MONITORING REPORT FORM (CDM-MR) *
Version 01 - in effect as of: 28/09/2010

CONTENTS

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

MONITORING REPORT
Version 01, 16/03/2012

AES Tietê Afforestation/Reforestation Project in the State of São Paulo, Brazil
UNFCCC Reference Number: 3887
Monitoring period 1 (15/12/2000 – 14/02/2012)

SECTION A. General description of the project activity

A.1. Brief description of the project activity:

The main purposes of the project activity are to restore the structure, function and ecosystem services of riparian forests located along the borders of ten hydropower reservoirs; enhance the biodiversity of degraded riparian areas, and contribute to the creation of ecological connectivity along the rivers; increase carbon sequestration in riparian forests; improve water recharge in the reservoirs and control soil and water erosion; contribute to stop and reverse land degradation processes in the State of Sao Paulo, with special focus on riparian ecosystems and provide employment and recreational opportunities for local residents in the vicinity of the reservoirs.

Since the date considered as the starting of crediting period to the year of 2010, the project activity were implemented on 2,001.2 hectares at expropriation areas which surround ten hydroelectric plants reservoirs of AES Tiete Company.

Total emission reductions achieved 215,382 tCO2e within the riparian areas eligible for reforestation activities based on definitions provided in paragraph 1 of the Annex to Decision 16/CMP.1 ("Land use, land-use change and forestry"), as requested by Decision 5/CMP.1 ("Modalities and procedures for A/R project activities under the Clean Development Mechanism in the first commitment period of the Kyoto Protocol"), and AR-AM0010.

A.2. Project Participants

The project participants involved are:

Host Parties:
- AES Tiete S.A – Brazil

Bilateral and Multilateral Funds:
- International Bank for Reconstruction and Development as a trustee for the BioCarbon Fund – Authorized by Canada

Other Parties involved:
Canada
Authorized Participants: Government of Canada - Ministry of Foreign Affairs and International Trade

France
Authorized Participants: Eco-Carbone S.A.S

Italy
Authorized Participants: Government of Italy - Ministry for the Environment, Land and Sea

Japan
Authorized Participants: Idemitsu Kosan Co., Ltd. ; Japan Iron and Steel Federation (JISF) ; Japan Petroleum Exploration Co., Ltd. (JAPEX); The Okinawa Electric Power Co., Inc. ; Sumitomo Chemical ; Sumitomo Joint Electric Power Co., Ltd. ; Suntory Holdings Limited; The Tokyo Electric Power Co., Inc.

Spain
Authorized Participants: Kingdom of Spain- Ministry of the Environment and Rural and Marine Affairs & Ministry of Economy and Finance

Luxembourg
Authorized Participants: Ministry of Sustainable Development and Infrastructure

A.3. Location of the project activity:

The project is located in Brazil at Southeastern region, states of Sao Paulo and Minas Gerais,

Reforestation areas that comprise the project activity are located along the reservoirs borders located at the municipalities listed by Table 1. The location for each hydropower plant headquarters, by municipality, is indicated in Table 1 in a bold and underlined text (e.g. **Ibitinga**).

The table below lists the municipalities in which the hydropower plants (i.e. reservoirs) are located.

Table 1. Project Location

Reservoirs	Municipalities
UHE Ibitinga	• Arealva, Bariri, Boracéia, **Ibitinga**, Itaju, Iacanga and Pederneiras (State of São Paulo).
UHE Promissão	• Sabino, Uru, Reginópolis, Guaiçara, Cafelândia, Lins, Iacanga, Ibitinga, Pirajuí, Pongaí, **Promissão**, José Bonifácio, Borborema, Adolfo, Sales, Ubarana, Urupês, Novo Horizonte, Mendonça, Nova Aliança, Potirendaba and Irapuã (State of São Paulo).
UHE Bariri	• Bariri, Barra Bonita, **Boracéia**, Igaraçu do Tietê, Itapuí, Jaú, Macatuba and Pederneiras (State of São Paulo).
UHE Barra Bonita	• Anhembi, **Barra Bonita**, Botucatu, Conchas, Dois Córregos, Igaraçu do Tietê, Laranjal Paulista, Mineiros do Tietê, Piracicaba, Santa Maria da Serra, São Manuel and São Pedro (State of São Paulo).
UHE Nova Avanhandava	• Birigui, Brejo Alegre, **Buritama**, Lourdes, Santo Antonio do Aracanguá, Turiúba, Zacarias. (State of São Paulo).
PCH Mogi Guaçu	• Aguaí, Araras, Conchal, Espirito Santo do Pinhal, Estiva Gerbi, Itapira, Leme, **Mogi-Guaçu**, Moji Mirim, Pirassununga. (State of São Paulo).
UHE Caconde	• **Caconde**, Divinolândia Tapiratiba, São José do Rio Pardo, (State of São Paulo) • Botelhos, Cabo Verde, Muzambinho, Poços de Caldas, (State of Minas Gerais).
UHE Euclides da Cunha	• Caconde, Casa Branca, Divinolândia, Itobi, Mococa, **São José do Rio Pardo**, São Sebastião da Grama, Tambaú, Tapiratiba, (State of São Paulo).
UHE Limoeiro	• Casa Branca, **Mococa**, São José do Rio Pardo, Tambaú, Tapiratiba (State of São Paulo). • Arceburgo, Cássia dos Coqueiros, Guaranésia, Monte Santo, (State of Minas Gerais).
UHE Água Vermelha	• Cardoso, Icem, Indiaporã, Macedônia, Mira Estrela, Orindiúva, Paulo de Faria, Pedranópolis, Pontes Gestal, **Ouroeste** and Riolândia (State of São Paulo) • Campina Verde, Fronteira, Frutal, Itapagipe, Iturama and São Francisco de Sales (State of Minas Gerais).

The location of each hydropower reservoir and its geographical coordinates is listed below:

- ***UHE Água Vermelha*:** is situated on the Grande River, north of the State of Sao Paulo and south of the State of Minas Gerais, between 19°37' and 20°30' south latitudes and 49°05' and 50°30' west longitudes.

- ***UHE Bariri*:** is situated on the middle course of the Tietê River, in the center of the State of Sao Paulo, between 22º28'48" and 22º09'00" south latitudes and 48º45'36" and 48º38'24" west longitudes.

- ***UHE Barra Bonita*:** is situated on the middle course of the Tietê River, in the center of the State of Sao Paulo, between 22º52'12" and 22º30'00" south latitudes and 48º31'48" and 47º57'36" west longitudes.

- ***UHE Ibitinga*:** is situated on the middle course of the Tietê River in the center of the State of Sao Paulo, between 21º 45' and 22º 00' south latitudes and 48º 50' and 49º 00' west longitudes.

- ***UHE Promissão*:** is situated on the middle course of the Tietê River in the center west region of the State of Sao Paulo, between 21º18'00" and 21º45'36" south latitudes and 48º59'24" and 49º46'48" west longitudes.

- ***UHE Nova Avanhandava*:** is situated on the middle course of the Tiete River in the center west region of the State of Sao Paulo, between 21°06`00`` south latitudes and 50°12`00`` west longitudes.

- ***PCH Mogi Guaçu*:** is situated on course of Mogi-Guaçu River, in Mogi-Guaçu municipality of the State of Sao Paulo, between 22°23`00`` south latitudes and 46°54`00`` west longitudes.

- ***UHE Caconde*:** is situated on course of Pardo River, in Caconde municipality of the State of Sao Paulo, between 21°34`00``south latitudes and 46°37`00``west longitudes.

- ***UHE Euclides da Cunha*:** is situated on course of Pardo River, in Sao Jose do Rio Pardo municipality of the State of Sao Paulo, between 21°36`00``south latitudes and 46°56`56`` west longitudes.

- ***UHE Limoeiro*:** is situated on course of Pardo River, in Mococa municipality of the State of Sao Paulo, between 21°37`00`` south latitudes and 47°00`00`` west longitudes.

A.4. Technical description of the project

Forest planting and management techniques were taking into account the local knowledge of the species and research and development experience of AES Tietê professionals and partners in the region since the 1980s.

The technology implemented in the project in different project activities such as seedling development, site preparation, planting, and plantation management were based on the research and development activities initiated by AES Tiete's project team and partners during 2001 to 2007. The technologies implemented in project activities are summarized below:

Seedlings development

The collection and treatment of seeds was done from forest fragments within the Atlantic Rainforest biome. Fruits from a variety of species were selected and screened for seed collection. The seeds were treated to break dormancy, as for example, the process of scarification of the *Guapuruvu* (*Schizolobium parahyba*) seeds, which were submerged into the water for one or two days. Seeds were then planted in small tubes holding 53cm of substrate involving soil, humus, carbonized rice straw and chemical fertilizer. Small tube supports germination and seedling growth and can hold up to 192 units. The trays were placed in suspended beds with 50 fifty percent shade cover and automated irrigation within in the nursery, which ensures control of growth conditions. In some cases, when the seedlings require better care, the seeds were planted in the germination nursery before transplanting into tubes.

AES currently operates a greenhouse of seedlings at UHE Promissão with a capacity to produce 1,000,000 seedlings per year. This production capacity had been used for this project activity.

Site preparation

In areas planted from 2001-2010, a less intrusive method of mechanized clearing and soil preparation was used to minimize physical, biological or chemical degradation. To minimize the disturbance of vegetation and soils during site preparation, restoration activities limited the area affected (preparing only the sites where seedlings were planted, using small holes 30-40 cm in diameter or subsoiler to open the planting lines on the soil), retained as much of the existing vegetation, and positioned holes along the contour lines to reduce soil loss.

Fertilizers were applied directly to the small planting holes rather than being spread across the plantation.

Approximately 10 (ten) days after the land was cleared, workers, accompanied by a qualified technician treated the soil with granulated bait or pulverized liquid insecticide to control ants. The insecticide was applied throughout the proposed planting area, as well as a minimum of 100 meters from the fences. For effective weed control, gliphosate was applied using mechanized pulverization tractors.

Planting

For planting activity, 0.04 x 0.04 x 0.04 meter pits were prepared. Each pit was spaced 3.0 x 2.0 meters apart. The seedlings inside the tubes were placed in boxes or buckets and transported to the planting area.

Species were identified as fast and slow growing. These groups had complementary demands, regarding the need for light. Fast growing species create a seedbed that restarts the regeneration process. They also provided shade during the initial growth phases of the slow-growing species, facilitating harmonic development of both types. The two groups were planted simultaneously and irrigated. A mix of 80 fast-slow-growing species were planted during the 4 (four) months between November and February to take advantage of the rainy season. A second round of planting in the same area took place 60-90 (ninety) days following the first planting. In this operation, the entire planted area was surveyed to identify dead or failed seedlings and replanting undertaken. Each pit was covered with dried grass to maintain soil moisture.

The reforestation model applied from 2001-2010, using native species, was induced secondary succession. Knowledge of succession processes and of the ecological features of tree species present in each succession stage indicated the best species that could be employed for successful long-term regeneration of riparian forests.

Plantation management

During the first eight months following planting, the area was treated with insecticide and herbicide every two months in the same manner as it was treated prior to planting. Vines and other tropical plants that strangle the seedlings were manually cut and grassy areas were cut using mechanized equipment. Over the first three years of planting, project areas were managed with the objective of achieving maximum survival and establishment. Following this period, plantation protection and monitoring measures were continued during the project lifetime.

Fencing

Fencing activities were take place at selected areas with higher risk of human disturbances such as cattle grazing. Only renewable wood from Eucalyptus tree species were used as fencing material. Wooden poles with diameter between 6-11cm and a total height of 1.20m were placed 6m apart according to specifications provided by AES Tietê technical team.

A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

- ***Approved afforestation and reforestation baseline and monitoring methodology:***

A/R-AM0010 / Version 04, Sectoral Scope 14, EB 50 – Annex 20, October 16 2009 – "Afforestation and reforestation project activities implemented on unmanaged grassland[18] in reserve/protected areas".

A.6. Registration date of the project activity:

This project activity was registered by the UNFCCC on January 7th, 2011.

A.7. Crediting period of the project activity and related information (start date and choice of crediting period):

The fixed crediting period comprehends the period between December 15th, 2000 to December 14th, 2030.

The project proponent's concession, which includes the areas to be reforested, has a duration of 30 (thirty) years, starting in 1999 and terminating in 2029. The legal foundation of the concession allows AES-Tietê to renew it for an equal period of 30 (thirty) years through a legal decree and approval by the Brazilian Electrical Energy Agency (ANEEL). Given the fact that AES Tietê operates public utilities under the concession, no time lag is expected between the expiration of the current concession and renovation of the second 30-year period. Given these assumptions, AES Tietê considers a fixed period of 30 (thirty) years for the crediting period as the best choice in the given situation.

A.8. Name of responsible person(s)/entity(ies):

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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

As proposed on the PDD and mentioned previously, the starting date of the crediting period is considered as December 15th, 2000.

From this date, total area planted in each hydroelectric reservoir is demonstrated in the following table. At 2000 year, from December 15th to 31st period, the soil preparation was performed on the borders of the hydropower plants reservoirs.

Table 2. Planted area within riparian eligible area at hydroelectric reservoirs of AES Tietê within the period of 2001 to 2010

UHE	Planted Area (ha)
Água Vermelha	1365.3
Barra Bonita	44.2
Bariri	113.6
Caconde	40.6
Euclides da Cunha	-
Ibitinga	275.2
Limoeiro	1.8
Mogi Guaçu	23.4
Nova Avanhandava	-
Promissão	1,137.1
Total	**2,001.2**

During this monitoring period no particular event occurred that could impact the methodology applicability.

During the project implementation, a specific field survey was performed to know the land use of the borders of all AES Tiete hydropower reservoirs. After this land use assessment, the total area suitable for reforestation decreased in comparison with the area estimated in the PDD.

As per by "Guidelines on accounting of specified types of changes in A/R CDM project activities from the description in registered project design documents"[1] – versions 01.0 (EB 63, Annex 27, 29 September 2011), changes in year-wise areas planted, resulting in a part of the project not planted are considered as minor changes and not require a submission of a notification or approval.

B.2. Revision of the monitoring plan

The monitoring plan was revised and an updated version submitted to the DOE together with this Monitoring Report.

B.3. Request for deviation applied to this monitoring period

Not applicable.

B.4. Notification or request of approval of changes

Not applicable.

[1] Available in: http://cdm.unfccc.int/Reference/Guidclarif/ar/methAR_guid31.pdf

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

SECTION C. Description of the monitoring system

The monitoring system was performed in accordance with "Procedures Manual of Monitoring Plan" (Manual de Procedimentos para Monitoramento de Parcelas Permanentes), which includes the following items:

1. Monitoring area

The monitoring process aimed to obtain estimates of carbon stock of the AES Tiete carbon sequestration project areas with more than three years. Thus in monitoring addressed all discrete units (plots of heterogeneous reforestation of native species) implanted between 2001 and 2009, defined as areas eligible under mandatory tool: "Procedures to define the eligibility of lands for the project activities of afforestation and reforestation" approved by CDM Executive Board (EB35) to demonstrate the eligibility of land within the project boundary and definition as requested by decision 5/CMP.1 ("Modalities and procedures for project activities F/R under the CDM in the first period commitment to the Kyoto Protocol"). These sampling units are located on the banks of hydropower reservoirs located in the Tietê and Rio Grande Valley, as shown in Table 2 – Section B.

1.1 Plot allocation

The Permanent sample plots were randomly assigned to the project area. These were located in forested and eligible areas under the CDM criteria, in randomized points within each reservoir, following the precepts considered in the Guide to Good Practice for Land Use, Land Use Change and Forestry [GPG-LULUCF (IPCC 2003)].

1.2 Plot geo-referencing

The geographical positions of the four vertices that define each plot were recorded with the use of a Trimble Pro-XTGPS receiver with sub-metrical accuracy in UTM WGS84 projection and later projected to SAD 69. This procedure not only contributes to the spatial location of plots but also aids the NDVI calculation.

1.3 Plot dimensions

The plots are rectangular and have a consistent area of 400 m^2, but with dimensions that may and should vary due to different plant spacing used during planting seasons. The width of the plot was established to contain 4 rows. The sides of the plot are parallel to planting rows of trees, Thus, the dimensions of both the width and length of the plot are variable depending on the spacing between lines used in the deployment, according to the example in Table 3.

Table 3: Variation of the width and length of the 400 m^2 rectangular polygon that defines the plot according to its spacing

Distance between plant lines (m)	Plot Width (m)	Plot Length (m)
3 m	12 m	33,33 m
2,5 m	10 m	40 m
2,0 m	8 m	50 m

The total number of sample plots used in the inventory was 111, less than the total amount actually measured, which was 115. The 4 plots that were missing from the analysis were rejected due to problems in geo referencing.

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

1.4 Database and Data Processing

The data collected in the field were stored in a System Manager relational database (RDBMS). This database was used to centralize all information collected in the field in a single location and in a way that allows people to examine them in various ways.

The "R" programming language was used for analysis of data generated by reports provided by the database. This software is free and has great power of analysis. In addition, it allows the processing of data with minimal manipulation, avoiding errors and ensuring reliability and consistency of the final monitoring results.

1.5 QA/QC

In order to ensure the quality of measurement procedures prediction model inputs, 10% of the biomass inventory plots were re-measured and its accuracy indices were calculated. Two indices commonly used in error analysis were chosen for this verification: The bias and the root mean squared error.

Regarding to the Operational and management structure, this A/R CDM project activity was implemented as follow:

- AES Tiete (Directory of Safety and Environment) with headquarters in Sao Paulo was responsible for general management of the project activity. Monitoring data for actual GHG removals by sinks and any leakage generated by the proposed A/R CDM project activity were reviewed by the team in Sao Paulo;

- UHE Promissao (Directory of Safety and Environment) with headquarters in Promissao, Brazil was responsible for the field activities coordination and seedlings supply; and,

- The Sao Paulo University, Escola Superior de Agricultura Luiz de Queiroz, (Dept. of Forestry Sciences) located in Piracicaba, Brazil was responsible for applying the monitoring plan in partnership with AES Tiete team from Sao Paulo and Promissao. Monitoring data for actual GHG removals by sinks and any leakage generated by the proposed A/R CDM project activity were compiled by the team in Piracicaba.

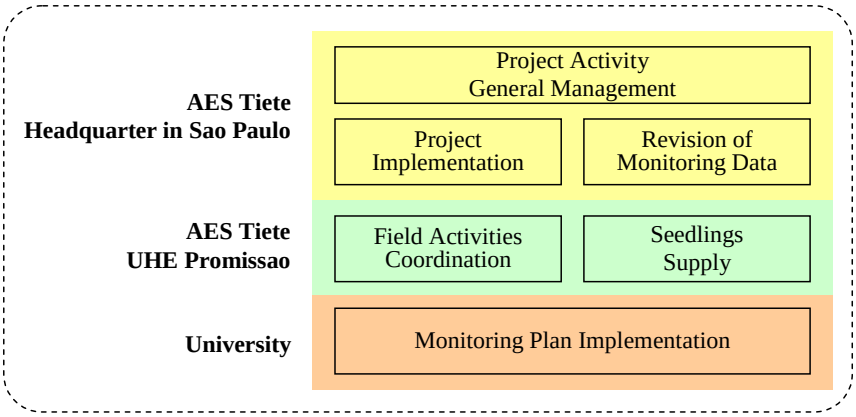

Figure 1. Operational and management structure

SECTION D. Data and parameters

As per by the "Guidelines on application of specified versions of A/R CDM methodologies in verification of registered A/R CDM project activities" – EB 63, Annex 27, Version 01.0 from 29 September 2011, only data and parameters obtained from field measurements are required to be monitored.

The monitoring of the baseline net GHG removals by sinks is not required by monitoring methodology AR/AM0010. Additionally, there are no potential leakage emissions attributable to the proposed A/R project activity as per by AR-AM0010.

For the initial verification, all parameters are described as following:

D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

Data / Parameter:	**Wood density**
Data unit:	**g/cm^3**
Description:	Wood Density is the oven dry mass over green volume.
Source of data used:	Literature
Value(s) :	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Additional comment:	This data are updated each new verification

Data / Parameter:	**Carbon fraction**
Data unit:	**Percentage (%)**
Description:	Fraction of carbon in wood biomass.
Source of data used:	IPCC default
Value(s) :	47%
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Additional comment:	-

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

Data / Parameter:	**Trunk biomass equation (BT)**
Data unit:	**Kg**
Description:	Allometric equation that calculates the trunk biomass of single trees starting from measurements of S30, total height and wood density
Source of data used:	Ferez, A. P. C. Efeitos de praticas silviculturais sobre as taxas iniciais de sequestro de carbono em plantios de restauração na Mata Atlântica. Dissertação de Mestrado: ESALQ/USP, Piracicaba, SP, 2011.
Value(s) :	Ln(BT) = 6.038757 + 0,94494.ln(S30) + 0.96147.ln(total height) + 1.02221.ln(wood density), R^2 = 0.942
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Additional comment:	In surveys of volume and biomass, we try to use an equation developed with sampled trees resulting from the same area where its will be applied. Although, Ferez (2011), was not an equation developed for this project, its allometric model was obtained in reforestation areas of similar ages and using species that, when they were not coincident, belonged to the same ecological classification . This makes, in our view, the equation applied in this monitoring most appropriate than the international equations recommended by the IPCC.

Data / Parameter:	**Root biomass equation (BR)**
Data unit:	**Kg**
Description:	Allometric equation that calculates the root biomass of a single tree starting from estimation of trunk biomass of the same tree
Source of data used:	Ferez, A. P. C. Efeitos de praticas silviculturais sobre as taxas iniciais de sequestro de carbono em plantios de restauração na Mata Atlântica. Dissertação de Mestrado: ESALQ/USP, Piracicaba, SP, 2011.
Value(s) :	Ln(BR) = -0.28815 + 0.74197.ln(BT), R^2 = 0.8721
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Additional comment:	In surveys of volume and biomass, we try to use an equation developed with sampled trees resulting from the same area where its will be applied. Although, Ferez (2011), was not an equation developed for this project, its allometric model was obtained in reforestation areas of similar ages and using species that, when they were not coincident, belonged to the same ecological classification . This makes, in our view, the equation applied in this monitoring most appropriate than the international equations recommended by the IPCC.

Data / Parameter:	**Crown biomass equation (BC)**
Data unit:	**Kg**
Description:	Allometric equation that calculates the crown biomass of a single tree starting from estimation of trunk biomass and root biomass of the same tree.
Source of data used:	Ferez, A. P. C. Efeitos de praticas silviculturais sobre as taxas iniciais de sequestro de carbono em plantios de restauração na Mata Atlântica. Dissertação de Mestrado: ESALQ/USP, Piracicaba, SP, 2011.
Value(s) :	$BC = 0.38355 + 0.12301.BT – 0.08622.BR$, $R^2 = 0.6149$
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Additional comment:	In surveys of volume and biomass, we try to use an equation developed with sampled trees resulting from the same area where its will be applied. Although, Ferez (2011), was not an equation developed for this project, its allometric model was obtained in reforestation areas of similar ages and using species that, when they were not coincident, belonged to the same ecological classification . This makes, in our view, the equation applied in this monitoring most appropriate than the international equations recommended by the IPCC.

D.2. Data and parameters monitored

Data / Parameter:	**Stratum ID**
Data unit:	Alphanumeric code
Description:	Strata identification by codes
Measured /Calculated /Default:	-
Source of data:	Field observations
Value(s) of monitored parameter:	None stratification was applied
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Fieldbook Ipaq HX2490
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	-
QA/QC procedures applied:	

Data / Parameter:	**Number of strata**
Data unit:	Alphanumeric code
Description:	Number of strata considered in the monitoring process
Measured /Calculated /Default:	-
Source of data:	Field observations
Value(s) of monitored parameter:	None stratification was applied, thus was considered just one strata corresponding the entire area of project
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	-
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	-
QA/QC procedures applied:	

Data / Parameter:	**Reforested Area**
Data unit:	ha
Description:	Total area of the project in hectares
Measured /Calculated /Default:	Measured
Source of data:	Satellite images and local measurements provided by reforestation companies
Value(s) of monitored parameter:	2,001.24 ha
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	ArcGIS ® 9.3 Software, no calibration required
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	
QA/QC procedures applied:	

Data / Parameter:	**Sample plot ID**
Data unit:	alphanumeric number
Description:	ID of sample plots. Consists of three letters identifying the location and two numbers identifying the plot inside location
Measured /Calculated /Default:	Observed
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Fieldbook Ipaq HX2490
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	
QA/QC procedures applied:	

Data / Parameter:	**Sample plot localization**
Data unit:	alphanumeric number
Description:	UTM coordinates of sample plot
Measured /Calculated /Default:	Measured
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Trimble Pro-XT GPS with sub-metric accuracy and no calibration required
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	
QA/QC procedures applied:	

Data / Parameter:	**Plot size**
Data unit:	m^2
Description:	Area of sample plot obtained by measurements of the length and width of the plot
Measured /Calculated /Default:	calculated
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Tape de 50 m, Starret. No calibration required.
Measuring/ Reading/ Recording frequency:	Recording each five years
Calculation method (if applicable):	Area = Length (m) .Width (m)
QA/QC procedures applied:	

Data / Parameter:	**C30**
Data unit:	cm
Description:	Tree C30 is outside bark diameter at 0.30 m above the forest floor on the uphill side of the tree.
Measured /Calculated /Default:	Measured
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Caliper Haglöf, with 50 cm of maximum capacity. Any calibration is required
Measuring/ Reading/ Recording frequency:	Measuring at the time of field measurements, reading at the time of biomass calculation process and recording at the time of measurements process (each five years)
Calculation method (if applicable):	
QA/QC procedures applied:	

Data / Parameter:	**S30**
Data unit:	m^2
Description:	Tree S30 is outside bark sectional area at 0.30 m above the forest floor on the uphill side of the tree.
Measured /Calculated /Default:	Calculated
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan plus "Procedures manual of the monitoring plan"
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	-
Measuring/ Reading/ Recording frequency:	Measuring at the time of field measurements , reading at the time of biomass calculation process and recording at the time of measurements process (each five years)
Calculation method (if applicable):	$S30 = \pi/4000. (C30^2)$
QA/QC procedures applied:	Re-measurement of 10% of the plots installed in the field. Statistic procedure verification was performed through "Root Mean Squared Error (RMSE) and Bias".

Data / Parameter:	**Common tree species name**
Data unit:	Alphanumeric code
Description:	Common name of the specie indentified in the field
Measured /Calculated /Default:	-
Source of data:	Field observations
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	-
Measuring/ Reading/ Recording frequency:	Observing at the time of field measurements , and recording at the time of measurements process (each five years)
Calculation method (if applicable):	-
QA/QC procedures applied:	

Data / Parameter:	**Botanical tree species name**
Data unit:	Alphanumeric code
Description:	Botanical name of the specie indentified in the field
Measured /Calculated /Default:	-
Source of data:	Literature observations
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	-
Measuring/ Reading/ Recording frequency:	Obtained from literature starting from common name , and recording at the time of measurements process (each five years)
Calculation method (if applicable):	-
QA/QC procedures applied:	

Data / Parameter:	**Total tree height**
Data unit:	m
Description:	Total tree is the distance along the axis of the bole of the tree from the ground to the uppermost point .
Measured /Calculated /Default:	Measured
Source of data:	Field measurements
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Clinometer Vertex 3 (Haglöf) with precision of 0,1 m. It is calibrated in the beginning of each day or when is needed.
Measuring/ Reading/ Recording frequency:	Measuring at the time of field measurements , reading at the time of biomass calculation process and recording at the time of measurements process (each five years)
Calculation method (if applicable):	
QA/QC procedures applied:	Re-measurement of 10% of the plots installed in the field. Statistic procedure verification was performed through "Root Mean Squared Error (RMSE) and Bias".

Data / Parameter:	**Trunk Biomass or Trunk dry mass**

Data unit:	Kg
Description:	The dry matter of the trunk of an tree when completely dried (lacks or excluding water).
Measured /Calculated /Default:	Calculated
Source of data:	Provided by measurements of C30, Total Heigth, and by the values of wood density applied to trunk biomass equation (Ferez, 2011)
Value(s) of monitored parameter:	Relational database of the monitoring plan plus "Procedures manual of the monitoring plan"
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The calculation is made by R software starting from reports provided by Relational database of the monitoring plan
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	Application of biomass equation from literature starting from inputs of S30, Total heigth, and wood density.
QA/QC procedures applied:	

Data / Parameter:	**Root Biomass or Root dry mass**
Data unit:	Kg
Description:	The dry matter of a root of an tree when completely dried (lacks or excluding water).
Measured /Calculated /Default:	Calculated
Source of data:	Provided by estimations of Trunk biomass applied to root biomass equation (Ferez, 2011)
Value(s) of monitored parameter:	Relational database of the monitoring plan plus "Procedures manual of the monitoring plan"
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The calculation is made by R software starting from reports provided by Relational database of the monitoring plan
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	Application of biomass equation from literature starting from inputs of trunk biomass.
QA/QC procedures applied:	

Data / Parameter:	**Crown Biomass or Crown dry mass**

Data unit:	Kg
Description:	The dry matter of a crown of an tree when completely dried (lacks or excluding water).
Measured /Calculated /Default:	Calculated
Source of data:	Provided by estimations of Trunk biomass and Root biomass applied to Crown biomass equation (Ferez, 2011)
Value(s) of monitored parameter:	Relational database of the monitoring plan "Procedures manual of the monitoring plan"
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The calculation is made by R software starting from reports provided by Relational database of the monitoring plan
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	Application of biomass equation from literature starting from inputs of trunk biomass and root biomass
QA/QC procedures applied:	

Data / Parameter:	**Total tree biomass**
Data unit:	Kg
Description:	The biomass of entire tree
Measured /Calculated /Default:	Calculated
Source of data:	Provided by estimations of Trunk biomass, Root biomass and Crown biomass equations (Ferez, 2011)
Value(s) of monitored parameter:	Relational database of the monitoring plan plus "Procedures manual of the monitoring plan"
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The calculation is made by R software starting from reports provided by Relational database of the monitoring plan
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	The sum of trunk biomass plus root biomass plus crown biomass
QA/QC procedures applied:	

Data / Parameter:	**Plot NDVI**
Data unit:	NDVI (no unit)
Description:	Rapid-Eye Satellite images
Measured /Calculated /Default:	Measured
Source of data:	Provided by Rapid-Eye Satellite Images. Minimum mapping unit is the default pixel size of $5x5m^2$. The mean plot NDVI is calculated by extraction of all pixels contained with at least 50% of its area inside the plot border
Value(s) of monitored parameter:	Relational database of the monitoring plan
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Correlation parameters used with actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Satellite images with calculations made by ArcGIS ® 9.3 Software.
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	Infrared band - red band / Infrared band + red band of the Rapid-Eye Satellite image
QA/QC procedures applied:	

Data / Parameter:	**Reservoir NDVI**
Data unit:	NDVI (no unit)
Description:	Rapid-Eye Satellite images
Measured /Calculated /Default:	Measured
Source of data:	Provided by Rapid-Eye Satellite Images. Minimum mapping unit is the default pixel size of $5x5m^2$. The mean reservoir NDVI is calculated by extraction of all pixels contained with at least 50% of its area inside the reservoir border. Reservoir is considered as all plantation inside. The value of entire project was obtained by the geometric mean of reservoirs taking into account their total area and mean NDVI.
Value(s) of monitored parameter:	0.333329
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Correlation parameters used with actual net GHG removals by sinks
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Satellite images with calculations made by ArcGIS ® 9.3 Software.
Measuring/ Reading/ Recording frequency:	Recording in each five years
Calculation method (if applicable):	Infrared band - red band / Infrared band + red band of the Rapid-Eye Satellite image
QA/QC procedures applied:	

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

The monitoring of the baseline net GHG removals by sinks is not required by monitoring methodology AR/AM0010.

E.2. Project emissions calculation

As per by the approved methodology AR-AM0010, v.04, project emission are not being considered by this project activity and , consequently, no monitoring is required.

E.3. Leakage calculation

As per by the approved methodology AR-AM0010, v.04, there are no potential leakage emissions attributable to this A/R project activity. Thus, no monitoring is required.

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E.4. Emission reductions calculation / table

As mentioned in the above items E.2 (Project emission calculation) and E.3 (Leakage calculation), project emission and leakage are not required to be monitored.

1. Calculations procedures

1.1 Biomass prediction equation

The biomass estimations were calculated through the forest inventory which considered 111 permanent plots (sample units) installed randomly on the total project area.

For the biomass calculation of each tree, it was utilized the allometric equation from Ferez, 2011[2]. This equation was obtained by the cutting of 80 trees from 20 different species – four trees of each specie with representative diameters considering the local trees population. These species were included in this project activity.

The coefficient of determination (R^2) obtained was equal to 0.9422, 0.8721 and 0.6149 for trunk, root and crown biomass, respectively.

This allometric equation was selected as the most appropriated and available to estimate the tree biomass of this project, attending minimally the Methodological Tool "Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities" – version 01.0.0 (EB 65, Annex 28, 25 November 2011)[3].

$$Ln(BT) = 6.038757 + 0{,}94494*\ln(S30) + 0.96147*\ln(\text{total height}) + 1.02221*\ln(\text{wood density}) \quad (1)$$

Where:

BT = Trunk biomass, in kg
S30 = Sectional area, in m^2
Total height = Total height, in m

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[2] "Efeito de práticas silviculturais sobre as taxas iniciais de sequestro de carbono em plantios de restauração da Mata Atlântica", Available in: http://www.teses.usp.br/teses/disponiveis/11/11150/tde-08022011-140851/pt-br.php

[3] Available in: http://cdm.unfccc.int/filestorage/H/5/8/H589K1VFNOUTCZLM3X2PJBWA7QE40S/eb65_repan28.pdf?t=QzB8bTB2eXdufDBhAu1MEKy6xfMMCNAesx_e

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

Wood density = wood density, in g cm^{-3}
R^2 = 0.9422

Ln(BR) = -0.28815 + 0.74197*ln(BT) (2)

Where:

BR = Root biomass, in kg
BT = Trunk biomass, in kg
R^2 = 0.8721

BC = 0.38355 + 0.12301*BT – 0.08622*BR (3)

Where:

BCP = Crown biomass, in kg
BT = Trunk biomass, in kg
BR = Root biomass, in kg
R^2 = 0.6149

1.2 Double sampling procedure

With area maps and all parameters described in section D in hand, the inventory procedures for monitoring carbon followed a double random sampling method.

The double sampling method is a sampling system where a low cost variable is randomly sampled with great intensity, in this case, NDVI, whereas a high cost variable is obtained with low intensity, this one being the actual biomass obtained from inventory plots (section D). The variable obtained with great intensity is then used as an aid to improve accuracy of the estimate of the variable obtained with low intensity.

Since the image parameter (NDVI) showed a good correlation with total mean biomass from the inventory, it was used as an auxiliary variable in the carbon estimation for all project area. Thus, it was used a regression estimator obtained by adjusting the relationship between NDVI and carbon plots. This adjustment is made using traditional regression analysis.

With the regression estimator in hands, it was applied to obtain biomass estimates and its carbon equivalent in the project area. The estimator of the mean in double sampling method according with Shivers and Borders (1996) is:

$$\widehat{\mu_r} = a + b\,\mu x \quad (4)$$

Or, using only in function of b:

$$\widehat{\mu_r} = \widehat{\mu y} + b\,(\mu x - \widehat{\mu x}) \quad (5)$$

Where $\widehat{\mu_r}$ is the estimated mean of total biomass by the regression estimator, $\widehat{\mu y}$ is the sample estimated mean of total biomass measured in the plots, μx is the population mean of NDVI, $\widehat{\mu x}$ is the sample mean of NDVI measured in the plots and a and b, are minimum squares estimates. The estimate of the mean variance is calculated by:

$$\widehat{VAR\{\widehat{\mu_r}\}} = \frac{s^2_{X.Y}}{n}\left(1 - \frac{n}{N}\right) \quad (6)$$

Where: $s^2_{X.Y} = \frac{\sum_{i=1}^{n}(yi-\widehat{\mu y})^2 - b^2\sum_{i=1}^{n}(xi-\widehat{\mu x})^2}{n-2}$, *yi* is an observation of biomass in the plots *i* and, *xi* is the NDVI observation in the plots *i*, **n** is the sample size and *N* is the size of the population.

The total population estimator is calculated by:

$$\widehat{T_r} = N\widehat{\mu y} \quad (7)$$

The total population variance is given by:

$$VAR\{\widehat{T_r}\} = N^2\, \widehat{VAR\{\mu_r\}} \quad (8)$$

The sample size for a given desired error is given by:

$$n^* = \frac{t^2 S_{X,Y}^2 N}{N E_d^2 + t^2 S_{X,Y}^2} \quad (9)$$

Where E_d is the desired error for an average or total population in Kg/ha.

The confidence interval was calculated by adding and subtracting the estimated mean or total value of the quantile of Student´s t distribution at a significance level of 90%[4] and corresponding degrees of freedom (n-1).

1.3 Detemination of NDVI index as auxiliary variable

Was part of the scope of the project development to elaborate and test methods of quantifying and aid in the quantification of biomass from vegetation indices derived from satellite imagery. In this particular project, NDVI (normalized difference vegetation index) was used. The procedures for generating this index are presented below.

Rapideye sensor provided rectified orto images that went through a process in GIS environment to extract the vegetation index. We used ArcGIS ® 9.3 software for these steps. Within ArcMap ®, we held a mathematical calculation using the "raster calculator", present on the "Spatial Analyst" tool. In this option, which resembles a normal calculator, we selected the bands three and five of the desired images, being these bands the visible red and infrared, respectively. Based on them, equation 7 was calculated, obtaining the NDVI. Once calculated, each NDVI was presented as a new raster image and was given a file name according to each reservoir, year, and year quarter of the original satellite image.

$$NDVI = \frac{NIR - R}{NIR + R} \quad (10)$$

Where NDVI is the normalized difference vegetation index, NIR is the infrared band and R is the visible red band.

The next step was the extraction of NDVI values for each inventory plot. To do so, they were computed using the "zonal statistics" tool contained in "spatial analyst" inside ArcMap ®. In this tool it was necessary to insert the desired image source from which the NDVI values would be extracted and the polygons which define the study area, in this case the sample plots. This procedure originated a table containing statistical attributes of pixel values contained in each sample plot. Among these statistics is the number of pixels contained within each polygon and the average value of NDVI. The average values were used to generate NDVI – biomass the correlation, already presented above.

Also, another "zonal statistics" was applied for plantations in each specific reservoir in order to have the average NDVI and total count of pixels for the entire reservoir plantation. Another step was to calculate a geometric mean of all reservoirs taking into account their total area and mean NDVI. This geometric mean is the population mean of NDVI **(μx)** used in the double sampling procedure analysis.

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[4] EB 63, Annex 26, 29/09/2011. Guidelines on application of specified versions of A/R CDM methodologies in verification of registered A/R CDM project activities. Available in: http://cdm.unfccc.int/Reference/Guidclarif/ar/methAR_guid30.pdf

2. Results

The table 4 shows the values of RMSE e BIAS for the QA/QC procedure. The Bias is a measure of systematic deviation and the RMSE is a measure of mean error

Table 4: Values of statistics used to verify the accuracy of biomass equation inputs

Parameter	Bias (%)	Root mean square error (%)
Total heigth	-1,79	16,85
S30	-5,65	17,29

The values of systematic errors was very small. The values of the mean error (RMSE) are above 10%. However, this is associated with the interval between the measurements and remesurements of the plots that in some cases, reached nine months.

The Table 5 shows the regression analysis results of the relationship between the biomass and NDVI. These showed a good relationship with coefficient of determination of 0.69. The regression was fitted without intercept, since it seems logical to believe that NDVI equal to 0 represents an area without tree biomass. That is why in that table only the value of the parameter b is reported.

Table 5: Values of statistics used to obtain estimates of mean and total biomass (Kg) of the population studied by the regression estimator.

Plot NDVI ($\widehat{\mu x}$)	Average biomass measured (Kg/ha) ($\widehat{\mu y}$)	Number of Plots (n)	NDVI (μx)	Estimator Parameter (sd*) (b)
0.3683617	68,874.92	111	0.333329	183523 (11717)

* sd is the standard deviation of the parameter b estimate

The Table 6 shows the estimates of population mean biomass in Mg/ha and its measures of uncertainty. The regression estimator was very effective in explaining the biomass variation in the study area, making the sample size sufficient for the required accuracy level.

Table 6: Mean biomass estimates (Mg) with respective uncertainty measures, obtained from the application of the regression estimator (Equation 2) in the values of Table 4

Estimated mean biomass (Mg/ha) ($\widehat{\mu_r}$)	Mean standard deviation (Mg/ha) ($\sqrt{\widehat{VAR}\{\widehat{\mu_r}\}}$)	Confidence interval (90%) of the mean (Kg/ha)	$T_{0.9,110}$	Sample plots required
62.44562	4.71727	6.081951	1.289295	0

The Table 7 shows the same results of Table 6 but converted to carbon equivalent (factor 3.667) and applied to the Total population estimator (equation 4). The uncertainty level was of 9.75154 % and adequate for the proposal of the monitoring plan.

Table 7: Results for Total of population converted to carbon equivalents (Mg)

Area (ha)	Total CO_2e (Mg)	Total standard deviation (Mg)	Total CI90 (Mg)	Uncertainty (%)

	$(\widehat{T}_r)$	$(\sqrt{\widehat{VAR\{\widehat{T}_r\}}})$		
2,001.24	215,382.20	16270.41	20,977.36	9.739597

This way, the total carbon equivalent estimate is of 225,992.00 ± 22,037.04t $CO_{2\,eq}$. with uncertainty of 10% in a significance level of 90%.

E.5. Comparison of actual emission reductions with estimates in the CDM-PDD

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO_2e)	**569,735**	**215,382**

E.6. Remarks on difference from estimated value in the PDD

There is no increase in the actual emission reductions achieved during the current monitoring period compared to the amount stated in the registered CDM-PDD.

History of the document

Version	Date	Nature of revision
01	EB 54, Annex 34 28 May 2010	Initial adoption.
Decision Class: Regulatory **Document Type**: Guideline, Form **Business Function**: Issuance		