CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY FOR AFFORESTATION AND REFORESTATION PROJECT ACTIVITIES: MONITORING (CDM-AR-NMM)

CONTENTS

SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

Methodology to Monitor the Component B: change in carbon stocks, fires, uncontrolled deforestation, deforestation baseline and leakage for conservation projects.

A.2. List of type(s) of A/R CDM project activity to which the methodology may apply:

Conservation projects

A.3. Conditions under which the methodology is applicable to A/R CDM project activities:

1. The proposed methodology for monitoring the change in carbon stocks is only applicable for conservation projects where logging took place before the implementation of the project and where further logging is avoided due to the implementation of the project.

2. The proposed methodology for leakage detection is only applicable for conservation projects which avoid deforestation at a relatively small scale where the people who deforest are bound to a certain region and cannot deforest wherever they wish. Otherwise the potential leakage could not be estimated with a buffer zone.

3. Availability of satellite imagery of at least three points in time which already show land use changes before project implementation and at least at one point in time after project implementation.

A.4 Carbon pools covered by the methodology:

- above-ground biomass (above ground woody biomass, palm biomass, understory)
- belowground biomass
- litter
- dead wood (standing dead biomass, lying dead biomass)
- soil organic carbon.

A.5. What are the potential strengths and weaknesses of this proposed new methodology?

Strengths

- In many cases deforestation rates are developed based on the deforestation between two or three points in time. Extrapolating this deforestation can easily lead to an over or underestimation. Using a reference area to adapt the deforestation rate provides much security to the extrapolation of the deforestation applied to the project because it is possible to adapt the deforestation rate to unforeseeable socio-economic changes which influence deforestation.
- Using a buffer zone to detect potential leakage is fundamental to estimate the real benefit of the project.
- The techniques and methods for measuring the carbon stocks are well established, and based on commonly accepted principles of forest engineering.
- The monitoring system described is intended to provide a cost-effective, precise and accurate accounting of carbon offsets for the Component B.
- The methodology uses the LULUCF good practice guidelines. It recommends implementation of quality assurance and control measures to ensure that monitoring procedures and results lead to accurate estimations of the carbon offsets.
- The methodology uses values, equations and assumptions considered good practice by the IPCC and recognized experts in the field of forestry.

Weaknesses

- For the adaptation of the deforestation rate inside the project boundaries to the deforestation occurring in the reference area, a quotient is being used which expresses the velocity of deforestation in the project area in comparison to the reference area. This ratio is calculated comparing deforestation at three points in time in both areas. In the no project case it is possible that this ratio changes over time. This can not be verified though.

SECTION B. Proposed new monitoring methodology

B.1. Overall summary description of the methodology:

Change in carbon stocks

The assumption used in the **baseline** is that no additional gains in carbon stocks occur during the 30-year life time of the project. Therefore the carbon stocks applied for the calculations of the carbon offsets of Component B stay constant. In the with-project-case there is an increment of biomass because all logging activities are stopped and the forest has a chance to recover. The change in carbon stocks regrowth will be quantified in the future monitoring period by a carbon inventory.

Fires

Anthropogenic fires reduce the carbon stocks of the vegetation. This reduction must be estimated in order to not overestimate the carbon offsets due to avoided deforestation. Using data of the Moderate Resolution Imaging Spectroradiometer MODIS Rapid Response System Fire Response products (Giglio 2005) the location of active fires can be detected in near real time. Using data of the Moderate Resolution Imaging Spectroradiometer MODIS Rapid Response System Fire Response products (Giglio 2005) the location of active fires can be detected in near real time.

Uncontrolled deforestation

Deforestation inside the project boundary after the implementation of the project can occur through natural disturbances such as floods caused by rivers, illegal deforestation or legal deforestation close to the communities which are located inside the project area.

To determine the net potential of carbon sequestration by avoiding deforestation the simulated land use change inside the project area has to be balanced with biomass loss due to uncontrolled deforestation. In case of natural disturbances or legal deforestation of the communities it is not justifiable to reduce the carbon offsets by the total amount of emissions. But in case there is an overlap with the simulation results from GEOMOD it is necessary to reduce the simulations by the area intersecting with deforestation. This approach is conservative, as it neglects the possibility, that areas, recover to a certain degree when new deforestation would have occurred in case without project.

Deforestation baseline and leakage

Three areas are used to monitor the deforestation rate of the baseline scenario and to quantify possible leakage: the project area, a buffer zone and a reference area. For all three areas it is necessary to quantify the amount of hectares deforested for three points in time before the implementation of the project. The buffer zone is the area of possible leakage. Leakage occurs when communities continue to deforest at the same rate as before the implementation of the project with the only difference that the deforestation is taking place outside the project area instead of inside. The buffer zone defines the area where the project influences deforestation outside of its boundary. This depends on the spatial boundaries of the people who cause deforestation avoided by the project. In case of substantial farmers it is highly unlikely that these people would travel long distances away from the project area in order to deforest outside the park what they would have deforested inside the park otherwise. The reference area may differ in size and socio-economic conditions of the project area as long as it is in the same region and reflects the overall trend of the area. The three points in time mark the beginning and end of two periods. Compared are the proportional deforestation in the reference area of period two in comparison to period one with the proportional deforestation in the project area plus its buffer zone of period two in comparison to period one. This relation is expressed in a quotient which is used to determine the baseline for the project area and the buffer zone after the implementation of the project. A baseline scenario for the buffer zone is necessary for the quantification of leakage. If the true deforestation detected in the buffer zone is lower than the baseline scenario, no leakage is occurring. The conclusion the baseline scenario is overestimating the reality is not valid, because compensation mechanisms are implemented in the buffer zone to reduce deforestation and generate alternative income. These activities must be due to the implementation of the project and are part of the logic of conservation projects.

Example for adapting the baseline scenario of the project area and buffer zone:

Before project implementation

- The amount of hectares deforested in the project area, reference area and buffer zone are known for three points in time which mark the beginning and ending of two periods.
- The deforestation in the project area and its buffer zone is twice as much in the second period in comparison to the first period.
- The deforestation in the reference area is three times as much in the second period compared to the first period.

Conclusion: the velocity of deforestation in the project area and its buffer zone is 2/3 of the velocity of deforestation in the reference area.

After project implementation

- The deforestation in the reference area is four times as much in the third period compared to the second period.
- The adapted deforestation in the project area is 4*(2/3) times as much in the third period compared to the second period.
- The adapted deforestation in the buffer zone is 4*(2/3) times as much in the third period compared to the second period

This way the baseline scenarios of project area and buffer zone can be adapted to what is occurring in the reference area for each monitoring period. If deforestation in the reference area proves to go up exponentially, the baseline scenarios are corrected accordingly.

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

B.2.1 Actual net GHG removals by sinks data:

"Actual net greenhouse gas (GHG) removals by sinks" is the **sum of the verifiable changes** in carbon stocks in the carbon pools within the project boundary, **minus the increase in emissions** of the GHGs measured in CO_2 equivalents by the sources that are increased as a result of the implementation of the afforestation or reforestation (A/R) project activity within the project boundary, attributable to the A/R CDM project activity.

Verifiable changes in carbon stocks in the carbon pools within the project boundary

The assumption used in the **baseline** is that no additional gains in carbon stock would occur during the 30-year life of the project. Therefore the carbon stocks applied for the calculations of the carbon offsets of Component B stay constant. In the with-project-case there is an increment of biomass because all logging activities are stopped and the forest has chance to recover. This regrowth will be quantified in the year 2010 comparing the results of a carbon inventory of 2010 with the results from the carbon inventory of 1997. To have comparable results the carbon inventory will likely be based on the same technique as the one applied in 1997.

Further changes in carbon stocks are due to fires and uncontrolled deforestation.

Increase in emissions

There is no increase in emissions of the GHGs measured in CO_2 equivalents by the sources that are increased as a result of the implementation of the project activities within the project boundary.

B.2.1.1. Data to be collected or used in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary from the proposed A/R CDM project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c) or estimated (e)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived? (electronic/ paper)**	**Comment**
Above ground woody and palm biomass								
B.2.1.1.01	Plot Number			observed	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.02	Vegetation type			observed	Beginning of the project, and reameasurement	100%	Electronic and paper	According to the vegetation map
B.2.1.1.03	Location of the plot				Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.04	Plot (Inner/outer)	Field observation		observed	Beginning of the project, and reameasurement	100%	Electronic and paper	I= internal, E = external
B.2.1.1.05	Diameter at breast heigth (DBH, 1.3m)	Field measure	cm	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	*Above-ground woody biomass:* Diameter of all woody vegetation 5 – 20 cm in dbh was measured in the inner plot (4 m in radius). Woody vegetation >20 cm dbh was measured in the plot 14 m in radius *Above-ground palms biomass*: the height of the palms should be measured

B.2.1.1.06	Species code	Field observation		observed	Beginning of the project, and reameasurement	100%	Electronic and paper	Species codes : H = Heliconia (Pataju), Pm = Palmeras (Motacu), Pa = Palmera Asaí, C = Cecropia, B=Bombacaceae, O = other (specify))
B.2.1.1.07	Carbon fraction of dry matter for above-ground biomass ($CF_{above\text{-}ground}$)	Appropriate literature sources (e.g. IPCC GPG-LULUCF)		observed	Updated before every verification	100%	Electronic and paper	Default value used =0.5
Litter, soil and herbaceous vegetation								
B.2.1.1.08	Number of the sampling frame for measuring herbaceous vegetation	Field observation	number	observed	Beginning of the project, and reameasurement			
B.2.1.1.09	Weight of the sample of herbaceous vegetation ($herb_i^{field\_weight}$)	Field measure	g	measured	Beginning of the project, and reameasurement	100%		
B.2.1.1.10	Weight of the sub-sample of litter ($herb_i^{sub\_sample\_weight}$)	Field measure	g	measured	Beginning of the project, and reameasurement	100%		
B.2.1.1.11	Oven-dry weight of herbaceous vegetation ($herb_i^{oven\_dry\_weight}$)	Lab results	g	estimated	Beginning of the project, and reameasurement	100%		
B.2.1.1.12	Weight of the sample of litter ($litter_i^{field\_weight}$)	Field measure	g	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	*The standing litter crop will be measured by collecting all of the litter on the soil surface in each of the sampling frames used for measuring herbaceous vegetation*

B.2.1.1.13	Weight of the sub-sample of litter ($litter_i^{sub\_sample\_weight}$)	Field measure	g	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	*Sub-sample to measure the moisture content*
B.2.1.1.14	Number of the sub-sample of litter				Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.15	Oven-dry weight of litter ($litter_i^{oven\_dry\_weight}$)		g	estimated	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.16	Carbon fraction of dry matter for litter (CF_{litter})	Appropriate literature sources (e.g. IPCC GPG-LULUCF)		observed	Updated before each verification	100%	Electronic and paper	
B.2.1.1.17	Soil sample number	Field observation	number		Beginning of the project, and reameasurement	100%	Electronic and paper	*Soil samples will be collected from the 0-30 cm horizon*
B.2.1.1.18	Soil sample weight	Field measure	g	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.19	Soil organic carbon concentration % (CC_i)	Lab calculation	percentage	calculated	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.20	Soil bulk density (BD)		g/cm^3	calculated	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.21	Belowground biomass	Appropriate literature sources (e.g. Cairns et al. (1997)	t	estimated	Updated before each verification	100%	Electronic and paper	Root biomass was estimated from root-to-shoot ratios of 0.20 given in Cairns et al. (1997)
B.2.1.1.22	Root:shoot ratio	Appropriate literature sources (e.g. Cairns et al. (1997)			Updated before each verification	100%		
Standing dead trees								

B.2.1.1.23	Plot Number				Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.24	Vegetation type				Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.25	Location of the plot				Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.26	Proportion remaining	Field observation		observed	Beginning of the project, and reameasurement	100%	Electronic and paper	Proportion remaining : 1) small twigs present 2) small branches and twigs 3) only large branches
B.2.1.1.27	Density class	Field observation		observed	Beginning of the project, and reameasurement	100%	Electronic and paper	Density class : S = sound, I = intermediate
B.2.1.1.28	Total height	Field measure	m	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.29	Buttress height	Field measure	m	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.30	Top diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.31	DBH	Field measure	cm	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
B.2.1.1.32	Base diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100%	Electronic and paper	
Lying dead wood								
B.2.1.1.33	Plot Number			observed	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	

B.2.1.1.34	Vegetation type			observed	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.35	Location of the plot				Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.36	Wood type	Field observation		observed	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	Wood Type: D = dead wood of hardwood species, not hollow H = hollow piece, P = palms, C = Cecropia , O = other (specify)
B.2.1.1.37	Sound diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.38	Intermed. Diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.39	Rotten diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.40	Diameter of hollow portion	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.41	Distance between stump and bottom of crown	Field measure	m	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	

B.2.1.1.42	Stump diameter	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.43	Diameter of the base of crown	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.44	Diameter of disc (*L1 and L2)*	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
B.2.1.1.45	Width of disc (*T1 y T2)*	Field measure	cm	measured	Beginning of the project, and reameasurement	100% (in 1999 only 56 plot were measured)	Electronic and paper	
Fires								
B.2.1.1.46	Date, Location	Moderate Resolution Imaging Spectroradiometer MODIS Rapid Response System Fire Response products (Giglio 2005)	Coordinates , date	observed	2000-11-01 until 2004-12-31 Future: Weekly during July until November	100%	electronic	
Uncontrolled deforestation								
B.2.1.1.47	Location, area	LANDSAT images of 1997, 2000, and 2005	Coordinates , ha	observed	LANDSAT images of 1997, 2000, and 2005	100%	electronic	

B.2.1.2. Data to be collected or used in order to monitor the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary, and how this data will be archived:								
ID number ***(Please use numbers to ease cross-referencing to table B.7)***	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c) or estimated (e)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived? (electronic/ paper)**	**Comment**
There are no GHG emissions that are increased as a result of the implementation of the proposed project activity within the project boundary.								

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B.2.2. Description of formulae and/or models used to monitor the estimation of the actual net GHG removals by sinks:

Actual net greenhouse gas removals by sinks:

"Actual net greenhouse gas (GHG) removals by sinks" is the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in emissions of the GHGs measured in CO_2 equivalents by the sources that are increased as a result of the implementation of the afforestation or reforestation (A/R) project activity within the project boundary, attributable to the A/R CDM project activity.

In the case of NK-CAP Actual net greenhouse gas removals by sinks are identical to the sum of verifiable changes in carbon stocks in the carbon pools within the project boundary because there is no increase in emissions of the GHGs measured in CO_2 equivalents by the sources that are increased as a result of the implementation of the project activity within the project boundary, attributable to the project activity.

B.2.2.1. Description of formulae and/or models used to monitor the estimation of the verifiable changes in carbon stock in the carbon pools within the project boundary (for each carbon pool in units of CO_2 equivalent):

Change in carbon stocks
To measure the increment of biomass formulae and/or models will be developed in the future monitoring period.

Discounting for anthropogenic fires inside the project area
Anthropogenic fires reduce the carbon stocks of the vegetation. This reduction must be estimated in order to not overestimate the carbon offsets due to avoided deforestation. Using data of the Moderate Resolution Imaging Spectroradiometer MODIS Rapid Response System Fire Response products (Giglio 2005) the location of active fires can be detected in near real time. Using data of the Moderate Resolution Imaging Spectroradiometer MODIS Rapid Response System Fire Response products (Giglio 2005) the location of active fires can be detected in near real time.

The detectable fire size is a function of various variables (scan angle, biome, sun position, land surface temperature, cloud cover, amount of smoke and wind direction, etc.). In general, "in many biomes the minimum flaming (~800-1000K) fire size typically detectable at 50% probability with MODIS is on the order of $100m^2$" (Web Fire Mapper 2005). As of October 2005, no information about burned areas is available.

The confidence level is a further restriction in estimating the damage caused by fires. The range of confidence is expressed between 0 and 100, 0 indicating very low and 100 very high confidence of the detected location. In case of 2004, which has been one the worst years in terms of fire frequency, 27 observations inside NK-CAP area showed a confidence level below 50, with 14 indicating 0 confidence.

It is important, to notice that fires not necessarily destroy the whole vegetation. Comparing LANDSAT TM images of the years 1997, 2000, and 2005 indicates, that areas burned before 1996 recovered largely until 2000. This observations suggests, that fire monitoring should detect, measure and classify the type of damage caused by fires.

Based on this observations we conclude:

- MODIS active fire data is an important tool to locate active fires. Their area still has to be detected by using routine monitoring instruments (airborne detection, land based patrols). Combining both ways will lead to reliable estimates of impacted areas, which should be categorized according to their damage based on field observations.
- Although the temporal extent of the database is still limited, the analysis suggests, that the fire risk increases in the project area. Changing climate conditions and/or human activities might be the underlying conditions.
- Taking into account the fire risk we recommend to investigate more systematically the relationship between located fires, climate conditions, observed damage, and biomass loss.
- Given the fact, that it is still impossible to precisely detect the spatiotemporal intersection between simulated deforested areas and damaged area we discount the biomass carbon stocks used for the carbon offset calculation of component B by 5%.

Suggestions for the monitoring mechanisms:

It is foreseeable, that in the near future remote sensing products will detect burned areas. For the time being fire monitoring should proceed the following steps:

Task	Responsibility	Frequency
Download, GIS analysis, and archiving of MODIS active fire data	Técnico Protección NKCAP	Weekly during July until November
Decision about sending land based or airborne patrol in urgent cases (3 detected fires in-between an area of 1 km around the first one within three days)	Técnico Protección NKCAP; Jefe protección SERNAP	As needed
Patrol to verify extent and damage of the fire (GPS measurement of damaged area, classification of damage, photo documentation)	Rangers SERNAP	As needed
Archiving of field observation in the GIS database	Técnico Protección NKCAP	As needed
Analysis of the annual fire events referring spatial distribution, damage observed, area affected	Técnico Protección NKCAP	Annually in December

Discounting for uncontrolled deforestation inside the project area

Deforestation inside the project boundary after the implementation of the project can occur through natural disturbances such as floods caused by rivers, illegal deforestation or legal deforestation close to the communities which are located inside the project area.
To determine the net potential of carbon sequestration by avoiding deforestation the simulated land use change inside the project area has to be balanced with biomass loss due to uncontrolled deforestation. In case of natural disturbances or legal deforestation of the communities it is not justifiable to reduce the carbon offsets by the total amount of emissions. But in case there is an overlap with the simulation results from GEOMOD it is necessary to reduce the simulations by the area intersecting with deforestation . This approach is conservative, as it neglects the possibility, that areas, recover to a certain degree when new deforestation would have occurred in case without project.

To determine the net area of avoided deforestation, each annual results of GEOMOD has to be reduced by the area intersecting with deforestation. This approach is conservative, as it neglects the possibility, that areas, which have been deforested between 1997 and 2000, might have recovered to a certain degree until 2005, when new deforestation would have occurred in case without project. The following table presents the results of the analysis using Map Algebra.

Future Monitoring

Detecting deforestation after 2005 using Landsat satellite imagery from the scenes 230069 and 230070.

B.2.2.2. Description of formulae and/or models used to monitor the estimation of the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary (for each source and gas, in units of CO_2 equivalent):

There is no increase in emissions of the GHGs measured in CO_2 equivalents by the sources that are increased as a result of the implementation of the project activities within the project boundary. This section is left blank on purpose.

B.2.3. As appropriate, relevant data necessary for determining the baseline net GHG removals by sinks and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B.2.3.01	a_1 = luc in project area in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.2.3.02	a_2 = luc in project area in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.2.3.03	b_1 = luc in buffer zone in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.2.3.04	b_2 = luc in buffer zone in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.2.3.05	c_1 = luc in reference area in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.2.3.06	c_2= luc in reference area in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected

B.2.3.07	c_i = luc in reference area in period i	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to adapt the deforestation rate.
B.2.3.08	a_i = luc in project area in period i	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to detect illegal deforestation.
B.2.3.09	b_i = luc in buffer zone in period i	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to detect leakage.
B.2.3.10	Driver map Rivers	manual digitalization	categories	-	once	0%	electronic	Already collected
B.2.3.11	Driver map Natural forest edge	Classification of Landsat images	categories	-	once	0%	electronic	Already collected
B.2.3.12	Driver map Roads	manual digitalization from Landsat images	categories	-	once	0%	electronic	Already collected
B.2.3.13	Driver map Towns pop<100	INE, Instituto Nacional de Estadística corrected with Landsat image	categories	-	once	0%	electronic	Already collected
B.2.3.14	Driver map Towns pop>100	INE, corrected with Landsat image	categories	-	once	0%	electronic	Already collected
B.2.3.15	Driver map Deforestation till1992	Classification of Landsat images	categories	-	once	0%	electronic	Already collected
B.2.3.16	Vegetation map with carbon stocks per vegetation class	Project input (e.g. Recoded Vegetation map Museo Historia Natural Noel Kempff 1998)	Vegetatio n classes, tC	m	once	0%	electronic	Already collected
B.2.3.17	Mask	Project input (e.g. Recoded Vegetation map Museo Historia Natural Noel Kempff 1998)	Vegetatio n classes, tC	m	once	0%	electronic	Already collected
B.2.3.18	Deforestation map for inside project area after project implementation	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	
B.2.3.19	Area affected by GEOMOD simulaton of forest type (FT) in time	Project output Not intersecting:	hectares	c	Every 5 years	100%	electronic	

	(t) for the intersecting (I) or not intersecting (N) area. (**$A_{t,FT,I/N}$**)	def_veg_sd_no_insec_[yy].img Intersecting: ab_insec_[yy]_veg.rst						
B.2.3.20	tC ha^{-1} in soil for each Forest type (FT) ($C^{B}soil_{FT}$ ha^{-1})	Carbon inventory	tC ha^{-1}	m	once	0%	electronic	
B.2.3.21	tC of biomass affected by GEOMOD simulation in time (t), in each forest type (FT) for the area not intersecting with Component A (N). **($C^{B}{}_{t}biomass_{FT,N}$)**	Carbon inventory	tC ha^{-1}	m	once	0%	electronic	
B.2.3.22	Area of intersection between component A and B at time t ($A_t^{intersec}$)	Project calculations (e.g.Balance_A_B.mxd)	ha	c	once	0%	electronic	
B.2.3.23	Total productive forest area of component A (A^A)	Project calculations (e.g.Balance_A_B.mxd)	ha	c	once	0%	electronic	
B.2.3.24	Extracted biomass due to logging (without leakage) at time t[tC] ($C_t^{extracted}$)	Project calculations (e.g. Balance_A_B_PDD02.02_.xls)	tC	c	Every 5 years	100%	electronic	
B.2.3.25	Emission ratio	Appropriate literature sources (e.g. IPCC Good Practice Guidance for LULUCF, Table 3A.1.15 Emission ratios for open burning of cleared forests)	neutral	c	Every 5 years	100%	electronic	
B.2.3.26	N/C ratio	Appropriate literature sources (e.g. IPCC Good Practice Guidance for LULUCF 3.2.1.4.2.2 Choice of Removals/Emission Factors)	neutral	c	Every 5 years	100%	electronic	
B.2.3.27	Global Warming	Appropriate literature sources	neutral	c	Every 5	100%	electronic	

	Potentials	(e.g. FCCC/TP/2004/3 15 June 2004 Information on Global Warming Potentials Technical Paper)			years			
B.2.3.28	Conversion factor between CO2 and C	Appropriate literature sources (e.g. IPCC)	neutral	c	Every 5 years	100%	electronic	
B.2.3.29	Proportional Land Use after forest clearing. ($\mathbf{LU_{Proportion}}$)	Appropriate literature sources (e.g. Pacheco,P.(1998) "Municipios y gestión forestal en el trópico boliviano")	%		Every 5 years	100%	paper	
B.2.3.30	tC ha^{-1} in biomass of LU ($\mathbf{C^B{}_t LU_{I/N}}$)	Appropriate literature sources (e.g. IPCC (2003).Good Practice Guidance for LULUCF, Chapter3, Cropland TABLE 3.3.8, DEFAULT BIOMASS CARBON STOCKS PRESENT ON LAND CONVERTED TO CROPLAND IN THE YEAR FOLLOWING CONVERSION Browns, S., Delaney, M.(2001)."Preliminary Carbon-Offset Analysis for the Guaraquecaba Climate Action Project: 2001 Findings and Status Report".)	tC*ha^{-1}	measured	Every 5 years	100%	electronic	

B.2.4. Description of formulae and/or models used to monitor the estimation of the baseline net GHG removals by sinks (for each carbon pool, in units of CO_2 equivalent):

Three areas are used to monitor the deforestation rate of the baseline scenario and to quantify possible leakage: the project area, a buffer zone and a reference area. For all three areas it is necessary to quantify the amount of hectares deforested for three points in time before the implementation of the project. The buffer zone is the area of possible leakage. Leakage occurs when communities continue to deforest at the same rate as before the implementation of the project with the only difference that the deforestation is taking place outside the project area instead of inside. The buffer zone defines the area where the project influences deforestation outside of its boundary. This depends on the spatial boundaries of the people who cause deforestation avoided by the project. In case of substantial farmers it is highly unlikely that these people would travel long distances away from the project area in order to deforest outside the park what they would have deforested inside the park otherwise. The reference area may differ in size and socio-economic conditions of the project area as long as it is in the same region and reflects the overall trend of the area. The three points in time mark the beginning and end of two periods. Compared are the proportional deforestation in the reference area of period two in comparison to period one with the proportional deforestation in the project area plus its buffer zone of period two in comparison to period one. This relation is expressed in a quotient which is used to determine the baseline for the project area and the buffer zone after the implementation of the project. A baseline scenario for the buffer zone is necessary for the quantification of leakage. If the true deforestation detected in the buffer zone is lower than the baseline scenario, no leakage is occurring. The conclusion the baseline scenario is overestimating the reality is not valid, because compensation mechanisms are implemented in the buffer zone to reduce deforestation and generate alternative income. These activities must be due to the implementation of the project and are part of the logic of conservation projects.

Calculation steps

Adaptation of the baseline scenario for the project area using a reference area

[1] $$luc_{PR} = (a_2 + b_2)/(a_1 + b_1)/(c_2 / c_1) \bullet (c_i / c_{i-1}) \bullet a_{i-1} \text{ [ha]}$$

where:

luc_{PR}: land use change in project area in period i [ha]
a_1: land use change in project area in period 1 [ha]
a_2: land use change in project area in period 2 [ha]
b_1: land use change in buffer zone in period 1 [ha]
b_2: land use change in buffer zone in period 2 [ha]
c_1: land use change in reference area in period 1 [ha]
c_2: land use change in reference area in period 2 [ha]
c_i: land use change in reference area in period i [ha]

Period 1 is the period between the 1st and 2nd point in time **before** project implementation.
Period 2 is the period between the 2nd and 3rd point in time **before** the project implementation.
Period i is the period **after** the project implementation.

The idea is to adapt the baseline scenario of the deforestation for the project area to the deforestation occurring in the reference area based on a comparison of the velocity of deforestation in the project area plus its buffer zone and the reference area before project implementation. The reason why project area and buffer zone are put together is because a baseline scenario of the buffer zone is needed for leakage detection.

Example: if the deforestation in the project area and its buffer zone is twice as much in the second period in comparison to the first period and in the reference three times as much as in the second period than in the first period, then the velocity of deforestation in the project area and its buffer zone is 2/3 of the velocity of the reference area.
This quotient is calculated by the following part of the equation:

$$(a_2 + b_2)/(a_1 + b_1)/(c_2 / c_1)$$

This term is multiplied by the proportional land use change that occurred in the reference area for the period i after project implementation:

$$(c_i / c_{i-1})$$

This gives the estimated proportional change for period i in the project area and the buffer zone. Multiplying this with the amount of ha deforested in the period i-1 of the project area, one receives the estimated amount of hectares deforested in the project area for period i.

$$a_{i-1}$$

Adaptation of the baseline scenario of the buffer zone using a reference area

[2] $$luc_{BZ} = (a_2 + b_2)/(a_1 + b_1)/(c_2 / c_1) \bullet (c_i / c_{i-1}) \bullet b_{i-1} \text{ [ha]}$$

where:

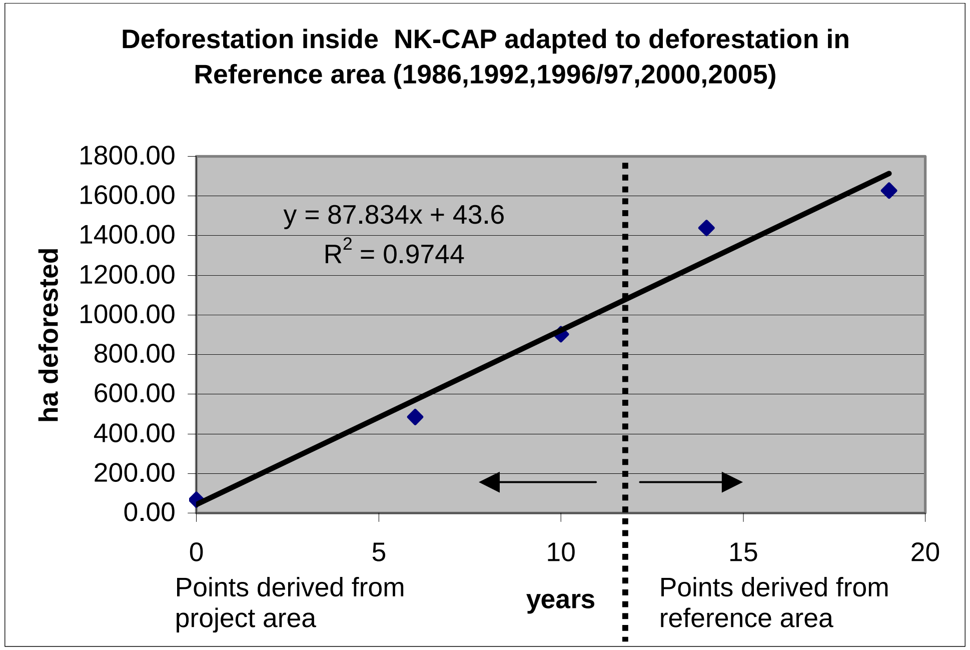
luc_{BZ}: land use change adapted in project area in period i [ha]

This equation works just as the equation explained above with the only difference that the last factor a_{i-1} has changed to b_{i-1} which is the proportional land use change in period i-1 in the buffer zone.

Table 1: Calculations steps

date	**years**	**accumulated ha def inside PAC**	**source**
Before 1986	0	67.00	
1986 till 1992	6	485.96	
1992 till 1996	10	902.32	Results from Land Use Change detection
1996 till 2000	14	1439.77	Results from adaptation using the Reference
2000 till 2005	19	1626.83	Area

This table gives the following graph



To calculate the amount of avoided deforestation the following formula was applied.

[3] $y = 87.834x + 43.6$ [ha]

where:

x: years, starting in 1986 with zero

y: area deforested [ha]

Additionally it is necessary to reduce the calculated deforestation by the amount where uncontrolled deforestation overlaps with the GEOMOD results as explained in section A.

Future monitoring:

In order to continue to monitor the quantity of deforestation and possible leakage it will be necessary to analyze the deforestation in the three areas for a defined time such as 2010 and to calculate a new deforestation rate for 2005 till 2010. Furthermore a new extrapolation till 2027 must be made. The new results must be then implemented in GEOMOD in order to localize the deforestation and calculate the avoided carbon offsets.

1. Buy or download Landsat satellite images 229070, 229071, 230069, 230070, 230071 for the year of the monitoring.
2. Quantify the deforestation which occurred between 2005 and the year of monitoring for all three areas (project area, buffer zone and reference area)
3. Adapt the baseline scenario for the project and the buffer zone.
4. Implement the new deforestation rate from 2005 till 2026 in GEOMOD.
5. Reduce this result by the areas which overlap with uncontrolled deforestation.
6. Estimate the carbon stocks of biomass and soil effected by the simulated deforestation in two areas:
   - The area where simulations intersect with the productive forest of Component A and
   - The area where simulations do not intersect with the productive forest of Component A.
7. For the area which intersects with the productive forest area of Component A, reduce the biomass carbon stock applying equation (5) from the Step 6.2 of the application of the baseline methodology component B. For the area which does not intersect with productive forest area of Component A, skip this step(7).
8. Reduce the amount of effected biomass carbon stocks by 5% due to anthropogenic fires.
9. Calculate the emissions of all GHG`s due to biomass burnings.
10. Calculate the emissions of carbon from soils.
11. Discount for carbon sequestered due to likely Land use after clearing.
12. Sum the calculated avoided carbon offsets of both areas.

B.3. Treatment of leakage in the monitoring plan:

Three areas are used to monitor the deforestation rate of the baseline scenario and to quantify possible leakage: the project area, a buffer zone and a reference area. For all three areas it is necessary to quantify the amount of hectares deforested for three points in time before the implementation of the project. The buffer zone is the area of possible leakage. Leakage occurs when communities continue to deforest at the same rate as before the implementation of the project with the only difference that the deforestation is taking place outside the project area instead of inside. The buffer zone defines the area where the project influences deforestation outside of its boundary. This depends on the spatial boundaries of the people who cause deforestation avoided by the project. In case of substantial farmers it is highly unlikely that these people would travel long distances away from the project area in order to deforest outside the park what they would have deforested inside the park otherwise. The reference area may differ in size and socio-economic conditions of the project area as long as it is in the same region and reflects the overall trend of the area. The three points in time mark the beginning and end of two periods. Compared are the proportional deforestation in the reference area of period two in comparison to period one with the proportional deforestation in the project area plus its buffer zone of period two in comparison to period one. This relation is expressed in a quotient which is used to determine the baseline for the project area and the buffer zone after the implementation of the project. A baseline scenario for the buffer zone is necessary for the quantification of leakage. If the true deforestation detected in the buffer zone is lower than the baseline scenario, no leakage is occurring. The conclusion the baseline scenario is overestimating the reality is not valid, because compensation mechanisms are implemented in the buffer zone to reduce deforestation and generate alternative income. These activities must be due to the implementation of the project and are part of the logic of conservation projects.

Example for adapting the baseline scenario of the project area and buffer zone:

Before project implementation

- The amount of hectares deforested in the project area, reference area and buffer zone are known for three points in time which mark the beginning and ending of two periods.
- The deforestation in the project area and its buffer zone is twice as much in the second period in comparison to the first period.
- The deforestation in the reference area is three times as much in the second period compared to the first period.

Conclusion: the velocity of deforestation in the project area and its buffer zone is 2/3 of the velocity of deforestation in the reference area.

After project implementation

- The deforestation in the reference area is four times as much in the third period compared to the second period.
- The adapted deforestation in the project area is 4*(2/3) times as much in the third period compared to the second period.
- The adapted deforestation in the buffer zone is 4*(2/3) times as much in the third period compared to the second period

This way the baseline scenarios of project area and buffer zone can be adapted to what is occurring in the reference area for each monitoring period. If deforestation in the reference area proves to go up exponentially, the baseline scenarios are corrected accordingly.

B.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage of the proposed A/R CDM project activity:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c) or estimated (e)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived? (electronic/ paper)**	**Comment**
B.3.1.01	a_1 = luc in project area in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.02	a_2 = luc in project area in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.03	b_1 = luc in buffer zone in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.04	b_2 = luc in buffer zone in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.05	c_1 = luc in reference area in period 1	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.06	c_2= luc in reference area in period 2	LUC Detection, satellite imagery	hectares	m	once	0%	electronic	Already collected
B.3.1.07	c_i = luc in referenc	LUC Detection, satellite	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to adapt the deforestation rate.

	e area in period i	imagery						
B.3.1.08	a_i = luc in project area in period i	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to detect illegal deforestation.
B.3.1.09	b_i = luc in buffer zone in period i	LUC Detection, satellite imagery	hectares	m	Every 5 years	100%	electronic	To be collected for future monitoring to detect leakage.

B.3.2. Description of formulae and/or models used to estimate leakage (for each GHG, source, carbon pool, in units of CO_2 equivalent):

Calculation steps

Adaptation of the baseline scenario for the buffer zone using a reference area

[4] $$luc_{BZ} = (a_2 + b_2)/(a_1 + b_1)/(c_2 / c_1) \bullet (c_i / c_{i-1}) \bullet b_{i-1} \text{ [ha]}$$

where:

luc_{BZ}: land use change in the buffer zone in period i [ha]
a_1: land use change in project area in period 1 [ha]
a_2: land use change in project area in period 2 [ha]
b_1: land use change in buffer zone in period 1 [ha]
b_2: land use change in buffer zone in period 2 [ha]
c_1: land use change in reference area in period 1 [ha]
c_2: land use change in reference area in period 2 [ha]
c_i: land use change in reference area in period i [ha]

Period 1 is the period between the 1st and 2nd point in time **before** project implementation.
Period 2 is the period between the 2nd and 3rd point in time **before** the project implementation.
Period i is the period **after** the project implementation.

The idea is to adapt the baseline scenario of the deforestation for the buffer zone to the deforestation occurring in the reference area based on a comparison of the velocity of deforestation in the project area plus its buffer zone and the reference area before project implementation. The reason why project area and buffer zone are put together is because a baseline scenario is developed for both areas.

Example: if the deforestation in the project area and its buffer zone is twice as much in the second period in comparison to the first period and in the reference three times as much as in the second period than in the first period, then the velocity of deforestation in the project area and its buffer zone is 2/3 of the velocity of the reference area.
This quotient is calculated by the following part of the equation:

$$(a_2 + b_2)/(a_1 + b_1)/(c_2 / c_1)$$

This term is multiplied by the proportional land use change that occurred in the reference area for the period i after project implementation:

$$(c_i / c_{i-1})$$

This gives the estimated proportional change for period i in the project area and the buffer zone. Multiplying this with the amount of ha deforested in the period i-1 of the buffer zone, one receives the estimated amount of hectares deforested in the project area for period i.

$$b_{i-1}$$

The result of luc_{BZ} is compared to the true deforestation occurring in the buffer zone. If the true deforestation detected in the buffer zone is lower than the baseline scenario, no leakage is occurring. Is it higher, than the difference between the two amounts is the quantified leakage.

B.4. Description of formulae and/or models used to estimate net anthropogenic GHG removals by sinks for the proposed A/R CDM project activity (for each GHG, carbon pool, in units of CO_2 equivalent):

"Net anthropogenic GHG removals by sinks" is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage".

Recalling the equations of the application of the baseline methodology:

*[*B.21] $C^B_t = C^B_t\, Offset_N + C^B_t\, Offset_I$ [tC]

where:

C^B_t: Total Carbon offsets of Component B in time t [tC]
$C^B_t\, Offset_N$: Carbon offsets of Component B in the area not intersecting with Component A in time (t) [tC]
$C^B_t\, Offset_I$: Carbon offsets of Component B in the area intersecting with Component A in time (t). [tC

Area not intersecting with Component A

[B.19] $C^B_t\, Offset_N = C^B_t GHG_{,BB,N} + C^B_t\, Offset_{,soil,N} - C^B_t LU_{,N}$ [tC]

where:

$C^B_t\, Offset_N$: Total Carbon offsets of Component B in area not intersecting with Component A [tC]
$C^B_t GHG_{BB,N}$: Carbon offsets due to biomass burning in area not intersecting with Component A [tC]
$C^B_t\, Offset_{soil,N:}$ Carbon offsets from soil in area not intersecting with Component A[tC]
$C^B_t LU_{N\ :}$ rbon sequestration due to Land Use after forest clearing in area not intersecting with Component A [tC]

Area intersecting with Component A

[B.20] $C^B_t\, Offset_I = C^B_t GHG_{BB,I} + C^B_t\, Offset_{soil,I} - C^B_t LU_I$ [tC]

where:

$C^B_t\, Offset_I$: Total Carbon offsets of Component B in area intersecting with Component A [tC]
$C^B_t GHG_{BB,I\ N}$: Carbon offsets due to biomass burning in area intersecting with Component A [tC]
$C^B_t\, Offset_{soil,I:}$ Carbon offsets from soil in area intersecting with Component A[tC]
$C^B_t LU_{I:}$ Carbon sequestration due to Land Use after forest clearing in area intersecting with Component A [tC]

B.5. Default values used in elaborating the new methodology:

Emission ratio	Appropriate literature sources (e.g. IPCC Good Practice Guidance for LULUCF, Table 3A.1.15 Emission ratios for open burning of cleared forests)
N/C ratio	Appropriate literature sources (e.g. IPCC Good Practice Guidance for LULUCF 3.2.1.4.2.2 Choice of Removals/Emission Factors)
Global Warming Potentials	Appropriate literature sources (e.g. FCCC/TP/2004/3 15 June 2004 Information on Global Warming Potentials Technical Paper)
Conversion factor between CO2 and C	Appropriate literature sources (e.g. IPCC values)
Proportional Land Use after forest clearing. (**$LU_{Proportion}$**)	Appropriate literature sources (e.g. Pacheco,P .(1998) "Municipios y gestión forestal en el trópico boliviano")
tC ha^{-1} in biomass of LU (**$C^B{}_t LU_{I/N}$**)	Appropriate literature sources (e.g. IPCC (2003).Good Practice Guidance for LULUCF, Chapter3, Cropland TABLE 3.3.8, DEFAULT BIOMASS CARBON STOCKS PRESENT ON LAND CONVERTED TO CROPLAND IN THE YEAR FOLLOWING CONVERSION Browns, S., Delaney, M.(2001).“Preliminary Carbon-Offset Analysis for the Guaraquecaba Climate Action Project: 2001 Findings and Status Report”.)

B.6. Please indicate how quality control (QC) and quality assurance (QA) procedures are applied to the monitoring process:

The following checklist has been applied as QC/QA procedure for the data monitored:

Table 1. Check Sheet of tasks, distribution, and responsibilities. (An * indicates the party which will take the lead responsibility)

	Recommended distribution			**Responsible party**		
Information type	Wide	Limited	TNC and FAN only	WI	TNC	FAN
1. Original field sheets			**X**			
a. Store originals at FAN and Winrock.				**X**		**X***
b. Develop and print master field sheets for follow-up measurements.						**X**
c. Take master field sheets to field for follow-up measurements.						**X**
d. Photocopy field sheets and data and						**X**

send to verifying organization.						
e. Store copies in dry/safe place.					**X**	**X**
f. Observe distribution guidelines.				**X**	**X**	**X**
2. Excel spreadsheets of field data			**X**			
a. Verify data, copy to CD-ROM, and send to TNC and FAN for storage.				**X**		
b. Consult experts on data storage format.					**X**	
c. Ensure that data format is current.				**X**	**X***	**X**
d. Observe distribution guidelines.				**X**	**X**	**X**
e. Inform others prior to seeking publication.				**X**	**X**	**X**
3. Summary plot data		**X**				
a. Make CD-ROM copies and send to TNC and FAN.				**X**		
b. Follow steps b and c from above.				**X**	**X***	**X**
c. Observe distribution guidelines.				**X***	**X**	**X**
4. Data analysis with Winrock's software						
5. Reports		At TNC/FAN discretion				
a. Compile all existing reports on CD-ROM and/or hard copies and send to TNC and FAN.				**X**		
b. Store hard and CD-ROM copies in dry/safe place.					**X**	**X**
c. Observe storage recommendations and distribution guidelines.				**X**	**X**	**X**
6. Field protocols		**X**				
a. Store documents on CD-ROM and send to TNC and FAN.				**X**		
b. Observe distribution guidelines.				**X**	**X**	**X**
c. Confer with Winrock about updates.					**X**	**X**

7. Remote sensing imagery and GIS products		**X**			**X**	**X**
a. Use file names in consistency with the actual version number of the PDD						**X**
b. Elaborate metadata for all images and GIS data used or generated						**X**
c. Data storage: compile all data to DVDs and send them to TNC and Winrock						**X**

One responsible of the Institutional Development Department of FAN and one responsible of the Finance and Management Department of FAN, shall check the previous list as QA/QC procedure every year.

B.7. Has the methodology been applied successfully for other purposes and, if so, in which circumstances?

No application of this specific monitoring methodology for other purposes so far. This is a project- specific methodology. However, some of its components have been widely applied in the Land use, land use change and forestry context around the world .

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