Draft Afforestation and reforestation baseline and monitoring methodology

AR-AM00XX

"Afforestation and reforestation of degraded mangrove habitats"

(Version 1.0.0)

I. SOURCE, DEFINITIONS AND APPLICABILITY

1. Source

This methodology is based on elements from the following methodologies:

- ARNM0038 "Afforestation and reforestation of degraded tidal forest habitats." The draft baseline and monitoring methodology and project design document were prepared by Silvestrum on behalf of a partnership comprising IUCN, Ramsar Secretariat and Group Danone;
- AR-ACM0001 "Afforestation and reforestation of degraded lands", version 05;
- AR-AMS0003 "Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands", version 01.

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

This methodology uses the latest approved versions of the following tools, procedures, guidelines and guidances:

- Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities;
- Guidance on application of the definition of the project boundary to A/R CDM project activities;
- Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities;
- Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities;
- Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity.

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

2. Definitions

This methodology uses the following methodology-specific definitions:

(a) "Degraded mangrove habitat" means wetlands[1] where, in their natural state, mangrove vegetation can grow and have soil or sediment that is usually water-logged with water that is saline or brackish, and that were subjected to impacts resulting in decrease of forest cover below that reported by the host Party to the CDM Executive Board according to paragraph 8 of annex to Decision 5/CMP.1 (A/R CDM modalities and procedures);

(b) "Soil disturbance attributable to the A/R CDM project activity" is any activity that impacts the soil profile, e.g. ploughing, ripping, scarification, digging of pits and trenches, stump removal, bulldozing, peat extraction, grading, compacting, and drainage of soil;

(c) "Planting" means propagation of mangroves or other tree species on land subject to project activity, and includes propagation using any of the following: (i) Nursery raised seedlings or saplings; (ii) Propagules; (iii) Direct sowing of seeds; (iv) Human-induced promotion of natural regeneration.

For definition of all other terms used in this methodology the following sources should be referred to:

(a) A/R CDM modalities and procedures;

(b) "Annex A: Glossary" of the Good Practice Guidance for Land Use, Land-Use Change and Forestry by the Intergovernmental Panel on Climate Change, 2003 (IPCC GPG LULUCF 2003); and

(c) Glossary of CDM terms.[2]

3. Selected baseline approach from paragraph 22 of the A/R CDM modalities and procedures

The project participants (PPs) shall select the one deemed most appropriate for the project activity among the following approaches:

(a) "Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary;"

(b) "Changes in carbon stocks in the carbon pools within the project boundary from a land use that represents an economically attractive course of action, taking into account barriers to investment;"

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

4. Applicability

This methodology is applicable to afforestation or reforestation of degraded mangrove habitat.

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[1] "Wetlands" as defined in "Annex A: Glossary" of the IPCC GPG LULUCF 2003.

[2] Available at <http://cdm.unfccc.int/Reference/Guidclarif/glos_CDM.pdf>.

The conditions under which the methodology is applicable are:

(a) The land subject to the project activity is degraded mangrove habitat;

(b) If more than 10% of the project area is planted with non-mangrove species then the project activity does not include any alteration of the hydrology of the project area;

(c) If at least 90% of the project area is planted with mangrove species then the project activity may include alteration of hydrology of the project area as required for restoration of the natural hydrology of the area;

(d) Soil disturbance attributable to the A/R CDM project activity shall not exceed 10% of the project area;

(e) The lands were abandoned at least two years before the start of the project activity, unless it can be demonstrated that pre-project activities, with the exception of fuel-wood collection, would be discontinued in the absence of the A/R CDM project activity.

5. Best practice option

Where the potential mangrove community in the project area is multi-species and/or zoned, planting should, as far as possible, be designed to re-establish the multi-species composition and/or zonation, taking into account the ecological requirements of each species concerned.

II. BASELINE METHODOLOGY

1. Project boundary and eligibility of land

The "project boundary" geographically delineates the afforestation or reforestation project activity under the control of the PPs. The A/R CDM project activity may contain more than one discrete area of land. Each discrete area of land shall have a unique geographical identification.

The "Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities" shall be used for demonstrating that each discrete area of land to be included in the project boundary is eligible for an A/R CDM project activity.

The "Guidance on application of the definition of the project boundary to A/R CDM project activities" may be applied in identification of areas of land planned for an A/R CDM project activity.

The carbon pools selected/not selected for accounting of carbon stock changes are shown in Table 1.

Table 1: Carbon pools selected/not selected for accounting of carbon stock changes

Carbon pool	Whether selected	Justification / Explanation
Above-ground biomass	Yes	Major carbon pool subjected to project activity
Below-ground biomass	Yes	Carbon stock in this pool is expected to increase due to the implementation of the A/R CDM project activity
Dead wood	Yes	This stock may increase (when compared to baseline) due to implementation of the project activity. The methodology provides a conservative default approach for accounting of increase in carbon stock in this pool
Litter	No	Litter biomass is subjected to high turnover and displacement due to tidal currents. It is a conservative choice to exclude the pool from accounting because the project activity will not decrease the rate of accumulation of the litter
Soil organic carbon	Yes	The methodology provides a conservative default approach to account for the increase in carbon stock in the soil organic carbon pool

The emission sources and associated GHGs selected/not selected for accounting of GHG emissions are shown in Table 2.

Table 2: Emission sources and GHGs selected/not selected for accounting of GHG emissions

Sources	Gas	Whether Selected	Justification/Explanation
Burning of woody biomass	CO_2	No	CO_2 emissions due to burning of biomass are accounted as a change in carbon stock
	CH_4	Yes	Burning of woody biomass for the purpose of site preparation, or as part of forest management, is allowed under this methodology
	N_2O	Yes	Burning of woody biomass for the purpose of site preparation, or as part of forest management, is allowed under this methodology

2. Identification of the baseline scenario and demonstration of additionality

This methodology uses the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities" for the purpose of identification of the baseline scenario and demonstration of additionality.

3. Stratification

If the project area is not homogeneous, stratification should be carried out to improve the precision of carbon stock estimations. Different stratifications may be required for the baseline and project

scenarios in order to achieve optimal precision of estimation of net GHG removals by sinks. In particular:

(a) For baseline net GHG removals by sinks, it is usually sufficient to stratify the area according to major vegetation types and their crown cover and/or land use type;

(b) For actual net GHG removals by sinks in mangroves the stratification for *ex ante* estimations is based on the project planting/management plan and/or tidal regime. Stratification for *ex post* estimations is based on the actual implementation of the project planting/management plan taking into account the tidal regime. If natural or anthropogenic impacts (e.g. local fires) or other factors (e.g. soil forming processes) significantly alter the pattern of carbon stock distribution in the project area, then the *ex post* stratification is revised accordingly.

Remotely sensed data reflecting the situation close to the time of project start and/or the occurrence of natural or anthropogenic impacts may be used for *ex ante* and *ex post* stratification.

4. Baseline net GHG removals by sinks

Under the applicability conditions of this methodology:

It is expected that the baseline carbon stocks in dead wood, litter, and soil organic carbon pools will not show a permanent net increase. It is therefore conservative to assume that the sum of the changes in the carbon stocks in these pools is zero for all strata in the baseline scenario.

The baseline net GHG removals by sinks is therefore calculated as follows:

$$\Delta C_{BSL,t} = \Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t} \quad \textbf{(1)}$$

where:

$\Delta C_{BSL,t}$	Baseline net GHG removals by sinks in year *t*; t CO_2-e
$\Delta C_{TREE\_BSL,t}$	Change in carbon stock in baseline tree biomass within the project boundary in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SHRUB\_BSL,t}$	Change in carbon stock in baseline shrub biomass within the project boundary in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities; t CO_2-e

5. Actual net GHG removals by sinks

The actual net GHG removals by sinks is calculated as follows:

$$\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t} \quad \textbf{(2)}$$

where:

$\Delta C_{ACTUAL,t}$	Actual net GHG removals by sinks, in year *t*; t CO_2-e
$\Delta C_{P,t}$	Change in the carbon stocks in project, occurring in the selected carbon pools, in year *t*; t CO_2-e
$GHG_{E,t}$	Non-CO_2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity, in year *t*, as calculated in the tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity"; t CO_2-e

Change in the carbon stocks in project, occurring in the selected carbon pools, is calculated as follows:

$$\Delta C_{P,t} = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{DW\_PROJ,t} + \Delta C_{SOC\_PROJ,t} \quad \textbf{(3)}$$

where:

$\Delta C_{P,t}$	Change in the carbon stocks in project, occurring in the selected carbon pools, in year *t*; t CO_2-e
$\Delta C_{TREE\_PROJ,t}$	Change in carbon stock in tree biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SHRUB\_PROJ,t}$	Change in carbon stock in shrub biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{DW\_PROJ,t}$	Change in carbon stock in dead wood in project in year *t*, estimated as 5% of the change in above-ground living tree biomass in project in year *t* as calculated using Equation (13) or Equation (26) of the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SOC\_PROJ,t}$	Change in carbon stock in the soil organic carbon (SOC) pool within the project boundary, in year *t*; t CO_2-e

The change in carbon stock in the SOC pool within the project boundary, in year *t*, is estimated as:

$$\Delta SOC_{PROJ,t} = \frac{44}{12} * \sum_{t=1}^{t} A_{PLANT,t} * dSOC_t * 1year \quad \textbf{(4)}$$

where:

$\Delta SOC_{PROJ,t}$	Change in SOC stock within the project boundary, in year *t*; t CO_2-e
$A_{PLANT,t}$	Area planted in year *t*; ha

$dSOC_t$ The rate of change in SOC stocks within the project boundary, in year *t*; t C ha^{-1} $yr^{-}1$

The following default value of $dSOC_t$ is used, unless transparent and verifiable information can be provided to justify a different value:

(i) $dSOC_t$ = 0.50 t C ha^{-1} yr^{-1} for $t = t_{PLANT}$ to $t = t_{PLANT}$ + 20 years, where t_{PLANT} is the year in which planting takes place;

(ii) $dSOC_t$ = 0 t C ha^{-1} yr^{-1} for $t > t_{PLANT}$ +20

6. Leakage

Under applicability conditions of this methodology leakage emissions can occur from displaced fuelwood collection.

Therefore, leakage is estimated as follows:

$$LK_t = LK_{FUELWOOD,t} \quad \textbf{(5)}$$

where:

LK_t GHG emissions due to leakage, in year *t*; t CO_2-e

$LK_{FUELWOOD,t}$ Leakage in year *t* due to the displacement of fuelwood collection; t CO_2-e

6.1 Estimation of leakage due to displacement of fuelwood collection ($LK_{FUELWOOD,t}$)

Unless it is demonstrated that there is no fuelwood collection in pre-project conditions, leakage due to fuelwood collection in year *t* is estimated by using the following simplified default equation:

$$LK_{FUELWOOD,t} = 0.10 * (C_{TREE\_BSL,t} + C_{SHRUB\_BSL,t}) \text{ for } t = 1 \text{ to } t = 5 \quad \textbf{(6)}$$

and

$$LK_{Fuelwood,t} = 0, \text{ for } t > 5 \quad \textbf{(7)}$$

where:

$C_{TREE\_BSL,t}$ Carbon stock in tree biomass in baseline within the project boundary at a given point of time in year *t* as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e

$C_{SHRUB\_BSL,t}$ Carbon stock in shrub biomass in baseline within the project boundary at a given point of time in year *t* as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e

7. Net anthropogenic GHG removals by sinks

The net anthropogenic GHG removals by sinks is calculated as follows:

$$\Delta C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t \quad \textbf{(8)}$$

where:

$\Delta C_{AR-CDM,t}$	Net anthropogenic GHG removals by sinks, in year *t*; t CO_2-e
$\Delta C_{ACTUAL,t}$	Actual net GHG removals by sinks, in year *t*; t CO_2-e
$\Delta C_{BSL,t}$	Baseline net GHG removals by sinks, in year *t*; t CO_2-e
LK_t	GHG emissions due to leakage, in year *t* ; t CO_2-e

7.1 Calculation of tCERs and lCERs

The *tCERs* and *lCERs* for a verification period $T = t_2 - t_1$, (where t_1 and t_2 are the years of the start and the end, respectively, of the verification period) are calculated as follows:

$$tCER_{t_2} = \sum_{1}^{t_2} \Delta C_{AR-CDM,t} \quad \textbf{(9)}$$

$$lCER_{t_2} = \sum_{t_1+1}^{t_2} \Delta C_{AR-CDM,t} \quad \textbf{(10)}$$

where:

$tCER_{t_2}$	Number of units of temporary Certified Emission Reductions issuable in year t_2
$lCER_{t_2}$	Number of units of long-term Certified Emission Reductions issuable in year t_2
$\Delta C_{AR-CDM,t}$	Net anthropogenic GHG removals by sinks, in year *t*; t CO_2-e
t_1, t_2	The years of the start and the end, respectively, of the verification period

If $lCER_{t_2} < 0$ then $lCER_{t_2}$ represents the number of *lCERs* that are replaced because of a reversal of net anthropogenic greenhouse gas removals by sinks since the previous issuance.

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period. All measurements should be conducted according to relevant standards. In addition, the monitoring provisions contained in the tools used in this methodology apply.

1. Monitoring of project implementation

Information shall be provided, and recorded in the project design document (PDD), to establish that commonly accepted principles and practices of forest inventory and forest management in the host

country are implemented. In the absence of these, standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for inventory operations, including field data collection and data management, shall be identified, recorded and applied. Use or adaptation of SOPs available from published handbooks, or from the *IPCC GPG LULUCF 2003*, is recommended.

2. Sampling design and stratification

An *ex ante* stratification, if needed, should be presented in the PDD. Further considerations relating to stratification and sampling are included in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities".

3. Precision requirements

Maximum allowable relative margin of error of the mean for estimation of tree biomass is ± 10% at 90% confidence level.

4. Data requirements under the methodology

Table 3 provides a list of the data and parameters that are required in order to apply this methodology. Full description of these data and parameters can be found in the tools used in this methodology.

Table 3: Data and parameters required under the methodology

Data/Parameter	Description	Unit
A. Data and parameters to be obtained from existing sources		
$BEF_{2,j}$	Biomass expansion factor for conversion of stem biomass to above-ground biomass for tree species or group of species *j*	Dimensionless
BDR_{SF}	Ratio of biomass per unit area in land having a shrub crown cover of 1.0 and default above-ground biomass content in forest in the region/country where the A/R CDM project is located	Dimensionless
B_{FOREST}	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located	t d.m. ha^{-1}
ΔB_{FOREST}	Default average annual increment in above-ground biomass in forest in the region/country where the A/R CDM project is located	t d.m. ha^{-1} yr^{-1}
CF	Carbon fraction of dry matter in biomass	t C t^{-1} d.m.
D_j	Basic wood density for species or group of species *j*	t d.m. m^{-3}
R_j	Root-shoot ratio for species or group of species *j*	Dimensionless
R_S	Root-shoot ratio for shrubs	Dimensionless

Data/Parameter	Description	Unit
$f_j\left(DBH, H\right)$	Allometric function for species or group of species *j* linking a tree diameter (e.g. diameter at breast height), and possibly tree height (*H*), to above-ground biomass of the living tree	t d.m.
$V_{TREE,j}$	Stem volume of a tree of species or group of species *j* for trees of given age/diameter/height	m^3
B. Data and parameters to be obtained from measurement		
A_i	(a) Area of tree biomass stratum *i;* (b) Area of SOC stratum *i* of the land meeting the applicability conditions of the SOC tool	ha
$A_{SHRUB,i}$	Area of shrub crown cover stratum *i*	ha
$A_{p,i}$	Area of sample plot *p* in tree biomass stratum *i*	ha
$CC_{SHRUB,i}$	Crown cover of shrubs in shrub stratum *i*, expressed as a fraction	Dimensionless
$CC_{TREE\_BSL,i}$	Crown cover of trees in the baseline, in baseline tree biomass stratum *i*, expressed as a fraction	Dimensionless
DBH	Tree diameter	cm
H	Tree height	m

All the data and parameters obtained from measurement shall be monitored every five years from the date of the initial verification.

IV. REFERENCES AND OTHER INFORMATION

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

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History of the document

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