SIMPLIFIED BASELINE AND MONITORING METHODOLOGIES FOR SELECTED A/R SMALL-SCALE CDM PROJECT ACTIVITY CATEGORIES

This text presents the general approach and the major elements considered for simplification of the baseline and monitoring methodologies for A/R small-scale CDM project activities.

Based on the comments by the public, the Executive Board will develop the complete set of methodologies to be presented for consideration to the first COP/MOP of the UNFCCC

1. Generalities

1.1 Scope of the report

This document contains simplified baseline and monitoring methodologies for selected small-scale A/R CDM project activity categories. Specifically it aims at developing:

- Simplified baseline methodology and default factors for small-scale afforestation or reforestation project activities conducted over: (a) Grasslands, (b) Croplands, (c) Wetlands and, (d) Settlements.

- Simplified monitoring methodology based on appropriate statistical methods to estimate or measure the actual net greenhouse gas removals by sinks. Specifically, to indicate different methods for different management types of afforestation and reforestation project activities under the CDM (plantations, agroforestry, and landscape restoration).

The methodologies outlined in this document have been designed to provide a simple, transparent, accurate and low-cost decision-making framework for small-scale A/R CDM project participants. As such, they encompass the most likely cases of prior land-use on lands to be used for small-scale A/R activities (namely cropland, grasslands, wetlands, and settlements) and three main A/R project activity types (plantations, agroforestry, and restoration forests). Cases that are very specific have not been addressed, because they add complications to the methodologies. As stated in the decision 14/CP.10, project participants interested in these specific cases can propose simplified methodologies tailored to their circumstances to the EB.

1.2 Means of simplification considered

These methodologies have been greatly simplified compared to regular A/R activities, according to the following:

- It is assumed that SCC A/R activities will concentrate on reforestation activities, since it would be more difficult and expensive to demonstrate the case for an afforestation activity. Afforestation requires that a given land should have been non-forested for the past 50 years, while reforestation applies to lands that were non-forested on 31 December 1989.

- A typology for SSC A/R projects activities has been defined to include three main types of: plantation, agroforestry and restoration. Methods for estimation of actual GHG removals by sinks including monitoring will be based on these three types.

- Two main pools are considered in detail, namely above-ground and below-ground biomass. Projects willing to consider more pools can use information on default values and formulae as provided. Monitoring methods are simplified to emphasize the tree biomass pools, with flexibility to measure other pools if they are assumed to change significantly as a result of the project activities.

- In cases where no significant changes in the carbon stocks within the project boundary are expected without the SSC A/R activity under the CDM, the carbon stocks assessed prior to the implementation of the project activity would be considered as the baseline and would be assumed to be constant throughout the crediting period (according to Decision 14/CP.10).

- If significant changes in the carbon stocks within the project boundary would occur in absence of the small scale A/R project activity, simplified baseline methodologies will be used in the form of default rates for the change in carbon stocks in various pools based on IPCC Guidelines and GPG.

- Default values are given for baselines for the four main land use types based on the IPCC Guidelines and GPG making it optional to measure the baseline case. Further scientific formulae are provided for estimating baseline and net carbon removals by sinks and for monitoring.
- There is no need to monitor the baseline, according to Decision 14/CP.10.
- The confidence interval for monitoring is 80%
- Statistical error analysis is not required.

1.3 Key definitions

Small Scale A/R CDM Project*:* The Conference of the Parties (COP), by its decision 19/CP.9, adopted modalities and procedures for afforestation and reforestation project activities under the clean development mechanism (CDM) in the first commitment period of the Kyoto Protocol. Paragraph 1 (i) of the annex to this decision defines small-scale afforestation and reforestation project activities under the CDM as those that are expected to result in net anthropogenic greenhouse gas removals by sinks of less than 8 kilotonnes of CO2 per year and are developed or implemented by low-income communities and individuals as determined by the host Party. If a small-scale afforestation or reforestation project activity under the CDM results in net anthropogenic greenhouse gas removals by sinks greater than 8 kilotonnes of CO2 per year, the excess removals will not be eligible for the issuance of tCERs or lCERs.

According to dec. 14/CP.10 a small-scale afforestation or reforestation project activity under the clean development mechanism will result in net anthropogenic greenhouse gas removals by sinks of less than 8 kilotonnes of carbon dioxide per year if the average projected net anthropogenic greenhouse gas removals by sinks for each verification period do not exceed 8 kilotonnes of carbon dioxide equivalent per year;

A small-scale afforestation and reforestation project activity under the clean development mechanism results in net anthropogenic greenhouse gas removals by sinks greater than 8 kilotonnes of carbon dioxide equivalent per year, the excess removals will not be eligible for the issuance of temporary certified emission reductions and long-term certified emission reductions;

The ***"project boundary"*** geographically delineates the afforestation or reforestation project activity under the control of the project participants. The project activity may contain more than one discrete area of land;

"Baseline net greenhouse gas removals by sinks" is the sum of the changes in carbon stocks in the carbon pools within the project boundary that would have occurred in the absence of the afforestation or reforestation project activity under the clean development mechanism (CDM);

"Actual net greenhouse gas removals by sinks" is the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in emissions of the greenhouse gases measured in CO2 equivalents by the sources that are increased as a result of the implementation of the afforestation or reforestation project activity, while avoiding double counting, within the project boundary, attributable to the afforestation or reforestation project activity under the CDM;

"Leakage" is the increase in greenhouse gas emissions by sources which occurs outside the boundary of an afforestation or reforestation project activity under the CDM which is measurable and attributable to the afforestation or reforestation project activity;

"Net anthropogenic greenhouse gas removals by sinks" is the actual net greenhouse gas removals by sinks minus the baseline net greenhouse gas removals by sinks minus leakage;

"Forest" is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. Within the ranges given in this definition, each host country shall fix its values for minimum land area, crown cover and minimum height at maturity in situ that will apply for the first commitment period.

"Afforestation" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources;

"*Reforestation*" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that had been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989;

*"**Woody perennial biomass**"* includes biomass from trees and shrubs that is present in croplands, grasslands, wetlands and settlements below the threshold (in terms of canopy cover, minimum area and tree height) used to define forests.

1.4 Definitions of prior land use

Consistent with the report of the Intergovernmental Panel on Climate Change (IPCC) entitled *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as the GPG-LULUCF or just GPG), as well as with land categories inferred in paragraph 4 of Appendix B to Decision 14/CP.10, the definitions of the prior land uses analyzed in this report are:

"Grassland", which includes rangelands and pasture land that is not considered as cropland. Grassland also includes systems with vegetation that falls below the threshold used in the definition for forest and is not expected to exceed, without human intervention, this threshold. Grassland also includes grasslands from wild lands to recreational areas as well as agricultural and silvo-pastoral systems, subdivided into managed and unmanaged consistent with national definitions

"Cropland", which includes arable and tillage land, and agroforestry systems where vegetation falls below the thresholds used to define "forest"

"Wetland", which includes land that is covered or saturated by water for all or part of the year and that does not fall into the cropland or grassland categories defined above

"Settlements", which includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.

1.5 Typology of A/R small-scale project activities

Forestry projects under the CDM are limited to two main types of projects, afforestation and reforestation (A/R projects from now on). Afforestation and reforestation are the conversion of non-forested land through planting and seeding and/or the human-induced promotion of natural seed sources.

There is a wide variety of potential A/R projects. These include planting with commercial timber species, planting with non-commercial native species, planting with multipurpose species (e.g. fruit trees, shade trees for coffee), combining trees with agriculture crops, or a combination of these species groups. For simplicity, three generic A/R project activity types will be used:

1. **“Plantations**”, which are forests established in purely tree stands mainly for the production of timber and other wood products such as fuelwood.

2. **“Agroforestry”** (including silvo-pastoral systems), which are trees mixed with agricultural crops or cattle, and may involve production of wood products as well as foliage biomass for fodder. Agoforestry activities can be divided into: a)silvopastoral, b)home-gardens, c)mixed of woody perennials and d) production agroforestry systems.

3. **“Restoration forests”,** which are forests established to recover degraded areas or protect landscapes such as catchment areas; restoration forests may produce timber or agricultural goods.

Under each A/R project activity type, the dynamics of the changes in carbon stocks differ as a consequence of the management activities such as planting patterns, species mix, thinning regimes as well as foliage biomass removal. As a consequence different monitoring methods are needed to capture these differences.

1.6 Carbon Pools and Significance of Change

A carbon pool is defined as the reservoir containing carbon. Carbon stock is the quantity of carbon in a pool. The carbon stock in a pool can change due to the difference between additions of carbon and losses of carbon. When the losses are larger than the additions, the carbon stock becomes smaller and thus the pool acts as a source to the atmosphere; when the losses are smaller than the additions, the pools acts as a sink to the atmosphere.

The specific carbon pools to be analyzed, consistent with IPCCC GPG-LULUCF, 2004 can include: above-ground biomass, belowground biomass, litter, dead wood and soil organic carbon. Each is defined as follows:

a) **ABOVEGROUND BIOMASS.** All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.

b) **BELOWGROUND BIOMASS.** All living biomass of live roots. Fine roots of less than (suggested) 2mm diameter are sometimes excluded because these often cannot be distinguished empirically from soil organic matter or litter.

c) **DEAD WOOD.** Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country.

d) **LITTER**. Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for example 10 cm), lying dead, in various states of decomposition above the mineral or organic soil. This includes litter, fumic, and humic layers. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included in litter where they cannot be distinguished from it empirically.

e) **SOIL ORGANIC MATTER.** Includes organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included with soil organic matter where they cannot be distinguished from it empirically.

Significant Changes in Carbon Pools and GHG removals by sinks

Following the GPG-LULUCF (2004) recommendations, a change of more than 10% of the original carbon stock (or GHG removals) is defined as “significant”. Any change less than or equal to 10% is considered as insignificant.

1.7 Summary of the Process for SCC A/R Project development

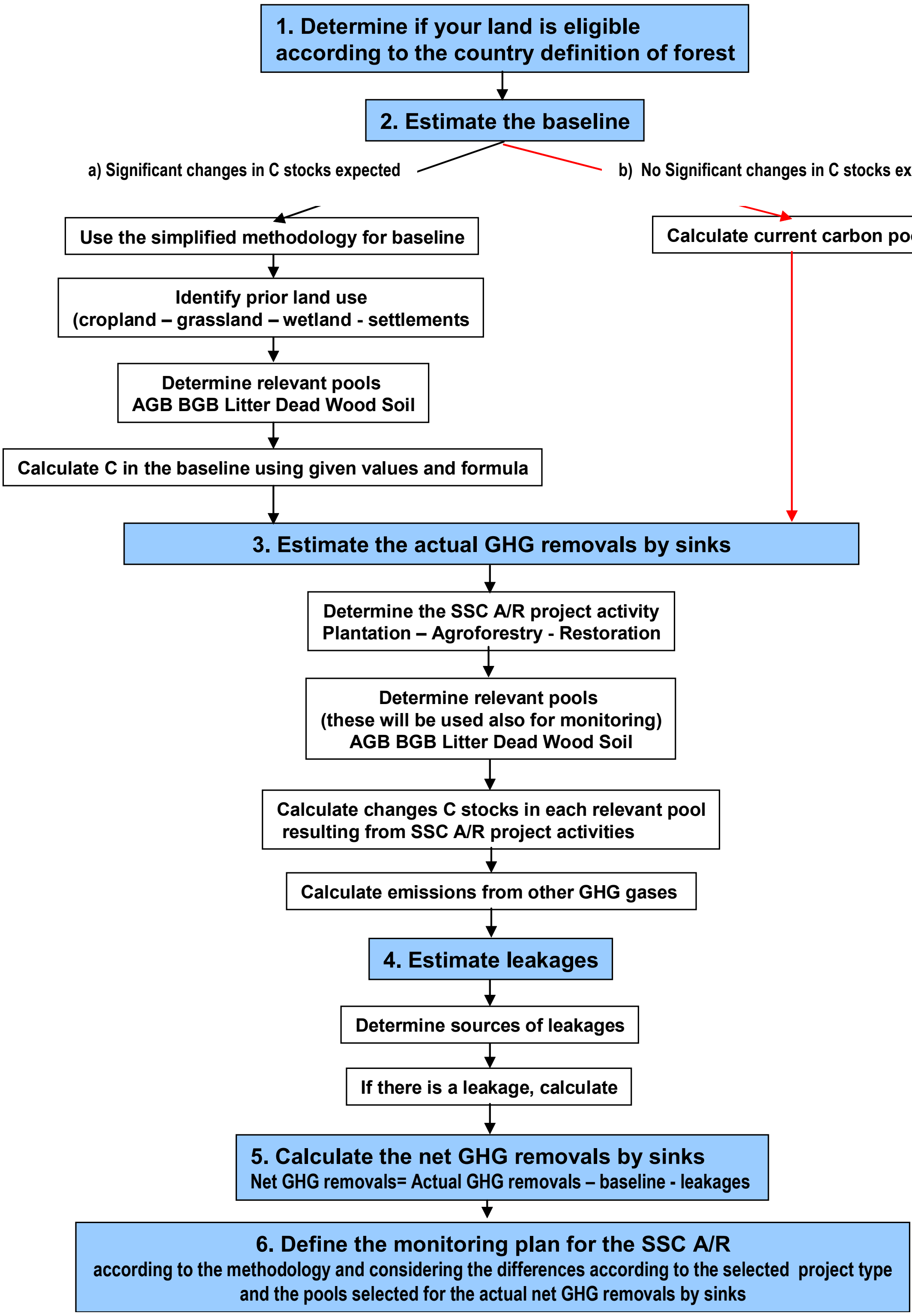

Figure 1. Flow of steps in the process of developing a SCC A/R project activity. Refer to the main text for definitions of keywords.

2. Determining eligible land

Eligibility of land for an A/R CDM activity involves demonstrating that the land to be used for the A/R activity was not forested by 31st December 1989. The definition of forest is based on a host country definition.

The status of land use at the end of 1989 can be verified using one or more of the tools for data collection described in the Good Practice Guidance (section 2.4.4) such as (1) remote sensing (RS) techniques (aerial photographs, satellite imagery) complemented by ground reference data; or, (2) ground based surveys (e.g. land use permits, land use plans or information from local registers such as cadastre, owners register, land use or land management register.

The output of determining eligible land would be a map or maps that clearly identifies eligible areas (areas of non-forest by 31 December 1989). These areas can be continuous or discrete. These maps would be the basis for defining project boundaries. Therefore such maps shall mark and identify precisely each piece of eligible land.

3. Estimating the Baseline

3.1 Decision Tree for the Baseline

As defined by the UNFCCC, "The baseline for project activities is the scenario that reasonably represents anthropogenic emissions by sources of GHGs and removals by sinks that would occur in the absence of the proposed project activity". Based on Decision 14/CP.10 Appendix B paragraphs 2 and 5, the following are decision trees for the estimation of the baseline:

Step 1: Select the most likely baseline scenario and establish additionality: simplest case would assume the current land use at the start of the project would be the most likely baseline scenario for the four main land use types of grassland, cropland, wetland and settlement. Apply the analysis of barriers approach in the EB additionality tool to establish additionality.

Step 2: Estimate baseline carbon stocks

- i. Apply default factors based on GPG for carbon stocks for each of the four land use types (grassland, cropland, wetland or settlement), or
- ii. Use project-specific methods that may involve national or local values, or new measurements

Step 3. Consideration of changes in baselines (without the need to monitor baselines)

- i. Assume no change in baseline carbon stocks during the period of the CDM A/R project activity, or
- ii. Assume baseline carbon stocks would change significantly during the project activity, in which case
  - a. Use default factors based on GPG to determine projections in carbon stock changes for the current land use type (cropland, grassland, wetland or grassland), or
  - b. Use project-specific methods.

3.2 Description of the Baseline Methodology

Title of the proposed methodology

Simplified baseline methodology for small scale CDM afforestation/reforestation project activities

List of type(s) of A/R CDM project activity to which the methodology may apply:

The types of project activities are reforestation in the form of plantations, agroforestry or restoration forestry activities on land currently under cropland, grassland, wetland or settlement areas.

B. Detailed description

1. Select the area proposed for the CDM project. Specify and clearly define spatial boundaries of the project lands on maps so as to facilitate accurate measuring, monitoring, accounting, and verifying the project. These boundaries need to be identifiable by all stakeholders including project developers and Parties. To provide clarity on the project boundaries, maps, records, physical identifiers, aerial photos or satellite data and other evidence can be used as appropriate.
2. Prepare or obtain current and past land-use trends of the project area to establish whether this land is likely to remain in this land use state (or carbon stock trend) in the absence of the project activity under the CDM. These can be obtained from statistical data, available historical land-use maps and/or satellite images, as well as through participatory rural appraisal with the communities concerned.

3. To prove additionality, use the analysis of barriers given in the EB's Additionality Tool. (attachment A in this document)
4. Select the most likely baseline scenario
5. Estimate baseline carbon stocks:
    a. Select carbon pools to be considered in the project.
    b. If demonstrated that the baseline carbon stocks would be constant, there is no need to estimate it.
    c. If baseline would change significantly during the accrediting period (such as in the case of a significant soil management change after 1990, as in case of a shift between tillage and no-tillage), then use default values and factors to estimate the baseline and subsequent changes during the project period as described in technical data sheets to be added based on the IPCC Guidelines and GPG.
    d. The carbon pools for the base-year project scenario are the carbon stocks in baseline scenario.

C. Choice of and justification as of baseline approach for A/R CDM project activities

C.1. General baseline approach.

The main change in carbon stocks will be most significant in the forest trees planted as part of the A/R project activity, and so, it is reasonable to assume minimal changes in other stocks under the SCC A/R CDM activities. This will greatly simplify the baseline methodologies and will keep costs to a minimum.

C.3. Project boundary and stratification

Maps are used as the primary data source for defining boundaries. In the case of several land units, each unit should be clearly marked, and 'wood or metal' stakes can be installed at the corners of the plots.

It is not necessary to mark the boundaries of each land unit with a GPS as this would be very costly. The center or one corner of each land unit [should]/[can be] marked using a GPS.

Within the project boundary, the area can be stratified into homogenous units based on previous land use or management regime (e.g. type and history of tillage in croplands) that will likely affect the amounts of carbon stocks in the baseline. Further stratification would be carried out during monitoring based on other factors.

D. Selection of Carbon pools of the Baseline Scenario and GHG Emissions of Project Scenario

Above ground biomass is the most significant part of small-scale A/R projects. It includes the biomass in tree and non-tree components. In the baseline the tree component is insignificant or non-existent and the non-tree component can be either insignificant or significant. The dead wood component in general is insignificant in the baseline and not likely to be significant at least in the early stages of small-scale A/R projects, but may increase over time. The below-ground biomass is closely related to above-ground biomass both in baseline and project scenario. Soil carbon stock generally presents a high level of variance in both baseline and project scenario and may increase slowly with A/R activities.

4. Estimation of the Actual GHG removals by sinks

The following are the steps for estimating the actual GHG removals by sinks

Step 1: Determine the SSC A/R type of activity or combination of activities (i.e., whether plantation, agroforestry or restoration forest)

Step 2: Determine relevant pools. In most cases, these will comprise above- and below-ground tree biomass.

Step 3: Calculate changes in carbon stocks in each pool. Project developers can use carbon accounting tools such as CO2FIX, CAMFOR or their equivalents to calculate and project carbon stocks based on appropriate inputs and definitions of the relationships (equations and parameters) used in these tools. Other tools and values are given in the GPG Ch.3 including the computer tool in Annex 4A.1: 'Tools for Estimation of Changes in Soil Carbon Stocks associated with management Changes in Croplands and Grazing Lands based on IPCC Default Data'.

Step 4: Calculate other emissions by sources, which result from the implementation of the project activity.

Step 5: Subtract the result of step 4 from result of step 3

4.1 Consideration of non-CO2 Greenhouse Gas Emissions from Project Activities

Greenhouse gas emissions from the direct use of energy in project operations can be significant. Such direct energy use includes both fuels and electricity consumed in both mobile and stationary equipment. Examples of mobile sources include tractors used for site preparation, fertilizer application, tillage, or planting; and road transport to and from sites for monitoring. Stationary equipment, which, for most A/R projects, will typically constitute a less significant source of greenhouse gas emissions than mobile sources, and could include machinery such as soil mixers and potting equipment in nurseries, irrigation pumps, and lighting.

Tree planting activities may also change emissions of other greenhouse gases, in particular CH_4 and N_2O. Specifically, planting of leguminous trees and application of fertilizers result in nitrous oxide emissions. Also, projects established on highly organic soils and/or in very humid conditions may alter the water level and cause methane emissions.

For most small scale A/R project activity, emissions of non-CO2 GHG will not be significant. Also, simplified methods are not currently available that are at the same accurate and simply enough to estimate these emissions. Participants dealing with project activities that involve significant changes in non-CO2 GHG may develop specific methodologies for consideration by the EB.

4.2 Project CO_2 Emissions and Non-CO2 GHG Emissions and Removals by Sinks

Tree-planting activities may cause changes in carbon dioxide emissions by burning of fossil fuels for project activities (e.g., use of farm equipment for site preparation or transportation of project staff, in addition to those in the baseline case). If the expected average annual net change in these CO2 emissions is less than 10% of expected average total annual net carbon stock changes, there is no need to measure these emissions. Otherwise they should be measured using the methods indicated in the monitoring section.

5. Leakage

The following potential sources for leakage in SSC A/R project activities have been identified:

- Displacement of baseline activities.
- Increment in wood consumption for fencing coming from nearby forest, especially at the beginning of silvo-pastoral systems

If in a given SSC A/R project activity a source of leakage is identified, project developers shall:

a) Determine of total area potential affected

b) Quantify CO2 changes in stocks in major pools and CO2e from all sources using the same steps established for the estimating the actual net GHG removals by sinks and avoiding double account.

6. Net GHG removals by sinks

"Net anthropogenic greenhouse gas removals by sinks" is the actual net greenhouse gas removals by sinks minus the baseline net greenhouse gas removals by sinks minus leakage

Net GHG removals = Actual net GHG removals – baseline net GHG removals - leakage

7. Monitoring

This section presents a monitoring methodology that has been simplified by considering the use of scientific accepted formulae and algorithms and by providing default values. These formulae, algorithms and values are to be used when local data/algorithms for local species is not available.

7.1 SECTION A. Identification of methodology

7.1.1 Title of the proposed methodology:

Simplified Monitoring Methodology for small scale A/R project actvities[1]

7.1.2 Type(s) of A/R CDM project activity to which the methodology may apply:

Three main generic types of small scale A/R project activities have been included: plantations, agroforestry, and restoration forests (see definitions in Section I). Each project type may have different spatial arrangements of the tree components, as well as distinct dynamics in terms of the removals achieved by the project, and the emissions resulting from its implementation. However, most of these changes can be accommodated within a single methodological framework. For these reasons, and to keep the methodology as simple as possible we describe the three generic project types within a single document, clearly indicating relevant differences when appropriate.

7.1.3 Carbon pools covered by the methodology:

Projects can only monitor the major pools (aboveground biomass and belowground biomass), where major changes in C stocks are expected.

Major pools

Aboveground biomass: Aboveground biomass includes all living biomass above the soil including trees, non-tree woody perennials, herb layer.

Belowground biomass: All living biomass of roots.

Minor pools

For the following pools, some methodological suggestions are made, but project developers are invited to submit simplified methodologies for these.

Soil organic matter: Includes organic carbon in mineral soils to 30 cm. depth. Only to be applied by those projects that decide to include soil organic matter GHG removal calculations or when the pool of soil organic matter is expected to decrease in the project scenario.

Dead Wood: all non-living biomass in various states of decomposition, with a diameter of more than or equal 10 cm, lying on top of the soil.

Litter: Includes all non-living biomass in various states of decomposition, with a diameter less than 10 cm, lying on top of the soil.

7.2 SECTION B. Proposed new monitoring methodology

7.2.1 Overall summary description of the methodology:

The monitoring methodology complements the baseline methodology. It presents conservative methods to monitor changes in carbon pools. It proposes a cost-effective monitoring framework with a specified tolerable error in order to maximize the precision and accuracy of the measured changes in carbon pools size with a minimum cost.

7.2.2 Steps involved:

Monitoring the net GHG removals by sinks implies to 1) monitor the actual net GHG removals by sinks, 2) monitor the baseline net GHG removals by sinks and 3) monitor the leakages.

1. ***Procedures for calculating and monitoring the actual GHG removal of sinks.***
    - Define which pools will be monitored
    - Defining parameters to estimate AGB taking into account existing models/allometric equations
    - Designing a sampling procedure
    - Establishing and marking permanent plots for monitoring
    - Defining the allowable limits for measurement errors
    - Measuring the parameters required to estimate AGB
    - Constructing additional allometric equations for computing AGB as needed
    - Estimating AGB from allometric equations
    - Estimation of BGB from AGB using the allometric relationship from IPCC GPG
    - Calculating GHG removals by sinks

Monitoring and estimating GHG removals may vary slightly among the three management types, as exemplified in the following table:

	Plantations	Agroforestry	Restoration
Plot shape	Two to three planted rows	Two to three planted rows, when trees are planted in rows Circular, square or rectangular plots when tree are planted irregularly	Two to three planted rows, when trees are planted in rows Circular, square or rectangular plots when tree are planted irregularly

Project Emissions

CO2 emissions from burning of fossil fuels from project activities can be estimated from standard methods, such as the fuel-based approach for the use of vehicles. In this case -gasoline and/or diesel fuel that is combusted during project practices needs to be monitored and recorded as detailed in the IPCC Guidelines and the GPG 2000.

Non- GHG Emissions from project activities can be estimated using the methods and default values indicated by IPCC GPG for LULUCF and Agriculture**.**

2. ***Monitoring of the baseline net GHG removals by sinks and the actual net GHG removals by sinks:***

According to Dec.14/CP 10 no monitoring of the baseline is requested. The values from the ex-ante baseline will be used to calculate Net GHG removals by sinks for the monitoring report.

3. ***Monitoring leakages***

The most important sources of leakage for small-scale A/R CDM activities are related to the displacement of baseline activities. Project needs to show arguments on how potential leakage will be treated and excluded from the monitoring plan if not expected to be significant.

7.2.3 Data for monitoring the actual net GHG removals by sinks

To monitor above-ground and below-ground biomass pool changes in the project scenario it is recommended to establish permanent plots. The measurements of carbon pools in the permanent sample plots can be used to assess the changes in the carbon pools between monitoring intervals. Since the net GHG removals in the baseline are treated as zero, the GHG removals of the project scenario represent the net anthropogenic GHG removals. A carbon accounting system such as CO2FIX (Schelhaas et al, 2004; Masera et al, 2004) and CAMFor (Richards and Evans, 2000) can be used to manage monitoring data and calculate carbon stocks at each monitoring interval. These types of models calculate the carbon flows associated with a stand of trees, including the wood products made from wood harvested from that stand. It calculates the carbon in the various tree, debris, soil and product components, and the carbon exchanged with the atmosphere, for several hundred years - through thinning, and multiple rotations.

Data on actual net GHG removals by sinks are measured by means of monitoring a statistically representative number of permanent sample plots established within the project boundary.

7.2.4 Project boundary and stratification

It is good practice that project boundaries are well defined and registered.. Monitoring of project boundaries should be carried out periodically, especially in the case that many small-scale farmers spread out over a large landscape are participating. Local cadastre registers can be used as basis to define and monitor project boundaries. It is recommended that a random selection of 50% of the participating farms is visited each time the project boundary is monitored and that all stakeholders are aware of this procedure.

A proportion of carbon pools under the project scenario fall under the category of changing pools. The number of plots needed for sampling change in carbon stocks in each pool is dependent on the maximum target error and the specific project type.

Stratification of the project area generally increases the accuracy and precision of the measuring and monitoring in a cost-effective manner. The size and spatial distribution of a project does not influence this step – one large contiguous block of land or many small parcels are considered the project area of interest and are stratified in the same manner. In general, stratification decreases the costs of measuring and monitoring because it is expected to diminish the sampling effort necessary to achieve a given level of confidence caused by smaller variance in each stratum than in the total project area. The stratification should be carried out using criteria that are directly related to the variables to be measured and monitored, e.g., the change in carbon stocks in trees for A/R activities.

The number of strata shall be designated based on the size and expected change of carbon pools in the project area.

Once the level of precision has been decided upon, sample sizes must be determined for each stratum in the project area and for each carbon pool to be measured. If only trees are going to be monitored, the variance of the tree biomass will determine the amount of samples in each stratum. If more pools are going to be monitored, care has to be taken on sample size, since each carbon pool may have a different variance. So, while the standard error of the mean for above-ground biomass may be 10% of the mean, the standard error for soil carbon may be 40% in the same amount of samples. Sources of error include sampling error, measurement error and model error (e.g. application of regression equations to field data). This means that for monitoring tree biomass, the sampling error should be set at less than 10% at a 95% confidence level, e.g. ± 7% of the mean. It is recommended to use permanent plots with individually marked trees to increase precision in determining change in stock. Increasing plot size will decrease variance so that less sample plots are required. If the project comprises a large number of small plots with highly variable strata (e.g. the project uses various tree species scattered over a large heterogeneous landscape), it is recommended to use a larger number of small plots, to allow for increased site coverage. Inventory manuals generally include formulae to calculate sample size based on measured variation and selected precision. For example, MacDicken (1997) describes two alternatives for determining sample size and allocating sample plots among strata: 1) sample plot allocation based on fixed precision levels and, 2) optimum allocation of plots among strata given fixed inventory costs.

Permanent plots cannot always be relocated for a variety of reasons. To help ensure to obtain the required precision, it is good practice to increase the number of plots with about 10% above the minimum calculated. If initial tree biomass data are not available for a project, preliminary samples should be taken from about 10 plots of equal area to estimate the variance required to calculate sample size.

7.2.5 Monitoring frequency

The monitoring frequency is based on the time interval needed to detect changes in carbon pools. Project boundary monitoring can be carried out with the same frequency as for the pool change monitoring, thereby reducing costs of transportation. Permanent sample plots should be excluded from the project boundary monitoring. A 5-year monitoring frequency of a statistically adequate number of permanent sample plots is considered appropriate for above-ground and below-ground biomass in the tree component. If the project decides to include soil or the pool is expected to decrease over time in the project scenario the monitoring frequency should be set at 10-20 years, since this pool changes slowly and presents a high spatial variance in the stock. Monitoring frequency of this pool could be synchronized with the crediting period set by the project. Project GHG emissions from fossil fuels should be monitored on an annual basis.

7.2.6 Data collection

Data collection shall be organized taking into account the carbon pools measured, the sample frame used and the number of plots to be monitored. Table 1 outlines the data to be collected for the project scenario to monitor the changes in the carbon pools. It is recommended to undertake frequent checks to verify data consistency, to confirm that electronic spreadsheet formats are used to archive the plot and carbon pool data along with hard copies, that errors are corrected and that the measurement error is calculated (see uncertainty analysis).

Table 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:

Data variable	Source	Data unit	Measured (m), calculated (c) or estimated (e)	Frequency	Proportion	Archiving	Comment
Plot location of participants	Project maps	Lat-long ha		Base year	100%	electronic	Location and size of all participating plots,
Plot location of participants	Project maps	Lat-long ha		5 years	50%	electronic	Participating plots, randomly sampled
Permanent sample plots	Project maps	Lat-long ha		5 years	100%	electronic	Plot location and size is registered with a GPS
Stratum	Stratum maps					electronic	Project area stratified
Diameter at breast height (1.30 m)	Permanent plot	cm	m	5 years	Trees in sample plot	electronic	Measure dbh for each tree that falls in the sample plot and applies to size limits
Tree height	Permanent plot	m	e	5 years	Trees in sample plots	electronic	Estimate tree height between regular intervals (every 2 m)

Wood density	**Permanent plots**	**Mg/m^3**	**m**	**once**	**3 individuals of the most important species**		**Tree biomass varies highly according to wood density. A correction factor for wood density can be developed from these data to apply in the default allometric equations or expansion factors.**
Diameter of standing dead wood **(in case needed to be monitored)**	**Permanent plots**	**cm**	**m**	**5 years**	**Dead trees in sample plots**	**electronic**	**A reduction factor is applied to dead standing trees (based on indicators, such as all branches present, only main branches present, only standing stem)**
Total CO_2	**project**	**Mg**	**c**	**5 years**	**All project data**	**electronic**	**Based on calculated data from all plots and carbon pools**

B.2.1.2. 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:

Data variable	Source	Data unit	Measured (m), calculated (c) or estimated (e)	Frequency	Proportion	Archiving	Comment
Fuel for transport	Log book of vehicles and equipment	Litres	e	Annual	100%	electronic	Estimated based on fuel type
GHG fuel emission factor	IPCC guideline	Kg/ltr	e	At the start	100%	electronic	Emission factor by fuel type

[Description of formulae and/or models used to monitor the estimation of the baseline net GHG removals by sinks (for each carbon pool, in units of CO2 equivalent) will be developed after the comments of the public]

7.3 Quality control (QC) and quality assurance (QA) procedures that need to be applied to the monitoring process:

This section will cover the following items:

- Measurement of carbon Pools
- Simplified procedure for the handling of uncertainty in SSC AR projects

8. Annex 1: Technical sheets

These will include default values and parameters for use in estimating the baseline based on prior land use.

8.1 Cropland

8.2 Grassland

8.3 Wetland

8.4 Settlements

8.5 Plantations

8.6 Agroforestry

8.7 Restoration

9. Annex 2: Proposed procedures to measure non-tree biomass and dead organic matter.

Non-tree biomass:

Herb layer: The biomass removals in herb layers represent a small proportion of the total biomass pool and in most circumstances the stock does not change significantly in the project scenario compared to the baseline. In such situations, the herb biomass change can be considered as zero and does not need to be monitored and measured (considering the monitoring costs involved).

Woody Perennials: Carbon in croplands can be stored in the biomass of perennial woody vegetation, including, but not limited to, monocultures such as coffee, oil palm, coconut, and rubber plantations, fruit and nut orchards, and polycultures such as agroforestry systems. The methodology for estimating changes in woody biomass is provided in the IPCC Guidelines Section 5.2.2 (Changes in Forest and Other Woody Biomass Stocks) and in Section 3.2.1.1 (Changes in Carbon Stocks in Living Biomass) under Section 3.2.1 (Forest land Remaining Forest land) of this report. According to these reports, Tier 1 acceptable assumptions (applicable to small-scale A/R activities) for the biomass removals of woody perennials are: 1) all carbon in woody perennial biomass cleared (e.g., biomass cleared and replanted with the same or different crop) is emitted in the same year of felling; and 2) perennial woody crops accumulate carbon linearly for an amount of time equal to a nominal harvest or maturity cycle. The second assumption implies that woody perennial crops accumulate biomass for a finite period until they are removed through harvest or reach a steady state where there is no net accumulation of carbon in biomass because growth rates have slowed and incremental gains from growth are offset by losses from natural mortality, pruning or other losses. To calculate base year carbon stock of woody perennial biomass there are two options:

Option 1: If each age class has the same area and species composition, the base year carbon density of woody perennials per unit area can be estimated as follows:

$$\mathbf{B_{NT} = \frac{(t_1/_2 + t_2)}{t_T} * B_{NTmat}}$$

where:

B_{NT} = non-tree woody perennial biomass in (Mg/ha)

t_1 = the number of years to maturity,

t_2 = number of years from maturity to final harvesting

t_T = total number of years from planting the woody crop till harvest

B_{NTmat} = the amount of carbon in the woody crop at maturity in (Mg/ha)

Example: If a coffee plantation takes 4 years to maturity reaching 25 Mg/ha of dry-weight biomass and will be maintained at this level for another 16 years, the average biomass density per ha of the base year would be:

(4/2 + 16)/20 * 25 (Mg/ha = 22.5 Mg/ha

Option 2: If the project area comprises plots with various woody perennial crops irregularly distributed over age classes and each crop with a particular harvesting or maturity cycle, the base year biomass stock can be calculated as follows:

$$\mathbf{B_{NT} = \Sigma_1^N {}_1^T (t_{IJ}/t_{IT}) * B_{INTmat} * A_I}$$

Where

I =1 to N	= number of strata with non-tree woody perennials
t_{IJ}	= age of stratum I at base year
t_{IT}	= age to maturity of stratum I
B_{INTmat}	= non-tree biomass at maturity of stratum I

Biomass and age at maturity of woody perennials can be obtained from local or national statistics, from published data from similar conditions in other countries, or from IPCC GPG-LULUCF default values.

Depending on the significance and fate of the perennial woody biomass in the project versus baseline scenario, the perennial woody biomass change can be considered either zero (no effect of project scenario on baseline scenario), increasing, or decreasing (positive or negative effect of project scenario on baseline). The first option (no change) can be applied to most agroforestry type projects, when trees are planted together with the existing perennial woody crops without changing significantly the biomass of this pool. Converting the perennial woody crop into commercial tree plantations may remove the perennial woody crop completely over time, and thus all carbon from this will be emitted eventually. In the latter case the initial stock has to be estimated and considered as an emission, according to the first Tier 1 assumption. If the woody perennial biomass is expected to increase in the project scenario versus baseline, Table B1 of baseline methodology can be used to decide if the pools will be taken into consideration in the project.

If the pool is taken into account, it is good practice to calculate the emission/removal factors of the woody crop annually, using either local or national statistics, or default carbon accumulation rates and losses (e.g. Table 3.3.2. IPCC GPG-LULUCF, 2004). However, monitoring procedures need to be developed to measure non-tree biomass change over time. Adequate regressions equations need to be developed by the project developer, which can be done during thinning or clearing operations. The most common independent parameters used to estimate non-tree woody perennials are the diameters of the trunks at 30 cm above the ground and total height (Stewart et al, 1992)[2].

$$\mathbf{B_{NT} = \boldsymbol{a} + \boldsymbol{b} * H * \Sigma D_n^2}$$

---

[2] J.L. Stewart, A.J. Dunsdon et al (1992). Wood biomass estimations of Central American dry zone species. Tropical Forestry papers 26, Univ. of Oxford, UK.

Where:

B_{NT} = Biomass of woody perennial (in kg)

H = Total height measured from base to tip (in m)

ΣD_n^2 = the sum of all diameters squared of each individual woody perennial

In Stewart et al (1992) the values of *a* and *b* of 16 shrubs commonly used for agroforestry are presented, each with the estimated R^2.

Dead organic matter

Dead wood: The deadwood biomass is likely to be non-existent or negligible in the baseline scenario and in the early years of any project scenario. If the deadwood proportion increases at the later years of the project scenario, it can be monitored, measured, and accounted. Line intersect sampling is the most widely used method to measure dead wood (See IPCC GPG-LULUCF Section 4.3.3.5.1) Lines of 100 m length in total are established around each permanent monitoring plot and diameters of lying dead wood (>10 cm diameter) intersecting the lines are measured at the intersection. Each dead wood is assigned to one of three density states (sound, intermediate, and rotten), and the volume of lying deadwood per unit area is calculated using the equation (Warren and Olsen, 1964):

$$\mathbf{V_{DW} = 9.869 * (D^2/8) * T}$$

Where,

V_{DW} = Volume of lying deadwood per m^2 (in m^3/m^2).

D = Diameter of dead wood square (in m).

T = Transect length (in m).

To convert volume to mass per unit area, the mean density of lying dead wood is calculated from a representative sub-sample of dead wood belonging to the three density states.

$$\mathbf{B_{DW} = V_{DW} * MD}$$

Where

BLDW = Biomass in lying deadwood

MD = Mean density of wood (in Mg/m^3)

Stock change over time is quantified via the Reliable Minimum Estimate (RME) approach (IPCC GPG-LULUCF; Dawkins, 1957). In the RME approach, from the monitoring results a mean for the sample population at time "two" is calculated with the 95% confidence interval. The minimum estimate (mean – 95% confidence interval) of carbon stock at time "two" is subtracted from the maximum estimate of the carbon stock at time “one” (mean + 95% C.I at time “one”). The resulting difference represents, with 95% confidence, the minimum detected change in soil carbon from time “one” to time “two”.

Litter: Litter in the cropland baseline can be considered zero or negligible. If the project takes into account carbon removals in litter, this can be monitored by means of a sample frame of a certain radius to collect litter that falls within the frame, taking about 4-5 samples in each plot. If litter is to be collected, all litter covering leaves, fruits, and small wood (<10 cm dbh) that falls inside the frames has to be collected, dried, weighed, and converted to carbon by appropriate coefficients (See IPCC GPG-LULUCF Section 4.3.3.5.1). Care has to be taken that the litter is sampled at the same time of the year at each census to eliminate seasonal effects. Stock change over time is quantified via the Reliable Minimum Estimate (RME) approach (IPCC GPG-LULUCF; Dawkins, 1957).

10. Annex 3: Attachment A to Appendix B

The following are the barriers established for A/R project activities:

Investment barriers, other than the economic/financial barriers*, inter alia*:

- Debt funding is not available for this type of project activity;
- No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented;
- Lack of access to credit;

Institutional barriers, *inter alia*:

- Risk related to changes in government policies or laws;
- Lack of enforcement of forest or land use-related legislation.

Technological barriers, *inter alia*:

- Lack of access to planting materials
- Lack of infrastructure for implementation of the technology.

Barriers related to local tradition, *inter alia:*

- Traditional knowledge or lack thereof, laws and customs, market conditions, practices;
- Traditional equipment and technology;

Barriers due to prevailing practice, *inter alia*:

- The project activity is the "first of its kind": No project activity of this type is currently operational in the host country or region.

Barri**ers due to local ecological conditions**, *inter alia*:

- Degraded soil (e.g. water/wind erosion, salination, etc.);
- Catastrophic natural and / or human-induced events (e.g. land slides, fire, etc);
- Unfavourable meteorological conditions (e.g. early/late frost, drought);
- Pervasive opportunistic species preventing regeneration of trees (e.g. grasses, weeds);
- Unfavourable course of ecological succession;
- Biotic pressure in terms of grazing, fodder collection, etc.

Barriers due to social conditions, *inter alia*:

- Demographic pressure on the land (e.g. increased demand on land due to population growth);
- Social conflict among interest groups in the region where the project takes place;
- Widespread illegal practices (e.g. illegal grazing, non-timber product extraction and tree felling);
- Lack of skilled and/or properly trained labour force;
- Lack of organisation of local communities.

The identified barriers are only sufficient grounds for demonstration of additionality if they would prevent potential project proponents from carrying out the proposed project activity if it was not expected to be registered as an A/R CDM project activity.

11. References

Brown, S. 1997. Estimating biomass and biomass change of tropical forests. A primer. FAO Forestry Paper 134. Food and Agriculture Organization of the United Nations, Rome, Italy.

Brown, S., A.J.R. Gillespie, and A.E. Lugo. 1989. Biomass estimation methods for tropical forests with applications to forest inventory data. Forest science 35: 881-902.

Cairns, M.A.; Brown, S. et al. (1997) : Root biomass allocation in the world's upland forests. Oecologia (1):1-11.

Dawkins, H.C. 1957. Some results of stratified random sampling of tropical high forest. Seventh British Commonwealth Forestry Conference 7 (iii) 1-12.

IPCC Revised Guidelines

IPCC GPG-LULUCF, 2004. Good Practice Guidance for Land Use, Land-Use Change and Forestry. IPCC, Switzerland.

MacDicken, K.G. 1997. A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Projects. Winrock International. http://www.winrock.org/what/ecosystem_pubs.cfm

Martínez-Y., A.J., J. Sarukhan, A. Perez-J., E. Rincón, J.M. Maas, A. Solis-M, and L. Cervantes. 1992. Above-ground phytomass of a tropical deciduous forest on the coast of Jalisco, Mexico. Journal of Tropical ecology 8: 87-96.

Masera, O., Garza-Caligaris, J.F., Kanninen, M., Karjalainen, T., Liski, J., Nabuurs, G.J., Pussinen, A. & de Jong, B.J. 2003. Modelling carbon sequestration in afforestation, agroforestry and forest management projects: the CO2FIX V.2 approach. Ecological Modelling 164: 177-199.

Richards, G. and D. Evans 2000. Carbon Accounting Model FOR FORESTS (CAMFOR) USER MANUAL VERSION 3.35 , Australian Greenhouse Office. Technical Report No. 26. http://www.greenhouse.gov.au/ncas/reports/pubs/tr26final.pdf

Schelhaas, M.J., P.W. van Esch, T.A. Groen, B.H.J. de Jong, M. Kanninen, J. Liski, O. Masera, G.M.J. Mohren, G.J. Nabuurs, T. Palosuo, L. Pedroni, A. Vallejo, T. Vilén, 2004. CO2FIX V 3.1 - description of a model for quantifying carbon sequestration in forest ecosystems and wood products. ALTERRA Report 1068. Wageningen, The Netherlands.

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