Ibi-Batéké degraded savannah afforestation project for fuelwood production - Democratic Republic of Congo
MONITORING PLAN
December 1st, 2010

ONF International

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1. Objective and components of the Monitoring Plan

The monitoring plan is intended to facilitate monitoring, recording, reporting, and verification activities necessary for assessment of the project performance and determination of the emissions reductions achieved in compliance of the approved methodology AR-AMC0001 version 3 under the Clean Development Mechanism of the Kyoto Protocol's Article 12 and other applicable requirements.

The following components are addressed in the monitoring plan (MP) for quantifying the carbon sequestered under the Ibi Batéké degraded savannah afforestation project:

- Project boundary
- Sources of variability and management of heterogeneity in biomass pools via stratification
- Procedures for monitoring of the carbon pools
- Determination of sampling intensity required to achieve a desired precision
- Allocation of sample plots over the project area
- Measurement and calculation of changes in carbon pools
- Scheduling of monitoring, measurement and verification
- Implementation of quality assurance procedures
- Verification of results by a third party

2. Project boundary

The project boundary is delineated to cover all land parcels of the project and the boundaries of the parcels are demarcated using global positioning system (GPS) and verified through field surveys. Project boundary will be periodically verified and any change is measured and recorded in the project database for submission to the DOE at the time of next verification.

3. Stratification and sample size for aboveground biomass pools

The procedures of *ex post* stratification of the project are outlined in the PDD. Sources of variability within project lands are managed by stratification, whereby the project is divided into a reasonable number of relatively homogeneous units in order to reduce the number of plots needed for monitoring.

Species composition

The following groups of species will be planted :

- *Acacia sp.*
- *Eucalyptus sp.*
- *Pinus sp.*
- Other species

Natural regeneration will be enhanced by implementing management actions aimed at improving the biodiversity and protection against natural fires.

Management

- Acacia in agroforestry stands

The *Acacia* agroforestry stands will be managed for wood production, mainly for charcoal. No pruning or thinning is planned. Harvesting is planned between 5-21 years, depending on the stand. *Acacia* is to be regenerated through natural regeneration. Seedlings will be selected in order to obtain a density of 1100 trees/ha. Stumps will not be removed after harvesting. Harvesting will be done manually with the use of chainsaws. Logs will be cut on site and gathered for charcoal production.

- Eucalyptus in agroforestry stands

Eucalyptus agroforestry stands will be run on a rotation of 18 years. No pruning or thinning is planned. Regeneration is to be carried out through replanting. Stumps will not be removed after harvesting. Harvesting will be done manually with the use of chainsaws.

- Pine in agroforestry stands

Pine agroforestry stands will be run on a rotation of 18 years. No pruning or thinning is planned. Regeneration is to be carried out through replanting. Stumps will not be removed after harvesting. Harvesting will be done manually with the use of chainsaws.

- Other species in agroforestry stands

For stands of other species, a single harvest is planned after 30 years. No pruning or thinning is planned. Harvesting will be done manually with the use of chainsaws.

- Acacia in pure plantation

The pure Acacia stand will not be harvested. No pruning or thinning is planned.

- Eucalyptus in pure plantation

Pure stands of Eucalyptus will not be harvested. No pruning or thinning is planned.

- Pine in pure plantation

Pure stands of Pine will not be harvested. No pruning or thinning is planned.

- Other species in pure plantation

For stands of other species, a single harvest is planned after 30 years. No pruning or thinning is planned. Harvesting will be done manually with the use of chainsaws.

- Natural regeneration stand

No harvesting is planned for the natural regeneration stand.

Intercropped cassava will grow during a maximum of 18 months after the planting of seedlings before canopy closure becomes a limiting factor. Cassava will be harvested and replanted only at the end of each stand rotation. The collecting of cassava will be done manually however, its transportation from the stands to the processing unit will be done with the use of a tractor.

Timing of planting

The area managed under the project from 2008 to 2037 is presented in Table 1.

Table 1 – Planting and harvesting cycle for agroforestry and pure plantation stands

Year n°	Year	Planting (ha)	Existing vegetation	Type of stand	Tree species	Initial Id	Harvest (ha)	Id harvested	Remaining (ha)	Replanting (ha)	New Id after harvest and replanting
1	2008	641,21	Savannah	Agroforestry	Acacia	S_Ag_Ac_08					
		23,23	Savannah	Agroforestry	Eucalyptus	S_Ag_Eu_08					
		107,48	Savannah	pure plantation	Acacia	S_Pp_Ac_08					
		4,51	Savannah	Pure plantation	Eucalyptus	S_Pp_Eu_08					
2	2009	532,40	Savannah	agroforestry	Acacia	S_Ag_Ac_09					
		47.24	Savannah	agroforestry	Eucalyptus	S_Ag_Eu_09					
		46.38	Savannah	agroforestry	Pinus	S_Ag_Pin_09					
		46.29	Savannah	agroforestry	Local species	S_Ag_LS_09					
		46.55	Savannah	agroforestry	Other exotic species	S_Ag_OES_09					
		46.53	Savannah	pure plantation	Eucalyptus	S_Pp_Eu_09					
		46.20	Savannah	pure plantation	Local species	S_Pp_LS_09					
3	2010	581,25	Savannah	agroforestry	Acacia	S_Ag_Ac_10					
		116,27	Savannah	agroforestry	Eucalyptus	S_Ag_Eu_10					
		93.04	Savannah	agroforestry	Local species	S_Ag_LS_10					
		46.23	Savannah	pure plantation	Pinus	S_Pp_Pin_10					
		46.36	Savannah	pure plantation	Other exotic species	S_Pp_OES_10					

Year n°	Year	Planting (ha)	Existing vegetation	Type of stand	Tree species	Initial Id	Harvest (ha)	Id harvested	Remaining (ha)	Replanting (ha)	New Id after harvest and replanting
		578,30	Savannah	agroforestry	Acacia	S_Ag_Ac_11					
		116,34	Savannah	agroforestry	Eucalyptus	S_Ag_Eu_11					
		46.43	Savannah	agroforestry	Pinus	S_Ag_Pin_11					
4	2011	46.29	Savannah	agroforestry	Local species	S_Ag_LS_11					
		46.49	Savannah	agroforestry	Other exotic species	S_Ag_OES_11					
		46.51	Savannah	pure plantation	Local species	S_Pp_LS_11					
		107,49	Savannah	agroforestry	Acacia	S_Ag_Ac_12					
		139,54	Savannah	agroforestry	Eucalyptus	S_Ag_Eu_12					
		43,21	Savannah	agroforestry	Pinus	S_Ag_Pin_12					
		104,34	Savannah	agroforestry	Local species	S_Ag_LS_12					
5	2012	69.66	Savannah	agroforestry	Other exotic species	S_Ag_OES_12					
		11,77	Savannah	pure plantation	Acacia	S_Pp_Ac_12					
		23.07	Savannah	pure plantation	Eucalyptus	S_Pp_Eu_12					
		23.41	Savannah	pure plantation	Pinus	S_Pp_Pin_12					
		23.23	Savannah	pure plantation	Local species	S_Pp_LS_12					
6	2013						352,18	S_Ag_Ac_08	289,03 (S_Ag_Ac_08)	352,18	R_Ag_Ac_13
7	2014						289,03	S_Ag_Ac_08	532.40 (S_Ag_Ac_09)	289,03	R_Ag_Ac_14
8	2015						393.20	S_Ag_Ac_09	139.20 (S_Ag_Ac_09/C1)	393.20	R_Ag_Ac_15
9	2016										
10	2017										
11	2018										
12	2019										

Year n°	Year	Planting (ha)	Existing vegetation	Type of stand	Tree species	Initial Id	Harvest (ha)	Id harvested	Remaining (ha)	Replanting (ha)	New Id after harvest and replanting
13	2020						395.19	S_Ag_Ac_09 + S_Ag_Ac_10	325.25 (S_Ag_Ac_10)	395.196	R_Ag_Ac_20
14	2021						395.01	S_Ag_Ac_10 + S_Ag_Ac_11	508,56 (S_Ag_Ac_11)	395.01	R_Ag_Ac_21
15	2022						392,146	S_Ag_Ac_11	116.41 (S_Ag_Ac_11)	392,14	R_Ag_Ac_22
16	2023										
17	2024										
18	2025										
19	2026										
20	2027						210,04	S_Ag_Ac_11 + S_Ag_Eu_09 + S_Ag_Pin_09	0	116.41	R_Ag_Ac_27
21	2028						223,76	S_Ag_Ac_12 + S_Ag_Eu_10	0	107,49	R_Ag_Ac_28
22	2029						209,27	R_Ag_Ac_13 + S_Ag_Eu_11 + S_Ag_Pin_11	305.67 (R_Ag_Ac_13)	46,51	R_Ag_Ac_29
23	2030						229,24	R_Ag_Ac_13 + S_Ag_Eu_12 + S_Ag_Pin_12	259,19 (R_Ag_Ac_13)	46.48	R_Ag_Ac_30
24	2031						212,72	R_Ag_Ac_13	46,47 (R_Ag_Ac_13)	212,72	R_Ag_Ac_31
25	2032						128,73	R_Ag_Ac_13 + R_Ag_Ac_14	206,76 (R_Ag_Ac_14)	128,73	R_Ag_Ac_32
26	2033						185,61	R_Ag_Ac_14	21,15 (R_Ag_Ac_14)	185,61	R_Ag_Ac_33
27	2034						182,64	R_Ag_Ac_14 + R_Ag_Ac_15	231,72 (R_Ag_Ac_15)	182,64	R_Ag_Ac_34
28	2035						208,43	R_Ag_Ac_15	23.29 (R_Ag_Ac_15)	208,43	R_Ag_Ac_35
29	2036						23,29	R_Ag_Ac_15 + R_Ag_Ac_20	209,23 (R_Ag_Ac_20)	209,24	R_Ag_Ac_36
30	2037										

Stratification

The stratification of the project is based on the type of stands (agroforestry, pure plantation) and the species groups used in the project and their expected tree biomass. Therefore, stands planted with local species and other exotic species are considered as together. The need for *ex post* stratification will be evaluated at each monitoring event based on expected disturbance, management activities that are different from those described in section A.5.4 of the PDD or variation in carbon stock change for each stratum the project boundaries, species composition. The physical features relating to the project boundary and management variables will be represented on the stratification map. The carbon stock changes in each stratum shall be monitored by adopting the sampling strategy outlined below.

Lands selected for planting are homogeneous and composed of grassy savannah, without any woody vegetation, in addition to a few shrubby savannahs. Thus, selected lands represent a single *ex ante* baseline stratum.

The construction of the *ex-ante* stratification is based on type of stands and planted species. We have the following *ex-ante* stratification for the project scenario:

Table 2 – Stratification of the project

Type of stand	Tree species	Area (ha)	Stratum Id
Agroforestry	*Acacia sp.*	2 440.65 **ha**	1
Agroforestry	*Eucalyptus sp.*	442.62 **ha**	2
Agroforestry	*Pinus sp.*	136.02 **ha**	3
Agroforestry	Other species	289.95 **ha**	4
Pure plantation	*Acacia sp.*	162.69 **ha**	5
Pure plantation	*Eucalyptus sp.*	119.26 **ha**	6
Pure plantation	*Pinus sp.*	74.11 **ha**	7
Pure plantation	Other species	69.64 **ha**	8
Enhancement of natural regeneration	-	115.94 **ha**	9
	TOTAL (ha)	**4.129,70 ha**	

Sample size for measuring changes in the above ground biomass pool

The sample size determines the number of plots needed in each stratum to reach targeted precision levels taking into account the variance of each stratum and the area of the stratum. This means that highly variable strata covering small areas will have less influence on the total number of plots needed than those strata that cover larger areas. Based on empirical experience, it is recommended that a targeted total precision level of about +/- 10% of the mean at the 95% confidence level can be obtained at a modest cost.

The sample size estimation assumes a standard deviation of 50% of the mean value for *Acacia sp*., *Eucalyptus sp*. and *Pinus sp*. (the major species of the project), other species (local and exotic) and for the stand where natural regeneration is enhanced. Taking into account lack of local specific data on biomass estimates in the early stages of the species, this assumption is reasonable and conservative[1] – especially because seeds of *Acacia sp*., *Eucalyptus sp*. and *Pinus sp*. will be procured from certified source to avoid variability in growing stock,

[1] "Guidelines on conservative choice of data when estimating biomass stocks and change in woody vegetation (EB 46, annex 17, version 01)" recommend a standard deviation equal to 50 % of the mean value for above-ground volume increment of existing woody vegetation.

which is expected to minimize the intra-species variability in growth rates and the resulting variability in the carbon stocks of stands. Table 3 presents the reference values used for *ex ante* sample size calculations.

Table 3 – Reference values for *ex ante* sample size calculations for above-ground biomass

	Size of stratum (ha)	**Expected value for AGB (m^3/ha/year)**	**Standard deviation (% of the expected value)**	**Target precision for AGB**
Acacia sp. + cassava	2 440.65 **ha**	9.5	50 %	10 %
Eucalyptus sp. + cassava	442.62 **ha**	17.5	50 %	10 %
Pinus sp. + cassava	136.02 **ha**	14.5	50 %	10 %
Other species + cassava	289.95 **ha**	8.57	50 %	10 %
Acacia sp	162.69 **ha**	9.5	50 %	10 %
Eucalyptus sp.	119.26 **ha**	17.5	50 %	10 %
Pinus sp	74.11 **ha**	14.5	50 %	10 %
Other species	69.64 **ha**	8.57	50 %	10 %
Enhancement of natural regeneration	115.94 **ha**	3.36	50 %	10 %

Table 4 presents the number of sample plots calculated for monitoring the carbon stock changes in the above ground biomass. The sample size calculations will be revised further based on the availability of the species composition data of the major species groups.

Table 4 – Number of sample plots for measuring the changes of carbon stocks in living tree biomass

Id stratum	**Project stratum**	**Number of sample plots**
1	*Acacia sp. + cassava*	**52**
2	*Eucalyptus sp. + cassava*	**18**
3	*Pinus sp. + cassava*	**4**
4	*Other species + cassava*	**9**
5	*Acacia sp.*	**3**
6	*Eucalyptus sp.*	**3**
7	*Pinus sp.*	**2**
8	*Other species*	**3**
9	*Enhancement of natural regeneration*	**2**
		96

4. Allocation of permanent sample plots

Permanent sample plots will be used for monitoring aboveground biomass. Each plot will have its coordinates recorded using a GPS. The plot corners of rectangular plots (10 m x 25 m) will be located and the GPS coordinates are noted. Plot markers will not be prominently displayed to ensure that permanent plots do not receive differential treatment from forestry personnel.

The plot location will be determined as follow:

(a) Permanent sample plots will be located using the approach of aligned systematic sampling. In this approach a grid is laid over the entire project area, and the centre points of a permanent sample plots are

taken as those grid intersection points that fall within a stratum. The grid will have a random origin (i.e. the origin is a randomly selected set of map coordinates), and optionally a random orientation (a randomly selected compass orientation);

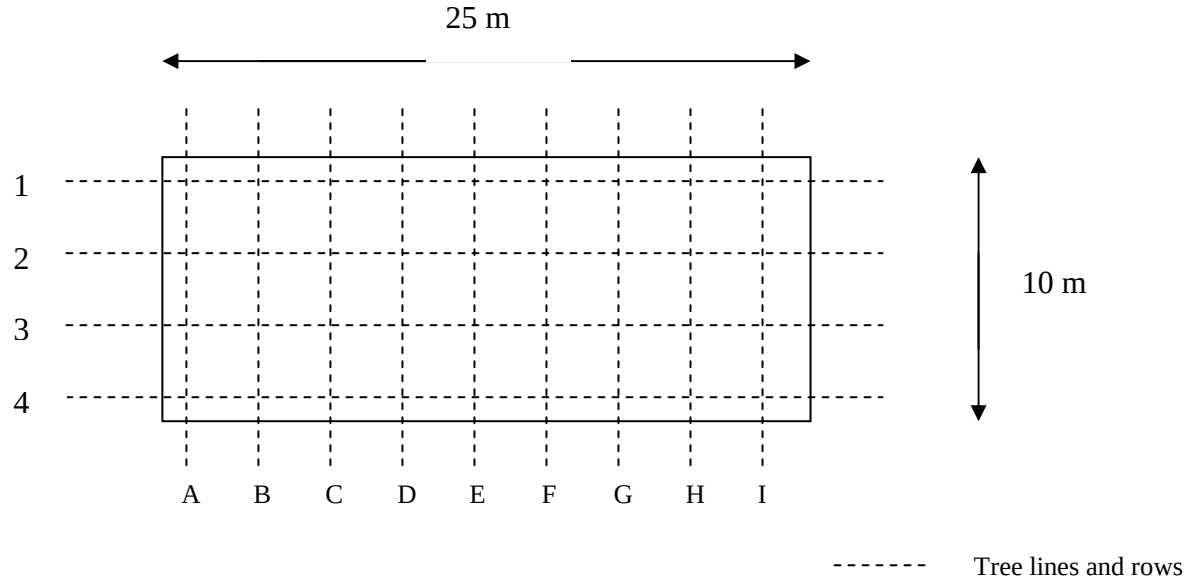
(b) To obtain the correct number of permanent sample plots in each stratum, the spacing of the grid (the distance between grid intersections) will vary until the necessary number of grid intersections in a stratum is obtained. It is not necessary to retain the same grid spacing for each stratum; however the same origin and orientation should be retained for the grid;

(c) Having assigned the centre points of the permanent sample plots using the above procedure, it is possible that, due to inherent and unavoidable uncertainty in mapping and/or sample plot location, during sample plot installation part of a sample plot may be found to fall outside of the area that is forested. In this case, the plot centre will be moved towards the centre of the parcel of land such that the outer edge of the plot coincides with the estimated position of the outer edge of the forest canopy at tree maturity. The direction of movement of the plot centre shall be at right-angles to the edge of the parcel of land;

(d) Sufficient sample plots should always be allocated to a stratum so that it is possible to omit any sample plots that prove to be inaccessible — while still maintaining the minimum number of sample plots calculated in Table 4.

During the sample plot establishment the field crew will follow a protocol in which all steps are recorded beginning with the starting point, surveying sample plots, recording azimuth and horizontal distance and polygonal layouts and fixed points in the surrounding are recorded.

Figure 1 – Permanent sample plots



5. Scheduling of measurement, reporting and verification events

Frequency of monitoring is related to expected changes in the carbon stocks through time—the smaller the expected change the greater potential for less frequent monitoring to detect significant changes in carbon stocks and vice versa. Monitoring intervals reflect the sequence of verification events over the first crediting period of the project. Table 5 outlines the proposed monitoring events over the project period.

The project will be verified at the end of each measurement period,i.e., at 5-year intervals after the first verification.

The verification has several components: verification of field data collection, data analyses, documentation and record keeping, data storage protocols, and project compliance. The Quality Assurance / Quality Control

(QA/QC) plan is designed to provide internal verification, whereas DOE verification is the external auditing of the measurements and the calculations of net GHG removals by sinks.

Table 5 – Schedule of carbon measurement events through 2036

Year	Measurement and verification activity
2011	Above ground biomass
2016	Above ground biomass
2021	Above ground biomass
2026	Above ground biomass
2031	Above ground biomass
2036	Above ground biomass

6. Monitoring of the forest establishment and management

As described in the PDD, the monitoring of the forest establishment and management will be carried out as follow.

Monitoring of the project boundary

This is meant to demonstrate that the actual area afforested is consistent with the afforestation area outlined in the PDD. The following activities are foreseen :

- Field surveys concerning the actual project boundary within which A/R activity has occurred, site by site;
- Measuring geographical positions (latitude and longitude of each corner polygon sites) using GPS;
- Checking whether the actual boundary is consistent with the description given in section A.4.2. ;
- Input the measured geographical positions that are in conformity with the description given in section A.4.2. of the PDD into the GIS system and calculate the area of each stratum and stand;
- The project boundary will be monitored periodically throughout the crediting period. If the forest area changes during the crediting period, for instance, because deforestation occurs in the project area, the specific location and area of the deforested land will be identified. Similarly, if the planting on certain lands within the project boundary fails these lands will be documented;
- Staff involved in the monitoring will be trained to identify the changes inside project boundary and to record changes in the project database for reporting of project verification.

Table 6 – Monitoring of project boundary

ID point	Longitude (dd/mm/ss)	Latitude (dd/mm/ss)	Local denomination

Monitoring of forest establishment

The monitoring of the forest establishment will cover site preparation, planting and establishment of the forest.

- The monitoring of site preparation activities covers the identification and recording of the area under site preparation. The area affected by site preparation will be measured using the GPS. These data are the basis for calculation of project emissions from the loss of biomass during site preparation (see also 9.) ;
- Information on planting schedule, location, area, species planted, and spacing will be recorded in plot journals and archived in the project database ;
- Survival rates of planted trees are counted during the three months of the planting and replanting is done to fill the gaps and the area and location of supplemental plantings undertaken to fill the gaps is recorded in the project database and identified on the strata maps. Re-planting will be conducted if the survival rate is lower than 90 percent of the final planting density expected.

Table 7 – Monitoring of planting activities

ID area	Area (ha)	Activity	Date (dd/mm/yyyy)	Duration	Comments

Monitoring of forest management

The monitoring of forest management will cover maintenance of plantation, intercropped cassava and firebreaks, harvesting of trees and replanting or sowing actions.

- Date, location and type of weeding actions in pure plantation will be recorded and archived in the project database;
- Date, location and type of maintenance actions in cassava plantations will be recorded and archived in the project database;
- Date, location and type of maintenance actions for firebreaks will be recorded and archived in the project database;
- Date, location, volume of tree harvesting will be recorded and archived in the project database ;
- Date, location of cassava harvesting will be recorded and archived in the project database ;
- Re-planting and re-sowing actions will be checked. Date, location and type of stand will be recorded and archived in the database ;
- Deviations in the forest management activities implemented in the field and the ones outlined in section A.4.2. of the PDD will be monitored, and reasons for deviations will be recorded.

Table 8 – Monitoring of forest management

ID area	Area (ha)	Activity (weeding, harvesting, planting, sowing)	Date (dd/mm/yyyy)	Duration	Comments

7. Monitoring and measurement of carbon pools

Tree biomass

Permanent sample plots located in the plantation plots will be located systematically with a random start. All data (location, stratum, sub-stratum) and coordinates will be recorded and archived. Those sampling plots, precisely located by GPS, will not present any specific obvious display in order to avoid discriminately treatment.

The project designs square sampling plots of 250 m^2. The growth of individual trees in sample plots will be measured at each monitoring event. Non-tree vegetation such as herbaceous plants, grasses, and shrubs will not be measured and accounted as per methodology applied.

Diameter at breast height (DBH, 1.3 m above ground) of all the trees within each permanent sample plot (250 m^2 ; 10 m x 25 m) above a minimum DBH (2 cm) will be measured. Height will be measured for *Eucalyptus sp*. The DBH position should take into account the tree form and topography. The procedures to be followed in the DBH measurements of trees on different topographic setting and with different irregularities are summarized in Figure 2.

Figure 2 – Implementation of DBH measurements taking into account the topography or tree irregularities (based on T.E. Avery, and H.E. Burkhart, 1983, *Forest Measurements*)

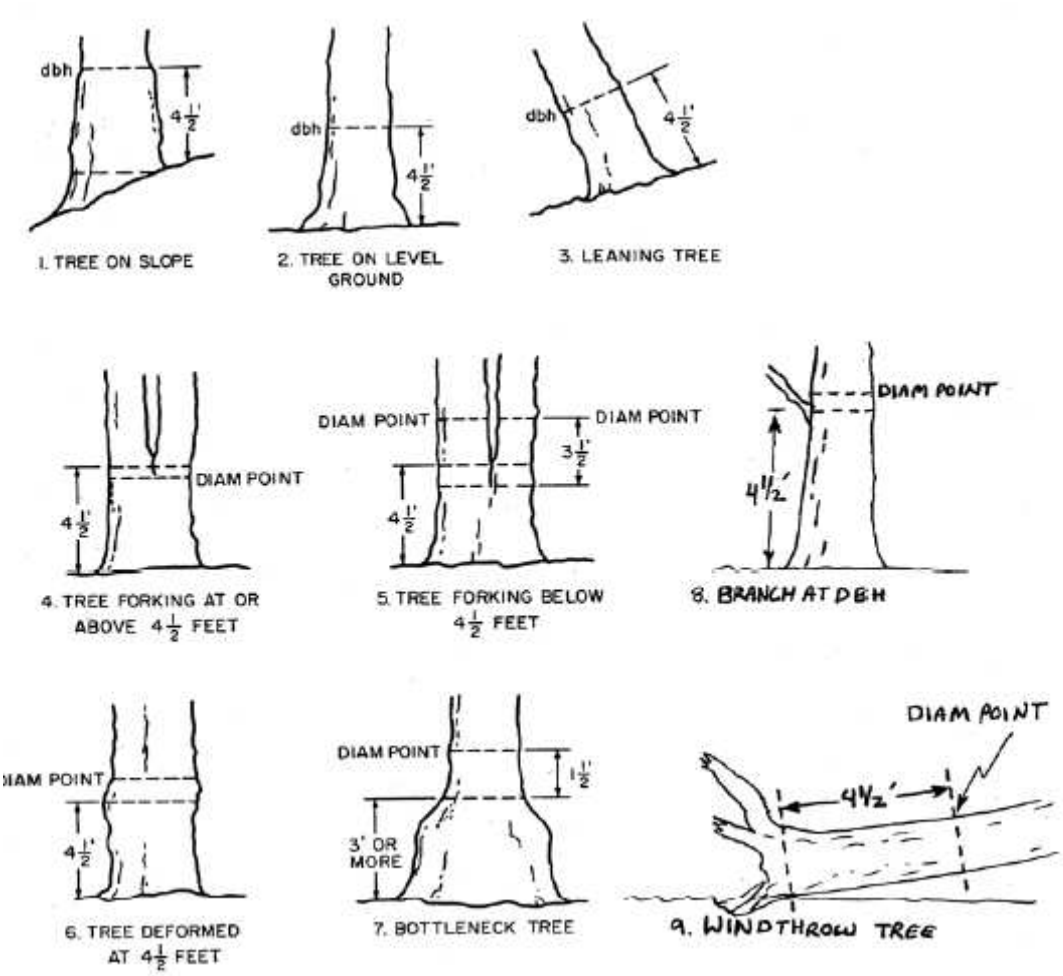


Figure 3 – Example of form for tree monitoring

Date (dd/mm/yyyy) :
Names of the team operators :
Type of stand (pure/agroforestry) :
Species planted :
Date of planting (mm/yyyy) :
Slope (%) :
Comments :

ID Plot	**ID Tree**	**Line**	**Tree Number**	**CBH** *(cm)*	**Total height** *(m)*	**Living/ dead**	**Health** *(optimal, good, regular, bad)*	**Form**[2]	**Comments**

[2] In compliance with Figure 2

If the permanent plot is located on a slope that is >10%, the slope should be measured and an adjustment made to the plot length or width using the formula:

$$L = Ls / \cos S$$

Where *L* is the plot length or width to be measured in the field along the slope, *Ls* is the standard (true horizontal distance) plot length (25 m) or width (10 m), *S* is the slope in degrees or percent (which must be converted to radians), and cos is the cosine of the angle. The adjusted length and/or width will be permanently marked in the field to guide future monitoring efforts in delimiting plot boundaries.

All trees measured will be permanently marked at the first aboveground biomass measurement with the placement of a tag inscribed with a unique number nailed into the stem at 1.2 meters height (10 cm below breast height); the DBH will then be measured at exactly 10 cm above the nail. If stems are not of sufficient size to support a nail (i.e. < 10 cm DBH), plastic ribbon will be tied around the base of the stem with a numbered tag. A mark will be made to indicate where DBH is measured, to ensure that future measurements will be done at the same place.

Step-wise procedures for allometric method and equation (19)-(21) in Section II.5.1.1 of the approved baseline and monitoring methodology (AR-ACM0001/version 03) will be followed to monitor the verifiable carbon stock changes in the above-ground and below-ground living biomass within the project boundary.

The carbon stock in above-ground biomass ($C_{AB\_tree,j,i,sp,t}$) in equation (19) of the methodology will be estimated using the following equations for the above-ground biomass :

***Acacia mangium*[3].** $\mathbf{AGB = 3.57 \times 10^{-4} \times (DBH \times \pi)^3 + 19.2 + 2.69 \times 10^{-5} \times (DBH \times \pi)^3 + 0.25}$
and BGB = 0.159 x AGB

***Acacia auriculiformis*[4].** $\mathbf{AGB = 4.16 \times 10^{-4} \times (DBH \times \pi)^3 + 11.22 + 2.02 \times 10^{-5} \times (DBH \times \pi)^3 + 2.36}$
and BGB = 0.132 AGB
with AGB and BGB in kg.d.m and DBH in cm

***Eucalyptus sp*.[5]** $\mathbf{AGB = 2.08 + (150.9 + 0.28\ age) \times (DBH^2 \times H \times 10^{-4})^{(0.87 + 0.0012\ age)}}$
where AGB : Above-ground biomass in kg.d.m
DBH : Diameter at breast height in cm
H : Height in meter
Age in months from the planting date

***Pinus sp*[6].** $\mathbf{AGB = \exp^{[-1.170 + 2.119 \ln(DBH)]}}$

Other species[7] $\mathbf{AGB = \exp^{[-2.134 + 2.530 \ln(DBH)]}}$
with AGB in t.d.m and DBH in cm.

[3] Bernhard-Reversat et al., 1993. Biomasse, minéralomasse et productivité en plantation d'*Acacia mangium* et *Acacia auriculiformis* au Congo, Bois et Forêts des Tropiques, 238 : 35-44.
[4] Bernhard-Reversat et al., 1993. Biomasse, minéralomasse et productivité en plantation d'Acacia mangium et Acacia auriculiformis au Congo, Bois et Forêts des Tropiques, 238 : 35-44.
[5] Saint-André L. and al., 2005. Age-related equations for above- and below-ground biomass of a Eucalyptus hybrid in Congo, Forest Ecology and Management 205 (2005) : 199 - 214
[6] 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. http://www.fao.org/docrep/W4095E/W4095E00.htm
[7] 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.

The above-ground biomass will be then converted to carbon stock in aboveground biomass using the following equation :

$$C_{AB\_tree,j,i,sp,t} = AGB_{tree,\ j,\ i,\ sp,\ t} \times CF_j$$

Where
CF_j : Carbon fraction of dry matter for species j in tC/tdm

Below ground biomass
The carbon stock in belowground biomass will be calculated using Equation (20) of the applied methodology and species-specific root-shoot ratio (Rj). These parameters are estimated from published data. IPCC default value (0.5) for the carbon fraction (CF_j) will be used. These values shall be updated every five years if the values from the national inventory are updated in the future.

9. Monitoring of project emissions

The GHG emissions that will occur during the implementation of the A/R CDM project activity are:

- CO_2 losses from pre-existing vegetation removal.

Emissions from site preparation activities would be assessed by monitoring the area affected in the site preparation filling Table 9 annually after each plantation campaign. This monitoring will be done based on field surveys. Amount of biomass lost is calculated by multiplying the area affected in the site preparation with the biomass of the unit area affected by the site preparation and the carbon fraction of the biomass.

Table 9 – Monitoring of site preparation

ID area	Area (ha) A_S	Activity	Date (dd/mm/yyyy)	Duration	Comments

As explained in the PDD, emissions from site preparation activities are equal to :

$$E_{biomassLoss} = 32.07\ A_S$$

with $E_{biomassLoss}$ in tCO_2e
and A_S in ha

10. Procedures in project implementation and monitoring

For the purpose of project monitoring and inventory, field crew should be organized into teams with one person assigned as a team leader. The number of members in a team and number of teams depends on the strata, administrative unit and sample size. Team leaders should be made responsible for organizing the field work. The overall organization of monitoring team is the responsibility of the project coordinator.
The monitoring will be based on the project data and information collected from project operations. The procedures to be followed in project implementation and monitoring are outlined in the sections below.

Procedures for training of monitoring personnel

Training of project monitoring personnel is a key step in ensuring the quality of data collection and accurate assessment of *ex post* carbon stock. Training helps in improving the technical skills of the project personnel. The training of monitoring personnel should cover the following technical aspects.

- The monitoring teams should be trained in the use of maps such as topographic and stratification maps and other physical and vegetation maps. The training should cover interpretation of maps and conversion of map scales to actual measurements on the ground.
- The training would cover the use of Global Positioning System (GPS), and instructions in the use of GPS, creating waypoints and data collection and use of the GPS in conjunction with compass, maps and field data collection techniques.
- Training to monitoring teams would be provided on the procedures for measuring forest growth and yield using permanent sample plots (PSPs).
- Training should also cover skills in identifying vegetation, species characteristics, sample plot location, codes and recommended practices of the inventory.
- Monitoring team members should be trained in the use of safety features such as the use of safety glasses, first aid kit, hand radio etc.
- The training should also cover the assessment of natural and anthropogenic risks and activities to be implemented in response to the risks of fire, droughts, pests etc.
- Training would cover the significance of meteorological data, such as maximum and minimum temperature, humidity, maximum wind velocity and average rainfall, interpretation of meteorological information and response to be implemented to address weather related emergencies.

Procedures to assessment GHG emissions due to fire inside project boundary

The project would implement fire management plan. The fire management plan would implement prevention measures such as establishment of firelines, clearance of bushwood and dry vegetation close to the project parcels. The project would further implement rapid response fire suppression measures.

In case of accidental fires, the area affected would be assessed by surveying the area and carbon stock affected. The procedures used for calculation of GHG emissions from natural fires under the project emissions would adopted to account the emissions and recorded in the project database.

Procedures to assess the impact of pests and disease on the carbon stock of the project

In case of pest or disease, monitoring team would assess the area and carbon stock of the affected area and implement pest/disease management measures to minimize negative impacts on the remaining carbon stock inside project boundary and to prevent the spread of infestation/disease to areas outside project boundary.

Impact of droughts on carbon stocks in the project boundary

Procedures would be implemented to assess the weather related natural hazard events such as droughts in the project area and survival of plantations in the affected areas. The data from field surveys of the affected areas would be used to assess the impact of droughts on the carbon stocks of the project.

Equipment used in inventories and calibration procedures for measurement accuracy

The equipment to be used in fieldwork should withstand the rigors of field use under adverse conditions. To avoid errors in the measurement of carbon stock, the following equipment used in monitoring and inventory activities would be calibrated using standard forest management and inventory operating procedures.

- Maps of the project area, stratum and planting site with GPS coordinates
- Compass for measuring bearings
- Fibreglass or metal tapes (100m and 30m) for measuring distances
- Global Positioning System (GPS) for locating plots
- Plot markers for marking plots
- Nails and number tags for marking trees
- Tree diameter at breast height (dbh) tape for measuring trees
- Diameter tape
- Pocket calculator

- Clinometers (percent scale) for measuring tree height and slope
- Coloured rope and pegs or a digital for marking plot boundaries measuring device (DME)
- Cloth (for example, Tyrek) or paper bags for collecting under storey samples
- Plastic file folder to put essential inventory documents, tables of correction for slope, etc,
- Pencil of average hardness (HB), a gum, and a penknife

Procedures for maintenance of monitoring equipment and installations
The common procedures to be followed in the maintenance of monitoring equipment are outlined below.

- When compass is used in the field, it is calibrated to compensate for the local difference between magnetic and true north (magnetic declination) and adjustment is made in order to facilitate the recording of accurate bearing.
- The aspect measurements should be recorded to the nearest eight directions: N, S, E, W, NE, SE, NW and SW. The same procedure is used to determine the azimuth to any desired target object such as a tree and the azimuth value should be recorded to the nearest percent, The azimuth direction is expressed in degrees: North at 360 (zero) degrees, East at 90, South at 180, and West at 270.
- It is recommended to use DBH tapes made of steel or aluminium. Cloth tapes should be avoided considering their propensity for wear and tear that could result in measurement inaccuracies.
- Pacing can be useful to establish the relationship between map and photo information with the measurements on the ground. One step represents half of a pace, two steps is one pace. Therefore, crew should be trained in pacing on flat ground.

Procedures for handling of records and storage and process performance documentation
The project information is stored in paper and electronic formats. The "Cellule Qualité et Suivi Statistique" (CQSS) has developed standardized operating procedures for collection, reporting, filing and archival of the project data and information. The reporting arrangements for handling of project documents and communications is aimed at continuous update of the operating procedures and communicating them widely to the project staff in the field so that project information is regularly updated and procedures for data storage and retrieval are updated as per the project requirements.

Procedures identified for review of reported results/data
The project implementation unit is expected to verify the plot data and decide on the need to return to the plot to re-measure the carbon pools. Prior to leaving a completed plot, the monitoring team would review plot data form to insure all data are properly collected and recorded. The review would include checks of equipment calibration to ensure accurate measurements and random checks of the collected data to ensure the accuracy of reported measurements in the project database. Besides, at the end of the field works, 10% of the measurements will be independently checked by different personnel. Field data collected at this stage will be compared with the original data
The reviewers of the data are expected to present their independent report to the project coordinator so that review feedback is shared with the monitoring team and suitable corrective measures are implemented.

Procedures identified for internal audits of GHG project compliance with operational requirements
The "Cellule Qualité et Suivi Statistique" (CQSS) would implement the internal audit in order to ensure that the project complies with the regulatory requirements in terms of meeting the requirements of approved methodology AR AMC0001-version 3 and the guidance of the CDM Executive Board. The internal audits would focus on the following aspects of the project

- Semi-annual and annual assessment of project documentation and reporting requirements to ensure compliance with the regulatory requirements.
- Arrangements for independent checks of the monitoring and inventory fieldwork over 10 % of the plots to ensure that the project data are collected and archived consistently following the standard procedures and the errors noticed are corrected and recorded.
- Audit of the procedures used in assessing the carbon stock changes based on the field data measurements

- Analysis of the effectiveness of the leakage prevention measures and improvements implemented to enhance the efficacy of leakage prevention measures.

Procedures identified for project performance reviews before data is submitted for verification
The "Cellule Qualité et Suivi Statistique" (CQSS) is expected to review the project performance based on the reports of project implementation and inventory. The project coordinator in charge of "Cellule Qualité et Suivi Statistique" (CQSS) is expected to certify the compliance of the project with the steps of the approved methodology AR AMC0001 and guidance of the CDM Executive Board.

Procedures identified for corrective actions in order to provide for more accurate future monitoring and reporting
The corrective action procedures ensure accurate monitoring and reporting on the project. The following procedures illustrate the corrective action procedures envisaged under the project.
The project coordinator or staff of the "Cellule Qualité et Suivi Statistique" (CQSS) could accompany monitoring teams to assist in the field measurements. The coordinator is expected to conduct random inspections to identify errors and make decisions on the re-measurement of sample plots in case errors are observed. Disagreements on inventory approaches would be discussed among the monitoring teams and consensus on monitoring and inventory procedures achieved would be implemented throughout the project area. The procedures at each inventory are recorded in the project database
The flora that is difficult to identify at the time of inventory, would be recorded based on its characteristics, and a leaf/branch sample is collected and its identification is undertaken after the plot inventory.
At each monitoring event, data from previous and current inventories would be compared in order to make an accurate assessment of in-growth, existing trees, and mortality.

11. Quality assurance and quality control plan

To develop a credible plan for measuring and monitoring carbon on the afforestation sites, steps must be taken to control for errors in sampling and data analysis. To provide confidence to all stakeholders that the reported carbon credits are reliable and meet minimum measurement standards, a quality assurance and quality control (QA/QC) plan is necessary. This plan includes formal procedures to verify methods used to collect field data and the techniques to enter and analyze data. To ensure continuity it is important that all data collected use the same procedures during the project life. Adhering to these procedures will ensure that in the event there is a change in personnel at NOVACEL, or if any of the people involved are questioned about any aspect of the project, all will be well informed. In addition to following the procedures outlined below, it is also important that a record be maintained to demonstrate that the steps are being followed; this needs to be done by developing a series of check sheets for each step.

For this purpose, procedures have been developed for:
- collecting reliable field measurements
- verifying methods used to collect field data
- verifying data entry and analysis techniques
- data maintenance and archiving

Procedures to ensure reliable field measurements
Collecting reliable field measurement data is an important step in the quality assurance plan. Those responsible for the measurement work shall be fully trained in all aspects of the field data collection and data analyses. Standard operating procedures for each step of the field measurements will be adhered to at all times so that future field personnel can check past results and repeat the measurements in a consistent fashion.
- Field-team members are fully cognizant of all procedures and the importance of collecting data as accurately as possible; Before field measurements all procedures are reviewed with the whole monitoring team
- All field measurements are properly supervised by a project coordinator fully aware of all monitoring procedures, and any errors in techniques are corrected;

- The field forms are filed in accordance with the standard operating procedures. The document will list all names of the field team and the project leader will certify that the team is trained;
- New staff is adequately trained by its homologue fully aware of all procedures.

Verification of field data collection

To verify that plots have been installed and the measurements taken correctly :

- All measurements are observed by two persons for cross-checking
- At the end of the field works, 10% of the measurements will be independently checked by different personnel. Field data collected at this stage will be compared with the original data. Any errors found will be corrected and recorded. Any errors discovered will be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

Verification of data entry and analysis

Surveys data are entered into a computer-based information system especially designed for the project.
Reliable estimates require proper entry of data into the data analysis spreadsheets. Possible errors are minimized by reviewing entries using expert judgment, where necessary and comparison with independent data to ensure that the data are realistic. Communication between all personnel involved in measuring and analyzing data allow resolving any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that cannot be resolved, the plot is not used in the analysis.

- data entry is made by two trained persons for cross-checking
- final analysis is made by the person who prepared the monitoring
- minimum files shall be used in order to avoid losses of data in time and to facilitate data analysis

The following elements shall be particularly considered :

- Stratum ID: cross-check with previous monitoring and management plans
- Age of plantations: shall be integrated to GIS
- Number of trees: shall be integrated to the GIS for initial plantations as for natural regeneration
- Diameter at breast height (DBH): circumference shall be preferred. Measurements shall be cross-checked by two trained persons
- Wood density shall be updated by the project coordinator on scientific studies improving knowledge on wood density
- Biomass expansion factor (BEF) shall be updated by the project coordinator on scientific studies improving knowledge on BEF
- Carbon fraction shall be updated by the project coordinator on scientific studies improving knowledge on carbon fraction
- Root-shoot ratio shall be updated by the project coordinator on scientific studies improving knowledge on root-:shoot ratio

Data maintenance and archiving

Data will be archived in both electronic and paper forms, and conserved at least two years after the end of the crediting period. All electronic data and reports will be copied on durable media and update format, such as compact discs (CDs), and copies of the CDs will be stored in multiple locations. The archives include:

- Copies of all original field measurement data, laboratory data, data analysis spreadsheets;
- Estimates of the carbon stock changes in all chosen carbon pools and non-CO_2 GHG sources and corresponding calculation spreadsheets;
- GIS products and update software ;
- Copies of the measuring and monitoring reports.