e	5 year	100% of plots	Local-derived and species-specific value have the priority
2.1.1.20	Root-shoot ratio	Local, national, IPCC	Dimensionless	e	5 year	100% of plots	Locally-derived and species-specific value have the priority
2.1.1.21	Carbon stock in above-ground biomass of tree	Calculated from equation	kg C tree ⁻¹	c	5 year	100% sampling plot	Calculated
2.1.1.22	Carbon stock in below – ground biomass of tree	Calculated from equation	kg C tree ⁻¹	c	5 year	100% sampling plot	Calculated
2.1.1.23	Carbon stock in above-ground biomass of plots	Calculated from equation	t C ha ⁻¹	c	5 year	100% sampling plot	Calculated
2.1.1.24	Carbon stock in below-ground biomass of plots	Calculated from equation	t C ha ⁻¹	c	5 year	100% sampling plot	Calculated
2.1.1.25	Mean carbon stock in above-ground biomass per unit area per stratum per species	Calculated from plot data	t C ha ⁻¹	c	5 year	100% of stratum and sub-stratum	Calculated from 2.1.1.06 to 2.1.1.23



ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.26	Mean carbon stock in below-ground biomass per unit area per stratum per species	Calculated from plot data	t C ha ⁻¹	c	5 year	100% of stratum and sub-stratum	Calculated from 2.1.1.06 to 2.1.1.20
2.1.1.27	Area of stratum and sub-stratum	Stratification map and data	ha	m	5 year	100%	Actual area of each stratum and sub-stratum
2.1.1.28	Carbon stock in above-ground biomass of stratum per species	Calculated from equation	t C	c	5 year	100% of stratum and sub-stratum	Calculated
2.1.1.29	Carbon stock in below-ground biomass of stratum per species	Calculated from equation	t C	c	5 year	100% of stratum and sub-stratum	Calculated
2.1.1.30	Carbon stock change in above-ground biomass per stratum per species	Calculated from equation	t C yr ⁻¹	c	5 year	100% strata and sub-strata	Calculated
2.1.1.31	Carbon stock change in below-ground biomass per stratum per species	Calculated from equation	t C yr ⁻¹	c	5 year	100% strata and sub-strata	Calculated
2.1.1.32	Total carbon stock change	Calculated from equation	t CO ₂ -e yr ⁻¹	c	5 year	100% project area	Summing up carbon stock change in 2.1.1.30 and 2.1.1.31 for all stratum, sub-stratum and tree species



Table III.2: Data to be collected or used in order to monitor the GHG emissions by the sources, measured in units of CO₂ equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary, and how this data will be archived:

ID Number	Data Variable	Source of data	Data unit	Measured (m) Calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	Comment
2.1.2.01	Amount of diesel consumed in machinery use for site preparation, thinning or loggings	On-site Monitoring	litre	m	Annually	100%	Monitoring either diesel consumption per unit area for site preparation, or per unit volume logged or thinned
2.1.2.02	Amount of gasoline consumed in machinery use for site preparation, thinning or loggings	On-site monitoring	litre	m	Annually	100%	Monitoring either gasoline consumption per unit area for site preparation, or per unit volume logged or thinned
2.1.2.03	Emission factor for diesel	GPG 2000, IPCC Guidelines, national GHG inventory	kg/litre	e	At the beginning of the project	100%	National inventory value should have priority
2.1.2.04	Emission factor for gasoline	GPG 2000, IPCC Guidelines, national GHG inventory	kg/litre	e	At the beginning of project	100%	National inventory value should have priority
2.1.2.05	Emission from fossil fuel use within project boundary	Calculated from equation	t CO ₂ -e yr ⁻¹	e	Annually	100%	Calculated using equations
2.1.2.06	Area affected by biomass burning	Measured during implementation if practiced	ha	m	Annually	100%	Measured for different stratum



ID Number	Data Variable	Source of data	Data unit	Measured (m) Calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	Comment
2.1.2.07	Mean above-ground biomass stock before burning	Local or national data, GPG for LULUCF	t d.m. ha ⁻¹	e		100%	Sampling survey for different strata and sub-strata before burning
2.1.2.08	Proportion of biomass burned	Measured after biomass burning	Dimensionless	m	Annually	100%	Sampling survey for different strata and sub-strata after burning
2.1.2.09	Biomass combustion efficiency	GPG for LULUCF, national GHG inventory	Dimensionless	e	Before the start of the project	100%	IPCC default value (IPCC default: 0.05) should be used if no appropriate value available
2.1.2.10	Carbon fraction	Local, national, IPCC	t C (t d.m.) ⁻¹	e	5 year	100%	
2.1.2.11	Loss of above-ground biomass carbon due to biomass burning	Calculated from equation	t C yr ⁻¹	c	5 year	100%	Calculated from equation
2.1.2.12	N/C ratio	GPG LULUCF, national GHG inventory	kg N/kg C	e	Before the start of the project	100%	IPCC default value (IPCC default: 0.001) should be used if no appropriate value is available
2.1.2.13	N ₂ O emission from biomass burning	Calculated using equation	t CO ₂ -e yr ⁻¹	c	5 year	100%	Calculated using equation
2.1.2.14	CH ₄ emission from biomass burning	Calculated using equation	t CO ₂ -e yr ⁻¹	c	5 year	100%	Calculated using equation
2.1.2.15	Increase in non-CO ₂ emission as a result of biomass burning	Calculated using equation	t CO ₂ -e yr ⁻¹	c	5 year	100%	Calculated using equation



ID Number	Data Variable	Source of data	Data unit	Measured (m) Calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	Comment
2.1.2.25	Total increase in GHG emission	Calculated using equation	t CO ₂ -e yr ⁻¹	c	Annually	100%	Calculated using equation

7. Leakage

Leakage is assumed to occur as a result of increased emissions from displacement of collection of fuelwood ($LK_{Fuelwood,t}$) and of the displacement of grazing activities to areas outside the project that lead to deforestation and land use change to grazing lands ($LK_{Displacement_grazing,t}$). As the land use in the absence of the project activity is grazing/pasture land the consideration of leakage due to displacement of agricultural activities is not applicable.

$$LK_t = LK_{Displacement_grazing,t} + LK_{Fuelwood,t} \quad (M.27)$$

where:

LK_t	Increase of GHG emissions outside the project boundary; tonnes CO ₂ -e yr ⁻¹ in year t
$LK_{Displacement_grazing,t}$	Increase in GHG emissions outside the project boundary resulting from displacement of grazing activities; tonnes CO ₂ -e yr ⁻¹ in year t
$LK_{Fuelwood,t}$	Increase in GHG emissions outside the project boundary resulting from displacement of fuelwood collection; tonnes CO ₂ -e yr ⁻¹ in year t

(a) Determination of leakage due to-displacement of grazing activities

Estimation of leakage due to displacement of grazing shall be done using the latest version of the tool for “Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity” where leakage due to conversion of land to grazing land ($LK_{Displacement_grazing,t}$) is estimated as the parameter $LK_{Displacement,t} / 1 \text{ yr}^{-1}$ (Leakage due to the displacement of animals in year t) as provided by the tool.

(b) Leakage from fuelwood collection

The management practices implemented by PPs may require at least temporary displacement of fuelwood collection.¹⁵ If part the fuelwood gathered outside the project boundary does not obey the most recent definition of renewable biomass as approved by the EB¹⁶ then leakage due to displacement of fuelwood collection ($LF_{Fuelwood}$) shall be estimated.

If application of the most recent version of the “Tool for testing significance of GHG emissions in A/R CDM project activities” leads to a conclusion that $LK_{Fuelwood}$ (as calculated using the Equation M.30) is insignificant then can be neglected, i.e. accounted for as zero.

To calculate $LK_{Fuelwood}$, first the volume of fuelwood gathered outside the project area will be estimated as follows:

$$FG_{outside,t} = FG_{BL} - FG_{AR,t} - FG_{Conv,t} \quad (M.28)$$

¹⁵ In this context, fuelwood refers both to fuelwood collection for direct use and for charcoal production.

¹⁶ See Glossary of CDM terms available at: <<http://cdm.unfccc.int/Reference/Guidclarif/>>.



where:

$FG_{outside,t}$	Volume of fuelwood gathering displaced outside the project area at year t ; $m^3 yr^{-1}$
FG_{BL}	Average annual pre-project volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
$FG_{AR,t}$	Average annual volume of fuelwood collected in the project area under the proposed A/R CDM project activity; $m^3 yr^{-1}$
$FG_{Conv,t}$	Average annual volume of fuelwood collected during conversion of land to grazing land; $m^3 yr^{-1}$
t	1, 2, 3, ... t years elapsed since the start of the A/R CDM project activity

Leakage due to displacement of fuelwood collection can be set as zero ($LK_{fuelwood} = 0$) under the following condition:

$$FG_{BL} \leq FG_{AR,t} + FG_{Conv,t}$$

$$FG_{BL} = \frac{sFG_{BL}}{SFR_{PAfw}} \quad \text{(M.29)}$$

where:

FG_{BL}	Average pre-project annual volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
sFG_{BL}	Sampled average pre-project annual volume of fuelwood gathering in the project area; $m^3 yr^{-1}$
SFR_{PAfw}	Fraction of total plots or households in the project area sampled; dimensionless

In all other cases, leakage due to displacement of fuelwood collection shall be estimated as follows (IPCCGPG-LULUCF 2003 - Equation 3.2.8):

$$LK_{Fuelwood,t} = FG_{outside,t} \cdot (1 - FRF) \cdot D_{DS} \cdot BEF_{2,DS} \cdot CF_{DS} \cdot \frac{44}{12} \quad \text{(M.30)}$$



where:

$LK_{fuelwood}$	Leakage due to displacement of fuelwood collection in year t ; t CO ₂ -e yr ⁻¹
$FG_{outside,t}$	Volume of fuelwood gathering displaced outside the project area at year t ; m ³ yr ⁻¹
FRF	Fraction of fuelwood collected outside the project boundary that obeys the definition of renewable biomass; dimensionless
D_{DS}	Basic wood density of dominant species DS collected as fuelwood; t d.m. m ⁻³ (see IPCC GPG-LULUCF 2003, Table 3A.1.9)
$BEF_{2,DS}$	Biomass expansion factor for conversion of volumes of extracted roundwood to total above-ground tree biomass for dominant species DS collected as fuelwood; dimensionless
CF_{DS}	Carbon fraction of dry matter for dominant species DS collected as fuelwood; t C t ⁻¹ d.m.



8. Data to be collected and archived for leakage

Table III.3: Data and information that will be collected in order to monitor leakage of the proposed A/R CDM project activity:

ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.01	Increase of GHG emissions outside the project boundary in year <i>t</i>	Calculated using equation	tonnes CO ₂ -e yr ⁻¹	C	Annual	100%	Calculated using equation
3.1.03	Increase in GHG emissions outside the project boundary resulting from displacement of grazing activities in year <i>t</i>	Calculated	tonnes CO ₂ -e yr ⁻¹	Calculated using A/R methodological tool “Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity”	c	Annually	100%
3.1.04	Increase in GHG emissions outside the project boundary resulting from displacement of fuelwood collection in year <i>t</i>	Calculated using equation	tonnes CO ₂ -e yr ⁻¹	C	Annual	100%	Calculated using equation
3.1.11	Average pre-project annual volume of fuel-wood gathering in the project area	Sampling	m ³ yr ⁻¹	e	Prior to the start of project activities		
3.1.12	Volume of fuel-wood gathered in the project area	Interview	m ³ yr ⁻¹	e	During monitoring		
3.1.13	Average annual volume of fuelwood collected during conversion of land to grazing land		m ³ yr ⁻¹	E			



ID number	Data Variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.14	Sampled average pre-project annual volume of fuelwood gathering in the project area	Sampling	m ³ yr ⁻¹	E			
3.1.15	Fraction of total plots or households in the project area sampled		Dimensionless	E			
3.1.16	Volume of fuelwood gathering displaced outside the project area at year <i>t</i>		m ³ yr ⁻¹	E			
3.1.17	Fraction of fuelwood collected outside the project boundary that obeys the definition of renewable biomass		Dimensionless	E			
3.1.18	Basic wood density of dominant species DS collected as fuelwood	Local, national or IPCC data	t d.m. m ⁻³	E			See IPCC GPG-LULUCF 2003, Table 3A.1.9
3.1.19	Biomass expansion factor for conversion of volumes of extracted roundwood to total above-ground tree biomass for dominant species DS collected as fuelwood	Local, national or IPCC data	Dimensionless	E			
3.1.20	Carbon fraction of dry matter for dominant species DS collected as fuelwood	Local, national or IPCC data	t C t ⁻¹ d.m.	E			

9. *Ex post* net anthropogenic GHG removal by sinks

The net anthropogenic greenhouse gas removals by sinks can be calculated following the generic equation:

$$C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t \quad (\text{M.31})$$

where:

$C_{AR-CDM,t}$	Net anthropogenic greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
$\Delta C_{BSL,t}$	Baseline net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
LK_t	Leakage; tonnes CO ₂ -e for year t

The calculation of lCER's and tCER's should follow and be performed in accordance with the guidance from EB 22, Annex 15 as outlined below.

t-CERs reflect the *existing stock change at the time of verification* minus project emissions minus leakage (t CO₂):

$$t-CER(t_v) = C_P(t_v) - C_B(t_v) - \sum_0^{t_v} E_t - \sum_0^{t_v} LK_t \quad (\text{M.32})$$

$$C_P(t_v) - \sum_0^{t_v} E_t = \sum_1^{t_v} \Delta C_{Actual,t} \quad (\text{M.33})$$

$$C_B(t_v) = \sum_1^{t_v} \Delta C_{BSL,t} \quad (\text{M.34})$$

l-CERs reflect the *increment of the stock change* at the time of verification minus project emissions minus leakage compared to the existing stock change at the previous time of verification (t CO₂):

$$l-CER(t_v) = [C_P(t_v) - C_P(t_v - \kappa)] - [C_B(t_v) - C_B(t_v - \kappa)] - \sum_{t_v-\kappa}^{t_v} E_t - \sum_{t_v-\kappa}^{t_v} LK_t \quad (\text{M.35})$$

$$C_P(t_v) - C_P(t_v - \kappa) - \sum_{t_v-\kappa}^{t_v} E_t = \sum_{t_v-\kappa}^{t_v} \Delta C_{Actual,t} \quad (\text{M.36})$$

$$C_B(t_v) - C_B(t_v - \kappa) = \sum_{t_v-\kappa}^{t_v} \Delta C_{BSL,t} \quad (\text{M.37})$$



where:

$t\text{-CER}(t_v)$	t-CERs issued at year of verification t_v (t CO ₂)
$l\text{-CER}(t_v)$	l-CERs issued at year of verification t_v (t CO ₂)
$C_P(t_v)$	Existing carbon stocks at the year of verification t_v (t CO ₂)
$C_B(t_v)$	Estimated carbon stocks of the baseline scenario at year of verification t_v (t CO ₂)
$E(t)$	Annual project emissions (t CO ₂)
$LK(t)$	Annual leakage (t CO ₂)
t_v	Year of verification
κ	Time span between two verification occasions (year)

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;¹⁷ 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.

¹⁷ 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.



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

Default values used in elaborating the new methodology

<i>CF</i>	Carbon fraction of dry matter default = 0.5 tonnes C (tonnes d.m.) ⁻¹
<i>GWPN₂O</i>	Global Warming Potential for N ₂ O = 310 kg CO ₂ -e. (kg N ₂ O) ⁻¹
<i>GWPC_H₄</i>	Global Warming Potential for CH ₄ = 21 kg CO ₂ -e. (kg CH ₄) ⁻¹
<i>ERN₂O</i>	Emission ratio for N ₂ O in biomass burning = 0.007 (kg CO ₂ -e. (kg C) ⁻¹)
<i>ERCH₄</i>	Emission ratio for CH ₄ in biomass burning = 0.012 (kg CO ₂ -e. (kg C) ⁻¹)
<i>CE</i>	Average combustion efficiency of biomass = 0.5
<i>N/C</i>	N/C ratio of biomass = 0.01 kg N (kg C) ⁻¹

Source: IPCC, 1996 Guidelines, IPCC GPG-LULUCF, GPG-2000 for energy, GPG-2000 for agriculture

**Section IV. Lists of acronyms and references** List of acronyms used in the methodologies**1. Acronyms**

Acronym	Description
A/R	Afforestation/Reforestation
C	Carbon
CO ₂	Carbon Dioxide
CO ₂ -e	Carbon Dioxide equivalent
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CF	Carbon Fraction
CH ₄	Methane
d.m.	Dry Matter
DBH	Diameter at Breast Height
EB	Executive Board
GHG	Greenhouse Gas
GPG for LULUCF	Good Practice Guidance for Land use, Land-use Change and Forestry
GPG2000	Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
GPS	Global Positioning System
GWP	Global Warming Potential
H	Tree Height
IPCC	Intergovernmental Panel on Climate Change
ICER	long-term Certified Emission Reduction
LULUCF	Land Use Land-Use Change and Forestry
N ₂ O	Nitrous Oxide
PDD	Project Design Document
QA	Quality Assurance
QC	Quality Control
tCER	temporary Certified Emission Reduction



History of the document

Version	Date	Nature of revision
03	EB 42, Para 35 26 September 2008	Revisions mainly in the following sections: <ul style="list-style-type: none">• Section II. Baseline methodology 7(b) Increase in emissions of greenhouse gases 8 Leakage• Section III. Monitoring Methodology 5(b) GHG emissions by sources 7 Leakage• To apply the guidance provided in para 35, EB 42 meeting report regarding accounting of GHG emissions in A/R CDM project activities, from the following sources (i) fertilizer application, (ii) removal of herbaceous vegetation, and (iii) transportation. The Board agreed that emissions from these sources may be considered as insignificant.
02	EB 42, Annex 10 26 September 2008	Changes to the leakage section, including reference to the leakage tool; and editorial changes to correct minor errors and provide further clarity.
01	EB 28, Annex 17 15 December 2006	Initial adoption.