

MONITORING REPORT 2011- 2014

NATURAL HIGH FOREST REHABILITATION PROJECT ON DEGRADED LAND OF KIBALE NATIONAL PARK, UGANDA



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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The project activity in Kibale National Park (KNP) is located in the western part of Uganda and is implemented by Uganda Wildlife Authority in cooperation with Face the Future. Due to the high precipitation, complex landform and undulating valleys, as well as continual human disturbance (fire, grazing, charcoal production and cultivation) and poor land management, the area has been subjected to severe degradation of the vegetation and soil erosion. The project contributes to climate change mitigation by sequestering GHGs in sinks through planting of indigenous tree species and assisted natural regeneration activities. The purpose of the project activity is to realize multiple socio-economic and environmental benefits (climate change mitigation, biodiversity conservation, local community development and soil erosion control) through restoring forest vegetation on degraded lands.

This Monitoring Report describes the results of project monitoring carried out from January 2011 to March 2014 for the purpose of verification of the GHG emission reductions resulting from project implementation. Since the start of the ARR project activities 3,996 hectares have been replanted and 2,593 hectares have naturally regenerated. However, since the trees in the compartments which have been replanted after 2010 are still too small to qualify, this carbon monitoring campaign only includes compartments with planting year of 2010 or older. Therefore this monitoring campaign includes 3,623 ha of replanted area and 2,593 ha of regeneration area.

The results of this monitoring campaign show that since the beginning of the project in 1994 a total of 1,011,194 t CO₂-e have been sequestered in living tree biomass within the project area. 508,096 t CO₂-e (140.25 t CO₂-e/ha) have been captured in the replanted area and 503,098 t CO₂-e (194.03 t CO₂-e/ha) in the regeneration area. The tree growth during the monitoring period, between January 2011 and March 2014, resulted in a net emission removal of 221,203 t CO₂-e.

The report is based on the monitoring plan provided in the VCS Project Document (PD) for Kibale version 1.2.

1.2 Sectoral Scope and Project Type

The project falls under scope 14 of the VCS, Agriculture Forestry and Other Land Use (AFOLU). The AFOLU category is Afforestation, Reforestation and Revegetation (ARR), and the ARR project activity type is Reforestation (R). The project utilizes a Clean Development Mechanism (CDM) methodology called "Approved consolidated afforestation and reforestation baseline and monitoring methodology AR-ACM0001: Afforestation and reforestation of degraded land", Version 05.0.0.

The project is not a grouped project.

1.3 Project Proponent

The implementation of the project is achieved through a partnership between UWA and Face the Future. The contact information of both project proponents are provided in Table 1 and Table 2.

Table 1 - Contact information - Face the Future

Organization name	Face the Future (FtF)
Contact person	Kars Riemer
Title	Project Manager

Address	Face the Future B.V. Prins Hendrikkade 185 1011 TD Amsterdam The Netherlands
Telephone	+31 20 217 03 70
Email	info@facethefuture.com

Table 2 - Contact information - Uganda Wildlife Authority

Organization name	Uganda Wildlife Authority (UWA)
Contact person	Wilfred Chemutai
Title	Warden Forest Restoration
Address	P.O. Box 403 Fort Portal Uganda
Telephone	+256 775 400 517
Email	chemutaikapture@yahoo.com

Face the Future is an organization that develops forest projects in order to sequester carbon dioxide to mitigate climate change whilst facilitating socio-economic and biodiversity benefits. Face the Future's projects are partly funded through the marketing of carbon credits generated by the projects themselves. In addition to the development of forest projects, Face also provides consultancy services with regards to carbon certification of forest projects, project implementation as well as funding of projects.

The Uganda Wildlife Authority (UWA) was established in August 1996 by the Uganda Wildlife Statute, which merged the Uganda National Parks and the Game Department. It is governed by a Board of Trustees appointed by minister responsible for wildlife. UWA is in charge of management of 10 National Parks, 12 Wildlife Reserves, 14 Wildlife Sanctuaries and provides guidance for 5 Community Wildlife Areas. UWA's vision is to be a leading self-sustaining wildlife conservation agency that transforms Uganda into one of the best eco-tourist destinations in Africa. Its mission is to conserve, economically develop and sustainably manage the wildlife and Protected Areas of Uganda in partnership with neighboring communities and other stakeholders for the benefit of the people of Uganda and the global community.

Face the Future and Uganda Wildlife Authority have successfully cooperated on the restoration of former encroached areas in Kibale National Park. Since the start of cooperation in 1994, 3,996 hectares have been replanted and 2,593 hectares have naturally regenerated.

The role of Face the Future has been to provide carbon development expertise and funding while the role of UWA has been to carry out all project implementation activities. Since 1994, Face has been providing significant amounts of funding from which the project implementation activities have been paid.

1.4 Other Entities Involved in the Project

IFER – Institute of Forest Ecosystem Research, Jílové u Prahy, Czech Republic is an independent research institute conducting ecosystem research, developing and applying modern forest monitoring techniques. IFER was contracted by Face the Future in 2002, 2008, 2011 and 2014 to conduct and / or support the implementation of carbon monitoring campaigns.

Table 3 - Contact information - Institute of Forest Ecosystem Research

Organization name	Institute of Forest Ecosystem Research (IFER)
Role in the project	Monitoring technology & design; Training and data analysis
Contact person	Martin Černý
Title	CEO
Address	Areál 1. Jílovské a. s., 254 01 Jílové u Prahy, Česká republika
Telephone	+420 2 4195 0607
Email	info@ifer.cz

1.5 Project Start Date

The project activity start date is 15th May 1994; however, the crediting period start date under VCS is 1st January 2009.

1.6 Project Crediting Period

The project activity uses a fixed crediting period of 60 years, starting from 1st of January 2009 and ending on 31st of December 2068.

1.7 Project Location

The project activity is located in western Uganda, near the base of the Rwenzori Mountains and about 200 km north of the equator (Figure 1). It falls into Kabarole district and is within half an hour's drive from Fort Portal town.

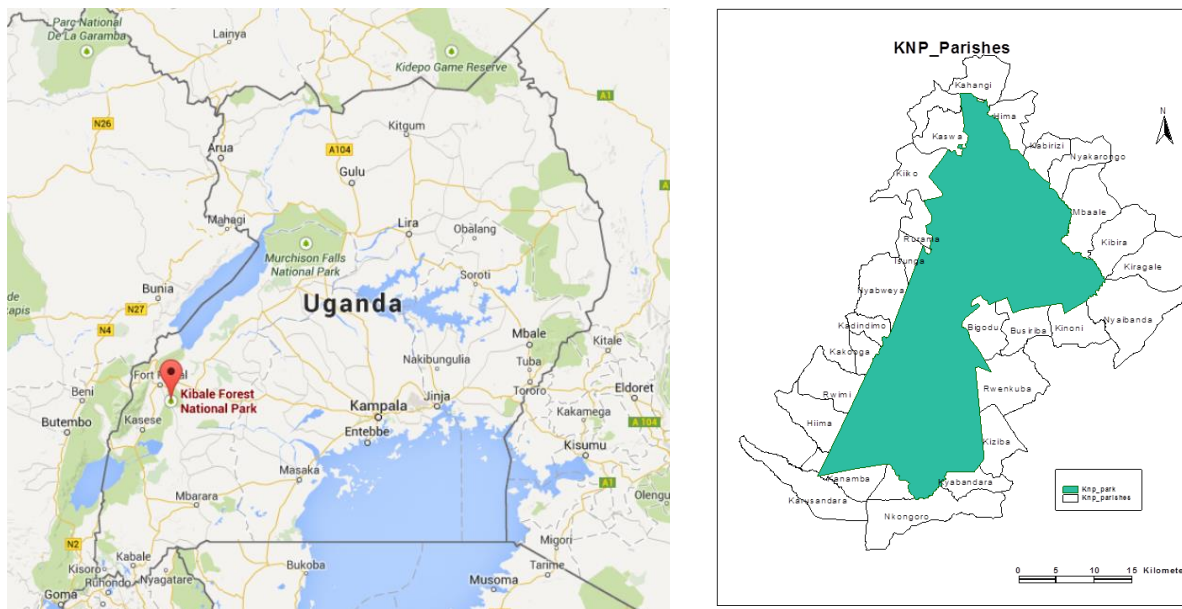


Figure 1 - Location of the proposed ARR VCS project activity and the communities surrounding Kibale NP.

1.8 Title and Reference of Methodology

This project activity uses the approved baseline methodology called “Approved consolidated afforestation and reforestation baseline and monitoring methodology AR-ACM0001: Afforestation and reforestation of degraded land”, Version 05.0.0.

1.9 Other Programs

Not applicable

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

Since the start of the ARR project activities 3,996 hectares have been replanted and 2,593 hectares have naturally regenerated. However since the trees in the compartments which have been replanted after 2010 are still too small to qualify, this carbon monitoring campaign only includes compartments with planting year of 2010 or older. Therefore this monitoring campaign includes 3,623 ha of replanted area and 2,593 ha of regeneration area.

An outline of the planted and natural regeneration areas within the project boundary is shown in Figure 2. The different planting years are presented in different colours ranging from orange (1995) to purple (2010).

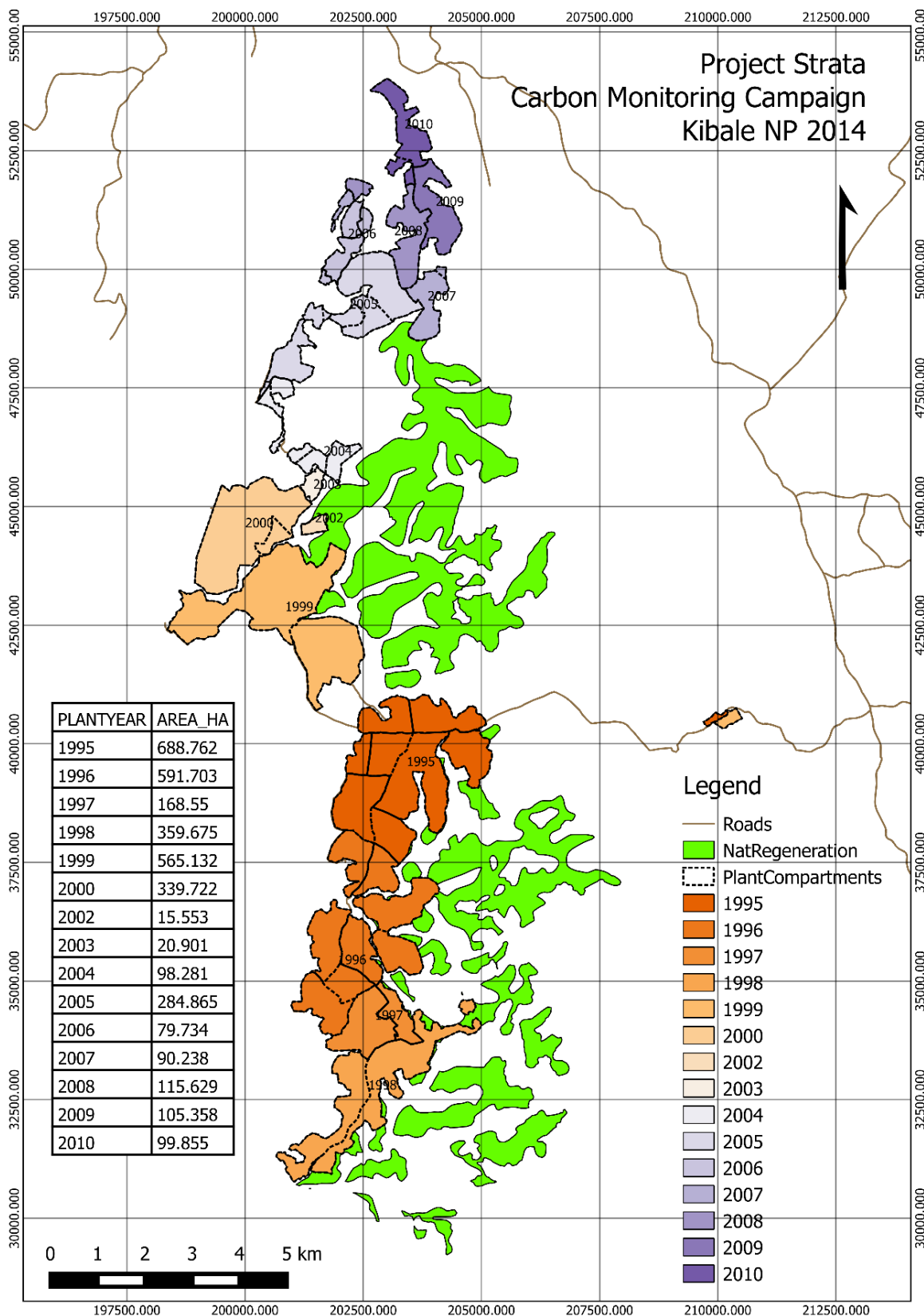


Figure 2 - Outline of planted and natural; regeneration areas within the project boundary

The AAR project activities in Kibale involved rehabilitation of degraded areas with native tree species comprising pioneers, intermediate, and climax species listed in Table 4.

Table 4 - List of species selected for the ARR VCS project activity

Genus	Species
Albizzia	<i>qummifera</i>
Bridelia	<i>micrantha</i>
Celtis	<i>durandii</i>
Chrysophyllum	<i>albidum</i>
Cordia	<i>africana/abyssinica</i>
Cordia	<i>mellenii/ugandensis</i>
Croton	<i>macrostachys</i>
Croton	<i>megalocarpus</i>
Diospyros	<i>mespiliformis</i>
Erythrina	<i>abyssinica</i>
Ficus	<i>natalensis</i>
Funtumia	<i>elastic</i>
Lovoa	<i>trichiliodes/L. brownii</i>
Markhamia	<i>Platycalyx</i>
Mimusops	<i>bagshawei</i>
Prunus	<i>african/Pygeum africana</i>
Sapium	<i>ellipticum</i>
Spathodea	<i>campanulata / similotica</i>
Trichilia	<i>drageana / splendida</i>
Uvariopsis	<i>congensis</i>
Warbugia	<i>ugandensis</i>

The project does not anticipate any significant emissions from the project implementation activities because:

1. All labour force used for the proposed ARR VCS project activity is from local villages; hence transportation for workers is not needed.
2. All seedlings are raised on or near the site and will be transported to the project sites by manpower and project vehicles, whose emissions are insignificant.
3. No harvesting or thinning of the forest expected to take place as the project area wholly contained within the National park.

Non-permanence risk assessment was carried out using the VCS' "AFOLU Non-Permanence Risk Tool" version 1 of 19 March 2015. According to this tool, the project activity was rated at a low risk after yielding a 4.5% buffer requirement. The project has a system in place to identify risks and established targets to reduce any non-permanent risks. Procedures have been developed and responsibilities are well assigned with internal auditing, reviews and training in place. The project also has a well-qualified, experienced local management team in place to ensure that the project activities are implemented effectively. The land planned for the project activity is wholly contained within a national park. Based on the Sections 3, 4 and 5 of the Uganda Wildlife Statute, the national park is fully owned by the government of Uganda under the UWA Act and mandated by Uganda Wildlife Authority on behalf of Uganda government and all Ugandans. Therefore, UWA has full control over the entire project lands. Additionally, the project will hold a 10% VCS buffer in reserve for use in case of any loss of permanence.

Reference is hereby made to the detailed VCS report called "Non-Permanence Risk Report: Natural High Forest Rehabilitation Project on degraded land of Kibale National Park", dated 19 March 2015, for more information.

2.2 Deviations

There have been no deviations to the monitoring plan so far.

2.3 Grouped Project

The project is not a grouped project activity.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	T
Data unit	years
Description	Monitoring period
Source of data	
Value applied:	3
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	Monitoring period $T = t_3 - t_2$ where: t_2 Date of verification 2011 t_3 Date of verification 2014

Data / Parameter	t_2
Data unit	date
Description	Date of verification 2011
Source of data	Carbon monitoring campaign 2011
Value applied:	January 2011
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	t_3
Data unit	date
Description	Date of verification 2014
Source of data	Carbon monitoring campaign 2014
Value applied:	March 2014
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	i
Data unit	dimensionless
Description	Stratum
Source of data	
Value applied:	Planting year; Natural regeneration area
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Determination of baseline scenario (AFOLU projects only) Calculation of baseline emissions Calculation of project emissions
Comments	Planting year was chosen in compartments area for stratification. While the entire naturally regenerated area was considered as a single stratum.

Data / Parameter	A_i
Data unit	ha
Description	Total area monitored for GHG sinks
Source of data	GPS coordinates

Value applied:	3,624 ha (compartment area) and 2,593 ha (natural regeneration area); see Figure 3 with area size per stratum
Justification of choice of data or description of measurement methods and procedures applied	Monitoring is carried out using GIS integrated with GPS and Remote Sensing data
Purpose of the data	Determination of baseline scenario (AFOLU projects only) Calculation of baseline emissions Calculation of project emissions
Comments	Project activity area

Data / Parameter	$a_{i,p}$
Data unit	m ²
Description	Area of permanent sampling plot p
Source of data	IFER
Value applied:	Plot size to measure trees with DBH 50mm - 150mm: 201.06 m² Plot size to measure trees with DBH 150mm - 300mm: 500 m² Plot size to measure trees with DBH > 300mm: 2,000 m²
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of baseline emissions Calculation of project emissions
Comments	See section 3.3.3.3 for the specifications of the IFER plot design

Data / Parameter	$A_{p,i}$
Data unit	ha
Description	Total area of all sample plots in stratum <i>i</i>
Source of data	Calculated based on the strata and the applied sampling scheme
Value applied:	Various depending on sampling scheme

Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of baseline emissions Calculation of project emissions
Comments	A regular grid is applied as a sampling scheme for all strata in the project area, see section 3.3.3.1 for details on the sampling scheme. Once selected, the size of the sampling frame is fixed until the end of the last crediting period.

Data / Parameter	<i>Plot position</i>
Data unit	GPS coordinates
Description	Plot position, GPS coordinates
Source of data	Field measurement
Value applied:	GPS coordinates
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of baseline emissions Calculation of project emissions
Comments	The GPS coordinates of the plot positions is used to navigate to the sample plots

Data / Parameter	<i>a,b,c,d</i>
Data unit	<i>Dimensionless</i>
Description	<i>Parameters used in in the allometric equation to calculate the fresh weight of above-ground tree biomass (W_{wet})</i>
Source of data	<i>National Biomass Study (NBS), Uganda</i>
Value applied:	See Table 7
Justification of choice of data or description of	Calculation of above-ground tree biomass

measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	<i>Varies according to tree diameter</i>

Data / Parameter	CF_a
Data unit	dimensionless
Description	Conversion Factor for the conversion of fresh weight to air dry weight of woody biomass
Source of data	National Biomass Study, Uganda
Value applied:	Species specific conversion factors to be found in Appendix 2 If a factor for particular species is unknown, a default value of 0.54 is applied.
Justification of choice of data or description of measurement methods and procedures applied	Calculation of above-ground tree biomass
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	CF_b
Data unit	dimensionless
Description	Conversion Factor for the conversion of air-dry weight to oven-dry weight of woody biomass
Source of data	National Biomass Study, Uganda.
Value applied:	0.853
Justification of choice of data or description of measurement methods and procedures applied	Calculation of above-ground tree biomass
Purpose of the data	Calculation of project emissions
Comments	Corresponds to moisture content of 14.7% for Ugandan experiments.

Data / Parameter	CF_c
Data unit	dimensionless
Description	Conversion factor for conversion of oven-dry weight to carbon stock in above-ground tree biomass
Source of data	IPCC 1995
Value applied:	0.50
Justification of choice of data or description of measurement methods and procedures applied	Calculation of above-ground tree biomass
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	CF_r
Data unit	dimensionless
Description	Conversion Factor for calculating root biomass
Source of data	CO2fix model (Mohren et al. 1999)
Value applied:	0.16
Justification of choice of data or description of measurement methods and procedures applied	Calculation of below-ground tree biomass (root system)
Purpose of the data	Calculation of project emissions
Comments	Root factor for calculating root biomass. Ranges from 0.32 for smallest trees, up to 0.08 for large trees.

Data / Parameter	$\frac{44}{12}$
Data unit	dimensionless
Description	Ratio of molecular weights of CO ₂ and carbon
Source of data	IPCC

Value applied:	44/12
Justification of choice of data or description of measurement methods and procedures applied	Calculation of CO ₂ sequestration in above- and below-ground tree biomass
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	ΔC_{BSL}
Data unit	t CO ₂ -e
Description	Baseline net GHG removals by sinks
Source of data	PD (section 2.5 and 4.2)
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	C_{TREE_BSL}
Data unit	t CO ₂ -e
Description	Baseline GHG removals by sinks
Source of data	PD (section 2.5 and 4.2)
Value applied:	19.1
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	Value based on the data provided by the 1999 study of Meijer.

Data / Parameter	<i>GHG_E</i>
Data unit	t CO ₂ -e
Description	Increase in non-CO ₂ GHG emissions within the project boundary as a result of the implementation of the ARR VCS project activity
Source of data	PD
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	<i>LK</i>
Data unit	t CO ₂ -e
Description	Total GHG emissions due to leakage
Source of data	PD (section 4.4)
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of project emissions
Comments	

3.2 Data and Parameters Monitored

Data / Parameter	<i>DBH</i>
Data unit	mm
Description	Diameter at breast height of tree - measured at 1.3m height
Source of data	Field measurements in inventory sample plots.
Description of measurement methods and procedures to be applied	DBH was measured for all qualifying trees (equal or greater than 50 mm DBH) in the sample plots using a calliper. Diameter was measured at 1.3m height (breast height).
Frequency of monitoring/recording	DBH is measured in the inventory sample plots during the monitoring campaigns (every 3 years).
Value monitored:	Tree DBH vary per tree age and tree species
Monitoring equipment	The DBH was measured in the field using a calliper. Data was stored in Field-Map.
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	To qualify for sampling and carbon stock calculation, only trees with dimensions greater or equal to 5 cm in diameter at breast height were considered.

Data / Parameter	<i>H</i>
Data unit	m
Description	Tree Height
Source of data	Field measurements in inventory sample plots.
Description of measurement methods and procedures to be applied	Triangulation using Field-Map Technology
Frequency of monitoring/recording	Tree Height is measured in the sample plots during the monitoring campaigns (every 3 years)
Value monitored:	Tree heights vary per tree age and tree species
Monitoring equipment	Field-Map Technology

QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	When field measurement was missing, tree height was modeled according to the exponential model: $H = 1.3 + \exp(P_1 + \frac{P_2}{DBH})$
Comments	Tree height was measured whenever it was possible. If it was not possible to measure tree heights in the field (e.g. bend or slanted trees) the tree heights were modelled using exponential model (see section 3.3.4.1).

Data / Parameter	CW
Data unit	m
Description	Tree crown width
Source of data	Field measurements in inventory sample plots.
Description of measurement methods and procedures to be applied	The crown width of the tree crown was measured using Field-Map technology.
Frequency of monitoring/recording	Tree Crown is measured in the sample plots during the monitoring campaigns (every 3 years)
Value monitored:	Tree crowns vary per tree age and tree species
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	When field measurement was missing, tree crown width was modeled according to the regression model: $CW = a * DBH^b + H^c$
Comments	Crown width was measured directly in the field. Field-Map provides functionality for mapping the horizontal crown projection. If projection was circular then only one point was measured (x, y co-ordinates in relation to the tree stem center), if horizontal projection was irregular then two points were taken to map the shortest and longest distance of crown circumference. Tree crown was measured whenever it was possible. If it was not possible to measure tree crowns in the field (e.g. bend or slanted trees) the tree crowns were modelled (see section 3.3.4.1).

Data / Parameter	<i>Tree species</i>
Data unit	dimensionless
Description	The name of the tree species, identified at both genus and species level.
Source of data	Field measurements in inventory sample plots.
Description of measurement methods and procedures to be applied	The name of the tree species are identified by highly skilled botanists in the field.
Frequency of monitoring/recording	The tree names are recorded in the sample plots during the monitoring campaigns (every 3 years)
Value monitored:	Tree species
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	The identification of tree species is necessary for the calculation of the amount of carbon stored in the trees

Data / Parameter	W_{wet}
Data unit	t
Description	Fresh weight of above ground tree biomass
Source of data	Field data monitoring; model by IFER
Description of measurement methods and procedures to be applied	Calculation of fresh weight of above ground tree biomass, based on the tree measurements in the field
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$\ln(W_{wet}) = \frac{a + b * \ln(DBH) + c * \ln(H) + d * \ln(CW)}{1000}$
Comments	See paragraph 3.3.4.1 for parameters used

Data / Parameter	W_{airdry}
Data unit	t
Description	Air-dry weight of above ground tree biomass
Source of data	Field data monitoring; National Biomass Study, Uganda
Description of measurement methods and procedures to be applied	Calculation of air-dry weight of above ground tree biomass, using conversion factor CF_a
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$W_{airdry} = W_{wet} * CF_a$
Comments	

Data / Parameter	$W_{ovendry}$
Data unit	t
Description	Oven-dry weight of above ground tree biomass
Source of data	Field data monitoring; National Biomass Study, Uganda
Description of measurement methods and procedures to be applied	Calculation of oven-dry weight of above ground tree biomass, using conversion factor CF_b
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$W_{ovendry} = W_{airdry} * CF_b$
Comments	

Data / Parameter	CS_{TAG}
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Data unit	tC
Description	Carbon stock in above-ground tree biomass
Source of data	Tree data; IPCC
Description of measurement methods and procedures to be applied	Calculation of carbon stock in above ground tree biomass, using conversion factor CF_c
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$CS_{TAG} = W_{ovendry} * CF_c$
Comments	

Data / Parameter	CS_{TBG}
Data unit	tC
Description	Carbon stock in below-ground tree biomass
Source of data	Tree data; CO2fix model (Mohren et al. 1999)
Description of measurement methods and procedures to be applied	Calculation of carbon stock in below-ground tree biomass (root system), using conversion factor CF_r
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$CS_{TBG} = CS_{TAG} * CF_r$
Comments	

Data / Parameter	C_{TREE}
Data unit	t CO ₂ -e
Description	GHG sinks in above- and below-ground tree biomass

Source of data	Tree data; IPCC
Description of measurement methods and procedures to be applied	Calculation of GHG sinks in above- and below-ground tree biomass
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	Depends on tree species and tree size
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$C_{TREE} = \frac{44}{12} * (CS_{TAG} + CS_{TBG})$
Comments	

Data / Parameter	ΔC_P
Data unit	t CO ₂ -e
Description	Sum of the changes the carbon stock in the selected carbon pools within the project boundary since the start of the ARR project activity
Source of data	Carbon monitoring campaigns
Description of measurement methods and procedures to be applied	Sum of the changes the carbon stock in the selected carbon pools within the project boundary since the start of the ARR project activity
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_{TREE,t}$
Comments	See section 4.2

Data / Parameter	ΔC_{ACTUAL}
Data unit	t CO ₂ -e

Description	Actual net GHG removals by sinks since the start of the ARR project activity
Source of data	Carbon monitoring campaigns
Description of measurement methods and procedures to be applied	Actual net GHG removals by sinks since the start of the ARR project activity
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$\Delta C_{ACTUAL} = \Delta C_P - GHG_E$
Comments	See section 4.2

Data / Parameter	C_{AR_VCS}
Data unit	t CO ₂ -e
Description	Net anthropogenic GHG removals by sinks
Source of data	Carbon monitoring campaigns
Description of measurement methods and procedures to be applied	the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$C_{AR\_VCS} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK$
Comments	See section 4.4

Data / Parameter	$VCUs$
Data unit	credits
Description	Number of Verified Certified Carbon Units

Source of data	Carbon monitoring campaigns
Description of measurement methods and procedures to be applied	the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage
Frequency of monitoring/recording	Each monitoring campaign (every 3 years)
Value monitored:	
Monitoring equipment	Field-Map Technology
QA/QC procedures to be applied	See section 3.3.5
Purpose of the data	Calculation of project emissions
Calculation method	$VCUs = C_{AR\_VCS,t_3} - C_{AR\_VCS,t_2}$
Comments	See section 4.5

3.3 Monitoring Plan

3.3.1 Information on how geographic coordinates of the project boundary are established, recorded and archived

The project boundary is used to delineate the project area. The location of each node of the project boundary will be measured during fieldwork and archived in the database. The project boundary is monitored at during events such as site preparation, planting, permanent sampling operations, fire monitoring events, carbon monitoring campaign, etc., during which compartment IDs and compartment areas are required to be entered. Two major activities are implemented with regards to the monitoring of the project boundary.

One of the major activities for monitoring utilizes a computer program called MONIS (Monitoring and Information System) which was developed with the specific aim to monitor the progress of the project over the lifetime of the contract. The program makes use of satellite images, ground photographs and topographic maps of the region. In addition to this program, Geographic Positioning System (GPS) is utilized in order to locate the specific boundaries of the project area and the National Park at large. An in-house training program was developed and implemented for relevant staff members and they were trained on the use of GPS technology. In order to store basic data in a logical order, data entry into MONIS is carried out on a monthly basis after the monthly reports have been submitted from the field.

The second major activity that is carried out is mapping of project and planted compartment boundaries using a hand-held GPS. Coordinates at each turning point on the compartment boundary are recorded in order to show proper boundaries of planted areas and to determine the actual planted areas. Mapping is carried out every year after planting targets have been achieved. The end product of the mapping exercises are maps of the rehabilitated areas.

All spatial data are archived at the UWA-Face office in Mainaro, Kibale, and at the Face the Future office in the Netherlands.

3.3.2 Stratification

Stratification was based on the ARR VCS project planting and management strategy. All planting stands comprised of mixed species planted at the same time and same density of 5x5m resulting in 400 trees per hectare across the project area. The same tending and weeding regime was applied in all planting stands of the same age for the respective species. As such, for the ex-ante actual net GHG removals by sinks, the planted areas were stratified into planting age cohorts. In addition to these strata, there exists a natural regeneration area stratum resulting from the planting of a buffer zone strategy of 1995 on the western part of the project area. As a result of full protection from fires due to project activities, the inner portion (eastern part) of the project area has started to regenerate naturally and forms a stratum of its own. Therefore, the management strategy, temporal and spatial information on the forest establishment will be adopted as stratification criteria. The geographical locations of the naturally regenerated area, planting sites, planting dates and the actual areas planted per year have been identified and are represented as polygons in the stratification map shown in Figure 3 below. A list with the planting sites and its corresponding GPS coordinates can be found in Table 5 below.

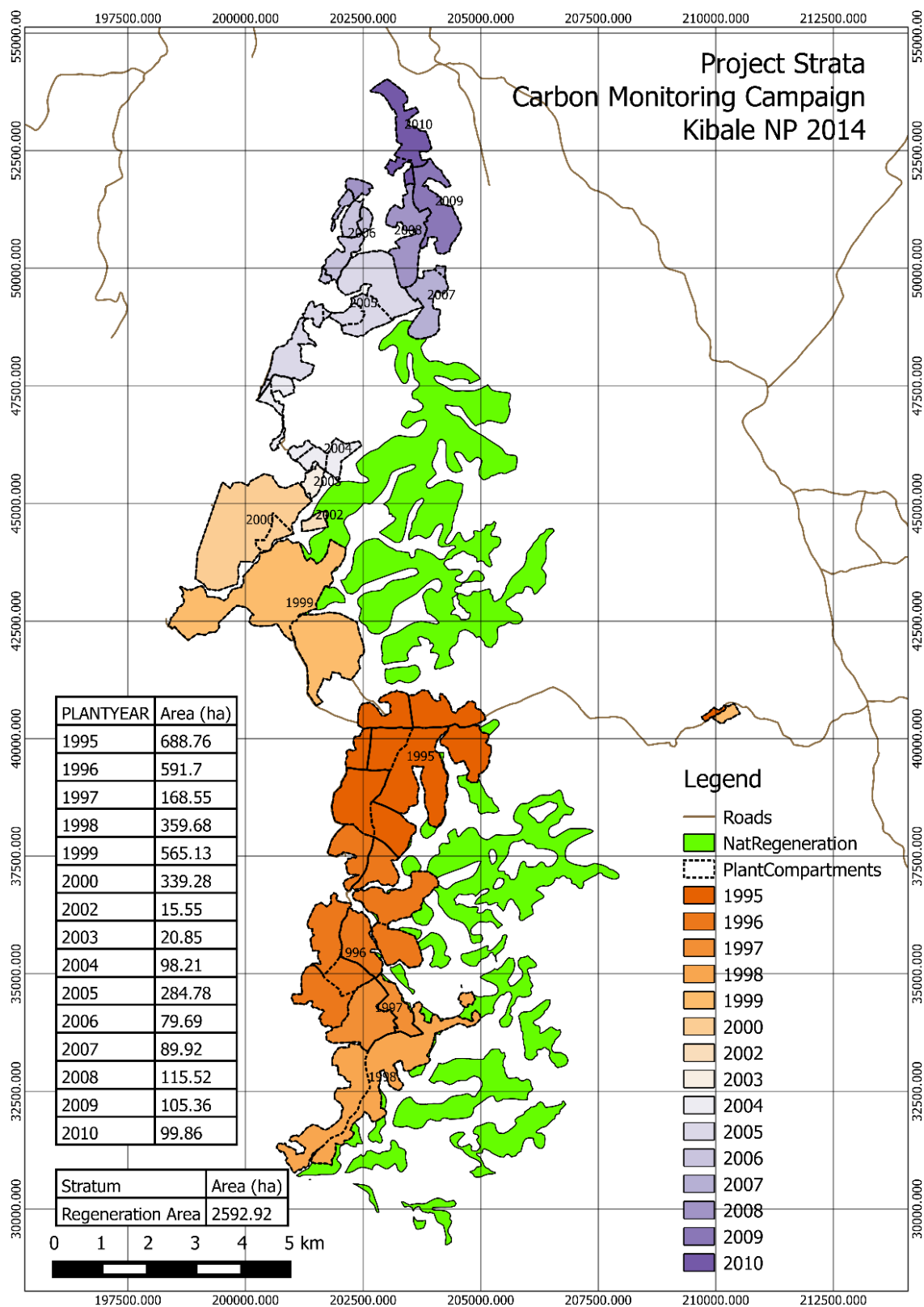


Figure 3 - Showing an outline of planted and natural regeneration areas within the greater National Park boundary.

Table 5 - Unique identification of the planting compartments for the KNP project (coordinates in UTM ARC 1960 Zone 36N).

Compartment ID	Grid Coordinates	
	Eastings	Northings
1	200707	44462
2	201537	44553
3	201445	45466
101	202919	39805
102	203380	39166
103	203196	40444
104	203103	38162
105	204763	39896
106	202458	39714
107	202365	38710
108	204026	40535
109	202365	37705
110	202826	37431
111	201719	35788
112	202364	35606
113	202088	35058
114	201719	34419
115	203194	36518
116	203102	35605
117	202548	33962
118	209927	40533
201	203286	34145
202	203101	33323
203	202271	32319

Compartment ID	Grid Coordinates	
	Eastings	Northings
204	204669	34418
205	201628	41997
206	200707	43275
207	210204	40533
301	199877	44554
403	200893	48114
404	201446	49027
405	201723	49026
406	202184	48935
407	202737	49026
408	202830	49848
409	200431	47566
401	201906	46014
410	200800	47475
501	201723	49848
502	201908	50122
503	202185	50944
504	202554	51035
602	203844	49482
603	204121	49939
701	202462	51765
702	203476	50395
1402	201445	45922
2402	200431	47201

3.3.3 Data collection

The carbon monitoring campaign in Kibale NP used the same plot design and methodology as were applied in Kibale NP during previous campaigns. For details about the general methodology see Methodology for Carbon Stock Monitoring (IFER, 2002).

3.3.3.1 Sampling scheme

A regular sampling grid was applied to all the compartment areas using clusters of four permanent sampling plots at a spacing of 500 x 500 meters. In the naturally regenerated areas, the same grid was employed, however, clusters of three permanent sampling plots was used for the natural regeneration area. This design allowed adding new clusters when new strata (planting years) are being added to the project area (see Figure 4).

In total there were 316 plots in 79 clusters established or re-measured in compartment areas. Of this number, 8 were newly established clusters with 32 inventory plots. The naturally regenerated areas comprised of 66 plots within 22 clusters.

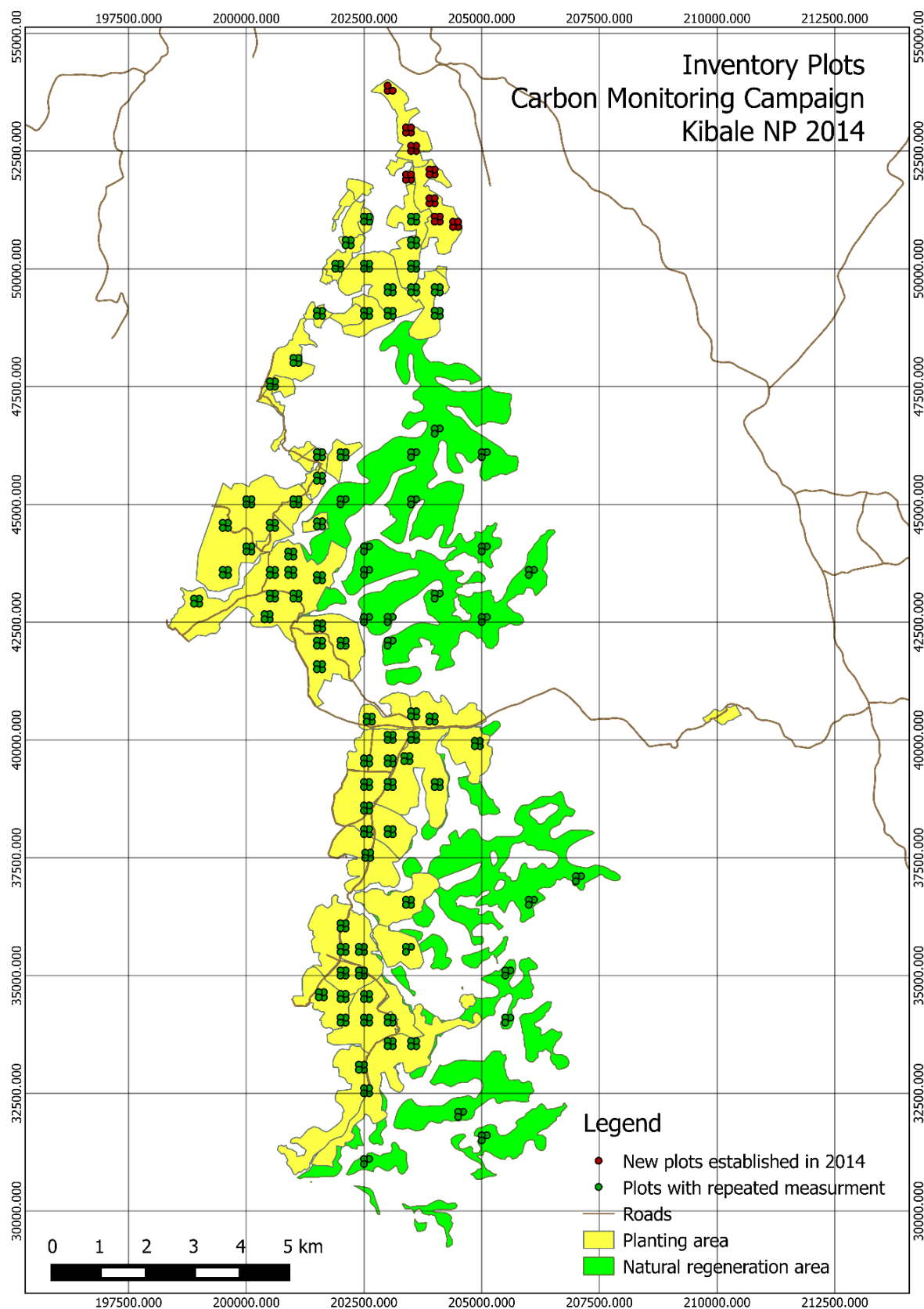


Figure 4 - Overview of carbon monitoring sampling grid in Kibale.

3.3.3.2 Cluster Design

The inventory plots were aggregated in clusters. It was planned that one field group would manage one cluster per day on average. The cluster design is described in Figure 5 below.

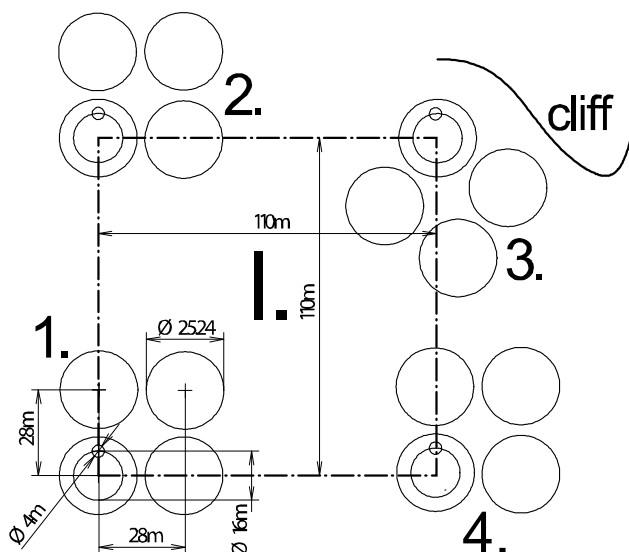


Figure 5 - The monitoring cluster (I.) consists of four plots (in compartments) or three plots (in naturally regenerated areas). Each sampling plot is composed of four circles 500 m² each. Plot 3 was rotated because of the obstacle. The obstacle can be road, cliff, river, etc.

3.3.3.3 Plot Design

Each inventory plot (Figure 6) was composed of four circles with an area of 500 m² each (i.e. 2,000 m² altogether). The key circle contained an additional circle, a concentric internal subplot to measure smaller trees. The applied limits for the inventory circles and tree size specified for the carbon monitoring project in Uganda are shown in Table 6.

Table 6 - Applied limits for trees given by diameter at breast height (DBH) for particular sub-plots within an inventory plot.

Circle radius	Tree DBH limit
Up to 8 m of the key plot centre	50 mm and more
Up to 12.62 m of the key plot centre (its entire area)	150 mm and more
Remaining three large circles of the plot	300 mm and more

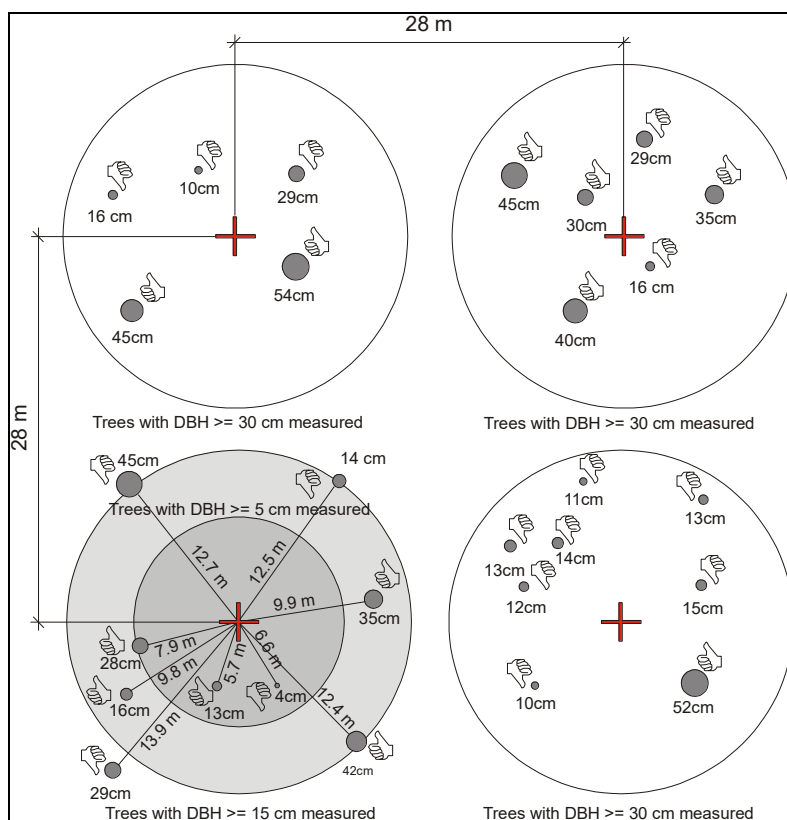


Figure 6 - Trees equal or greater than 300 mm of DBH are measured in the entire plot. Trees equal or greater than 150 mm of DBH are measured in the light gray circle. Trees equal or greater than 50 mm of DBH are measured in the inner dark gray circle.

3.3.3.4 Plot Monumentation

In order to comply with the requirement of the methodology (AR-ACM0001 - Version 05.0.0) for permanent sampling plots, all inventory plots are measured in a local Cartesian co-ordinate system with the center in the middle of inventory plot. The project utilizes both the Laser and GPS technologies to locate plot centers. The GPS is used in Global Coordinate System (i.e. on the navigation plot) whereas the Laser is utilized on both the local and global coordinate systems. The Laser is reliable for navigation under canopy, provides a precise navigation to the plot center and is utilized for all measurements carried out within the inventory plot.

From the center of an inventory plot, a position of marked tree is measured. This marked tree is then painted and if necessary some more descriptive comments are entered into the database. Selection of the tree to be painted is based on the size and type of the tree. For example, a tree of 200 mm DBH, belonging to the climax species group and not edible to wildlife, is preferably selected because it is more likely to still be alive during the next carbon monitoring campaign, 5 years later. Therefore, during the repeated measurements the geo-reference is taken from the painted tree. This means that upon reaching the inventory plot, the Field Team immediately searches around for painted tree and uses the positioning routine to get a reference from it.

3.3.3.5 Precision requirements

The number of permanent sampling plots and the targeted precision level for the biomass estimation is $\pm 10\%$ of the mean at a 90% confidence level and was determined using the approved CDM tool for

“Calculation of the number of sample plots for measurements within A/R CDM project activities” version 02.1.0 as required by the CDM methodology AR-ACM0001, version 05.0.0.

3.3.3.6 Measurement technology

Field-Map technology (www.field-mapping.com) was used for data collection and mapping in this monitoring campaign. Field-Map (© IFER-Monitoring and Mapping Solutions, Inc.) is an advanced computer aided field data collection technology based on modern electronic devices and user-friendly software. The complete Field-map solution includes specific features and utilities that are specifically important for the demanding field conditions of tropical regions. They include efficient field navigation, support for concentric sample plot circles, continuous georeferencing, remote diameter measurement allowing measuring trees with buttresses, several height measurement modes etc.

List of main parts of Field-Map equipment used in Kibale:

- Field computer
- Laser rangefinder (with integrated compass)
- Telescopic monopod
- Reference poles with reflectors
- Calliper
- GPS
- Accessories



Figure 7 - Field-Map set

3.3.4 Data processing

Statistical methods used in the Field-Map Inventory Analyst represent standard methods used for simple and stratified sampling design (Thomson, 1992). A complete description of methods used is available in Field-Map Inventory Analyst Manual (IFER, 2007).

The carbon stock assessment is based on the field inventory of ecosystem components containing carbon. Carbon in ecosystems is sequestered into biomass and residual organic material. Carbon is fixed in standing trees and other components such as deadwood, ground vegetation and soil as well. As described in the PD (section 2.3), only the above-ground and below-ground biomass of tree vegetation is included as carbon pool for the project activity. Dead wood, litter and soil organic carbon are conservatively excluded as carbon sink. Tree regeneration, ground vegetation, shrubs and stumps were also not included in the total carbon stock calculation. These components represent only an insignificant fraction of biomass in the project area. The carbon calculation in this report only concerns the tree biomass.

Using the collected data (measured or described) from the field, carbon calculation involves the following steps:

- Applying suitable allometric equations to calculate tree biomass (fresh weight), which is converted to dry weight and carbon units using species-specific density and average carbon stock held in biomass dry weight, respectively.
- Using statistical procedures to assess carbon stock in tree biomass in compartments and naturally regenerated areas (statistical extrapolation from plot to total area).

3.3.4.1 Calculating carbon stock held in trees

To qualify for sampling and carbon stock calculation, only trees with dimensions greater or equal to 5 cm in diameter at breast height were considered. The required input parameters for suitable allometric equations were: tree breast height diameter (DBH; cm), tree height (H; m) and crown width (CW; m).

Breast height diameter was measured for all qualified trees, height and crown width were measured whenever it was possible. Heights and crown projections were not measured for bent or slanted trees. Tree height samples measured in the field were used to parameterize DBH-Height exponential model to fill missing heights:

$$H = 1.3 + \exp(P_1 + \frac{P_2}{DBH}) \quad (1)$$

where:

H	Tree height; m
DBH	Diameter at breast height; mm
P_1, P_2	Exponential model parameters

If there were enough height samples measured (min. number of height samples per species was set to be 4) on single inventory plot per particular species, then the model was parameterized on the level of plot (i.e. local species model). In case there were not enough samples on the inventory plot the overall species model was adjusted to fit height samples available on particular inventory plot (i.e. adjusted species model). In very rare cases, when there were not any height samples available on the inventory plot for particular species, the general species model was applied (i.e. general species model). Modelled heights were used only for trees with no measured height (e.g. bend or slanted trees). The parameters for all DBH-H models used are given in Appendix 1.

Tree crown widths measured in the field were used to parameterize regression model:

$$CW = a * DBH^b * H^c \quad (2)$$

where:

CW	Tree crown width; m
H	Tree height; m
DBH	Diameter at breast height; mm
a, b, c	regression model parameters

All the trees regardless species with measured crown width were used for parameterization of the model. Measured crown widths were used in allometric equations. Modelled crown widths were used only for trees with no crown width (e.g. bend or slanted trees) or for outliers. To identify the outliers we calculated difference between measured and modelled crown width S_{xy} and any tree with S_{xy} out of 3 standard deviations was considered to be an outlier and its crown width was modelled.

The crown widths were modelled for both the compartment area and the regeneration area separately. Final parameters of the crown width regression model were:

Compartment Area

a = 0.17262

b = 0.63048

c = 0.04550

R = 0.757

Regeneration Area

a = 0.24316

b = 0.58758

c = 0.00016

R = 0.735

The allometric equations were formed as:

$$\ln(W_{wet}) = \frac{a + b * \ln(DBH) + c * \ln(H) + d * \ln(CW)}{1000} \quad (3)$$

where:

W_{wet} Fresh weight of above-ground tree biomass; t

DBH Diameter at breast height; mm

H Tree height; m

CW Tree crown width; m

a, b, c, d parameters

The parameters a, b, c, d were established for three tree size classes based on a wealth of destructively obtained data in Uganda (Velle 1997, Begumana 2000, IFER 2002). The parameters a, b, c, d that were applied in the calculation of W_{wet} : are shown in Table 7 (after Velle 1997 adjusted by Begumana 2000).

Table 7 - The set of parameters for Eq. 3 estimated by NBS, Kampala, Uganda.

Diameter range	Parameters			
	a	b	c	d
DBH<200 mm	-0.85989	1.54456	0.50663	0.33335
DBH 200-600 mm	-1.75089	1.94391	0.47373	0.24578
DBH>600 mm	-2.16650	2.03293	0.31292	0.43634

Conversion of fresh weight to air-dry weight of above ground tree biomass was performed by applying a conversion factor that is derived from the National Biomass Study NBS, Kampala, Uganda:

$$W_{airdry} = W_{wet} * CF_a \quad (4)$$

where:

W_{airdry} Air-dry weight of above-ground tree biomass; t

W_{wet} Fresh weight of above-ground tree biomass; t

CF_a conversion factor

The conversion factors are obtained from the National Biomass Study (Forestry Department, Uganda, 1992, App K). They are species-specific and range between 0.32 and 0.75. If a factor for particular species is unknown, a default value of 0.54 is applied. This corresponds to a mean value of the available factors for common tree species in Uganda. The species specific conversion factors are given in Appendix 2.

Conversion of air-dry weight and oven-dry weight of tree biomass is calculated by applying a conversion factor:

$$W_{ovendry} = W_{airdry} * CF_b \quad (5)$$

where:

$W_{ovendry}$ oven-dry weight of above-ground tree biomass; t

W_{airdry} Air-dry weight of above-ground tree biomass; t

CF_b conversion factor (0.853)

The value of the additional conversion factor CF_b (0.853) corresponds to a moisture content of 14.7 % in air-dry matter. This is the average value found in the local experiments (NBS, unpublished material).

Oven-dry matter is converted to carbon stock in above-ground tree biomass (CS_{TAG}) using conversion factor (CF_c) of 0.50, which is commonly used elsewhere (Matthews 1993, Schelhaas 2002, Kort 1999) and also recommended by the IPCC (1995 a, b):

$$CS_{TAG} = W_{ovendry} * CF_c \quad (6)$$

where:

CS_{TAG}	Carbon stock in above-ground tree biomass; tC
$W_{ovendry}$	oven-dry weight of above-ground tree biomass; t
CF_c	conversion factor (0.50)

Finally, the below-ground biomass component (root system) is accounted for by multiplying the above-ground carbon stock by a specific root factor:

$$CS_{TBG} = CS_{TAG} * CF_r \quad (7)$$

where:

CS_{TBG}	Carbon stock in below ground biomass in tree roots; tC
CS_{TAG}	Carbon stock in above-ground tree biomass; tC
CF_r	Root factor applicable on the level of individual trees (0.16)

CF_r is derived from the CO2fix model (Mohren et al. 1999) estimation using a default parameter set for tropical evergreen forest ecosystems (Nabuurs and Mohren, 1993). The model gives a root ratio in relation to mean stem volume and stand age. The volumetric information is used to derive a size-dependent root factor that is attributed to each measured tree stored in the database. The root fraction ranges from 0.32 for the smallest trees up to 0.08 for the largest trees. The average value of 0.16 is applied as root ratio for this monitoring campaign, this is a rather conservative value to comply with a rigorously “safe” assessment strategy involved in the assessment.

The total GHG sink in above-ground and below-ground tree biomass is calculated as:

$$C_{TREE} = \frac{44}{12} * (CS_{TAG} + CS_{TBG}) \quad (8)$$

where:

C_{TREE}	GHG sinks in above- and below-ground biomass in trees; tCO ₂ e
CS_{TAG}	Carbon stock in above-ground tree biomass; tC
CS_{TBG}	Carbon stock in below ground biomass in tree roots; tC
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

3.3.4.2 Stratification and Extrapolation

The stratification is a statistically sound approach for improving the quality of the results based on grouping members of the population into relatively homogeneous subgroups. Therefore, when sub-populations vary

considerably and each sub-population has smaller variability than the whole population, it is advantageous to employ stratification approach. Planting year was chosen in compartments area for stratification. While the entire naturally regenerated area was considered as a single stratum.

Standard statistics for stratified sampling (Thompson, 1992) has been used for calculations.

3.3.4.3 Technology for data processing

Advanced technology Field-Map was used also for data processing. The advantage of the Field-Map technology is the use of the field computers in data collection process. Therefore the data collected in the field are digitized instantly in the field and are stored in industry standard formats (maps in ESRI shape files, tables in Paradox or MS Access).

Field-Map Data Processing Tools are used for further processing (i.e. calculation of missing variables, data classifications/re-classifications, data aggregation), while Field-Map Inventory Analyst (© IFER-Monitoring and Mapping Solutions, Inc.) is used for statistical analyses.

3.3.5 Quality Assurance and Quality Control

3.3.5.1 Roles and responsibilities

Many people were involved in the monitoring campaign on different levels. Majority of them were workers doing the actual fieldwork. There were 3 field teams involved in the 2014 field campaign. For easy orientation these were called Red, Blue and Green teams.

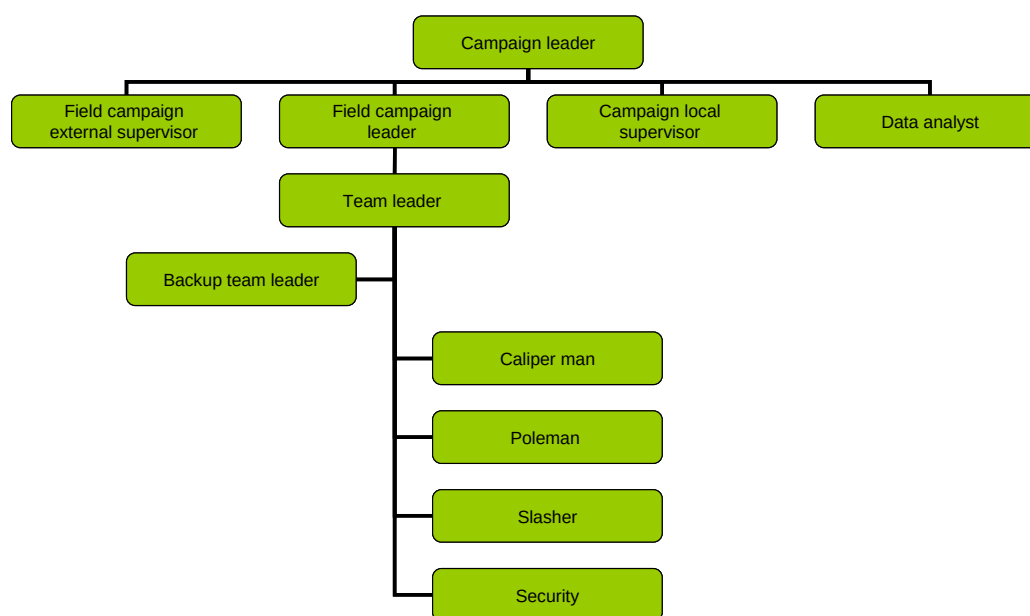


Figure 8 - Organizational Structure

Campaign leader

The leader of the campaign is responsible for the methodology of the campaign. He designs the project structure and supervises the data evaluation.

Field campaign leader

Leader is responsible for the operations on the ground. The main tasks of the leader are to select and hire local staff capable of works related to computer aided field data collection, manage monitoring teams in the training phase and also later in the field, organize repairs of broken equipment and assigned other responsibilities to team leaders.

Field campaign external supervisor

External supervisor is responsible for teaching the correct methodological approach to the local workers. He is present in the beginning of the campaign to ensure that all problems related to equipment and project database structure are solved and all questions regarding the methodology of data collection are answered. He leads the training of local staff. He is also present at the end of the campaign to check data quality and to check the quality of field work by revisiting random selection of inventory plots and re-measuring them.

Campaign local supervisor

Local supervisor is present during the campaign to ensure that the data collection in the field is done according to the correct methodological approach. The local supervisor answers questions with regards to the methodology of data collection in the field.

Data analyst

Data analyst is responsible for data check and data evaluation. He carries out the statistical computations and produces the final results.

Team leader

Team leader is responsible for managing local workers in the field and is operating the technology in the field and therefore must be familiar with it. He is also responsible for daily backup of collected data.

Backup team leader

Backup team leader acts as team leader in case that team leader is not able to participate in the field work on particular day. Otherwise he is regular member of the field crew.

Caliper man

Works with caliper. He needs to follow the methodology for DBH measurement and measure diameters responsibly.

Poleman

Poleman is operating measuring pole. He is familiar with the correct procedures for measuring positions of the trees and also procedure for navigation to the plot.

Slasher

Slasher helps to clear the way to the other team members. He must make sure that no excessive cutting takes place during the survey.

Security

Security man is armed and ensures safety of the team in the field.

Table 8 - List of people involved in the 2014 campaign

Team member	Team	Role
Kars Riemer	-	Campaign leader / Quality controller
Chemutai Wilfred	-	Field campaign leader
Petr Blazek	-	Field campaign external supervisor
Radek Russ	-	Data analyst
Martijn Snoep	-	Quality controller
Fredric Wanyama	-	Campaign local supervisor / Quality controller
Richard Kigenyi	Red	Team leader
Jamada Chebet	Green	Team leader
Nelson Enyagu	Blue	Team leader
Hillary Agaba	Red	Backup team leader
Patrick Kamara	Green	Backup team leader
Joseph Wasike	Blue	Backup Team leader

3.3.5.2 Training and support

The monitoring campaign started with a training in March 2014. The three field teams were trained in the hardware maintenance and software operation using Field-Map technology. Team leaders were also trained in backing up of the data. IFER, represented by Petr Blazek, led the training of the data collection.

3.3.5.3 Data check

The Field-Map software includes a number of automatic data checks. In addition, the build-in checking routines were amended by scripts written specifically for this monitoring campaign. Thus the data could be checked online in the field. The checking routines included:

- empty values (where database fields are defined as required, the data checking routine warns the user about empty values).
- values out of bounds (e.g. since the trees are measured for the second time the DBH should be larger and therefore a warning message pops up every time the new DBH is smaller than old DBH).
- dependency checks (conditional lookup lists shorten the choice for subordinate variable, e.g. selecting certain species group shortens list of individual species).
- SQL queries (final checking of the database performed by IFER is through the SQL queries. These checks are designed specifically for the purpose of this project at the time of data checking and validation at the end of the campaign).

The final checks of the database revealed some discrepancies, but there were not many since most of the potential mistakes were captured by automatic checks.

These errors were mainly concerning proper categorization of tree regeneration into height classes. The errors were corrected by moving the individual trees into proper classes.

Field checks were performed during the campaign. A total 38 plots were re-measured (32 plots in compartment area and 6 plots in regeneration area), which equals to 10% of the total number of plots. The field checks were conducted jointly by UWA and Face the Future. The difference between data collected by field teams and QA/QC teams expressed in tons of carbon per plot ranged from -45.52% up to +22.72% (checking data are considered to be 100%). Mean difference is 0.62 tC/plot and mean relative difference then being 2.08%. A detailed overview of the QC results can be found in Appendix 4.

3.3.5.4 Corrective and preventive measures

The Field-Map software contains a measurement assistant. The assistant is a software expert, which guides the user through the field measurement process. The assistant can be switched on for beginners and switched off for advanced users. The user interface is built for the project and contains lookup list populated with project specific values (e.g. species list contains only species occurring in the project area). This prevents the mistyping the names and values which is crucial for database consistency and further data processing.

For every numeric field in the data collection forms it is possible to define minimum and maximum accepted values. If smaller or larger value is entered, the software warns the user and the user needs to enter valid value.

The main window of the data collection software contains a map of the inventory plot showing the plot boundary, boundary of concentric circles, location of measured trees and circles showing DBH for every tree. Any time the measured tree location falls outside the plot, the user is warned. As soon as DBH of the tree is entered, the location of the tree is checked and compared to allowed DBH value in particular concentric circle. If there is a discrepancy, the user is warned and asked to either delete the tree or correct the DBH value.

In the 2014 monitoring campaign it was necessary to find existing trees in the field that had been measured in previous campaigns. The software has functions for searching the trees and comparing the new measured values with the old ones. More details on the functionality of Field-Map software are located at www.fieldmap.cz.

3.3.5.5 Management of monitoring data and archiving of documentation

Data are stored in the database called Field-Map project. Field-Map project is a folder containing database tables in Paradox or MS Access format, ESRI Shapefiles, XML configuration files and other necessary files. The structure of the Field-Map project is managed through Field-Map Project Manager application.

Field-Map is designed to work with distributed databases, which in practice means that many field teams can work on the same project at the same time and the results of the data collection can be easily combined together and stored in common database on daily basis.

The database was backed up on several locations and intervals during the field campaign:

- Field computers (Field teams stored their work on their computers.)
- USB drives of the field team leaders (Every day the teams backed up the work to computer in the office through USB stick. The data stayed on the USB stick as well.)

- Office computer (The data was combined together from all three groups and stored at UWA-Face office computer on daily basis).
- Computer at IFER (At the beginning and at the end of the campaign, when IFER supervisor was present in Kibale, the backups were done to the IFER computer as well. During the campaign IFER received data sets via email and stored these as back up.)

Since the entire data collection process is electronic, there is no need to store any paper forms.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

As stated in the Methodology AR-ACM0001/Version 05.0.0, the baseline net GHG removals by sinks is the sum of the changes in carbon stocks in the selected carbon pools within the project boundary that would have occurred in the absence of the ARR project activity.

Under the applicability conditions of AR-ACM0001 methodology, the baseline net GHG removals by sinks is determined as:

$$\Delta C_{BSL} = \sum_{t=1}^{t^*} (\Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t}) \quad (9)$$

where:

ΔC_{BSL}	Baseline net GHG removals by sinks; t CO ₂ -e
$\Delta C_{TREE\_BSL,t}$	Change in carbon stock in tree biomass in baseline within the project boundary in year t , as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO ₂ -e
$\Delta C_{SHRUB\_BSL,t}$	Change in carbon stock in shrub biomass in baseline within the project boundary in year t , as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO ₂ -e (Under the applicability conditions of this methodology, changes in carbon stock of above-ground and below-ground biomass of shrub vegetation may be conservatively assumed to be zero for all strata in the baseline scenario)
t	1, 2, 3, ... t^* years elapsed since the start of the ARR project activity; yr

As described in the PD (section 2.5 and 4.2), the baseline is in a steady state. There is no increase in GHG removal, therefore:

$$\Delta C_{BSL} = 0$$

The initial baseline carbon stock in tree biomass (C_{TREE_BSL}) is conservatively determined to be 5.2 tC/ha or 19.1 tCO₂/ha. As described in the same sections 2.5 and 4.2 of the PD, this value is based on data provided by the 1999 study of Meijer (Meijer, 1999). This baseline carbon stock is being used as the initial carbon stock value in the project area before the implementation of the ARR VCS project activity in the compartments:

$$C_{TREE\_BSL} = 19.1 \text{ tCO}_2/\text{ha}$$

4.2 Project Emissions

The actual net greenhouse gas removals by sinks were estimated using the equations described in section 5 of the CDM methodology AR-ACM0001/Version 05.0.0 as follows:

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \quad (10)$$

where:

ΔC_{ACTUAL}	Actual net GHG removals by sinks since the start of the ARR project activity; t CO ₂ -e
ΔC_P	Sum of the changes the carbon stock in the selected carbon pools within the project boundary since the start of the ARR project activity; t CO ₂ -e
GHG_E	Increase in non-CO ₂ GHG emissions within the project boundary as a result of the implementation of the ARR VCS project activity; t CO ₂ -e

Under the applicability conditions of this methodology, there is no quantification of project emissions because all the labor force used for the proposed ARR VCS project activity is from local villages; hence transportation for workers is not needed. All seedlings will be raised on or near the site and will be transported to the project sites by manpower and project vehicles, whose emissions are insignificant. No harvesting or thinning of the forest expected to take place as the project area wholly contained within the National park. Emissions from burning of woody biomass is also not accounted for since this burning does not takes place in the project area (PD section 2.4). Therefore, the increase in GHG emissions as a result of the implementation of the proposed ARR VCS project activity within the project boundary is set to zero:

$$GHG_E = 0$$

As described in the PD (section 2.3), only the above-ground and below-ground biomass of tree vegetation is selected as carbon pool for the project activity. Dead wood, litter and soil organic carbon are conservatively excluded as carbon sink. Furthermore, changes in carbon stock of above-ground and below-ground biomass of non-tree vegetation is conservatively set to be zero for all strata in the project scenario. Therefore the change in the selected carbon stock since the start of the ARR project activity is calculated as follows:

$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_{TREE,t} \quad (11)$$

where:

ΔC_P	Sum of the changes the carbon stock in the selected carbon pools within the project boundary since the start of the ARR project activity; t CO ₂ -e
$\Delta C_{TREE,t}$	Change in carbon stock in tree biomass within the project boundary, in year t; t CO ₂ -e
t	1, 2, 3, ... t^* years elapsed since the start of the ARR project activity; yr

The 2014 verification results for the actual net GHG emission removals by sinks since the start of the ARR project activity, are presented per stratum in Table 9. A detailed elaboration of the results can be found in the excel spreadsheet attached as separate file (Appendix 3).

Table 9 – Actual net GHG emissions removals by sinks per stratum in 2014 (the date of the verification)

Stratum <i>i</i>	Area monitored in 2014 (ha)	Carbon stock in selected pools (tree biomass) ΔC_P (t CO ₂ -e)	Project emissions GHG_E (t CO ₂ -e)	Actual net GHG removals by sinks ΔC_{ACTUAL} (t CO ₂ -e)
Planting year 1995	689	73,219	0	73,219
Planting year 1996	592	118,337	0	118,337
Planting year 1997	169	45,096	0	45,096
Planting year 1998	360	72,335	0	72,335
Planting year 1999	565	86,409	0	86,409
Planting year 2000	339	50,611	0	50,611
Planting year 2002	16	1,701	0	1,701
Planting year 2003	21	2,243	0	2,243
Planting year 2004	98	8,093	0	8,093
Planting year 2005	285	20,976	0	20,976
Planting year 2006	80	9,175	0	9,175
Planting year 2007	90	6,648	0	6,648
Planting year 2008	116	4,710	0	4,710
Planting year 2009	105	3,845	0	3,845
Planting year 2010	100	4,697	0	4,697
Natural Regeneration	2,593	503,098	0	503,098
Total	6,216			1,011,194

4.3 Leakage

Under applicability conditions of the CDM methodology AR-ACM0001/Version 05.0.0 leakage emissions are estimated as follows:

$$LK = \sum_{t=1}^{t^*} LK_{AGRIC,t} \quad (12)$$

where:

LK Total GHG emissions due to leakage; t CO₂-e

$LK_{AGRIC,t}$ Leakage due to the displacement of agricultural activities in year t, as calculated in the tool “Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity”; t CO₂-e

As described in the PD (section 4.4), leakage is not applicable to the project. Therefore leakage is not monitored and set to zero:

$$LK = 0$$

4.4 Net GHG Emission Reductions and Removals

The net anthropogenic GHG removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage, therefore, the following general formula is used to calculate the net anthropogenic GHG removals by sinks of the ARR VCS project activity:

$$C_{AR\_VCS} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK \quad (13)$$

where:

C_{AR_VCS}	Net anthropogenic GHG removals by sinks; t CO ₂ -e
ΔC_{ACTUAL}	Actual net GHG removals by sinks since the start of the ARR project activity; t CO ₂ -e
ΔC_{BSL}	Baseline net GHG removals by sinks; t CO ₂ -e
LK	Total GHG emissions due to leakage; t CO ₂ -e

The results for the net anthropogenic GHG removals by sinks in 2014, since the start of the ARR project activity, is presented in Table 10. A detailed elaboration of the results can be found in the excel spreadsheet attached as separate file (Appendix 3).

Table 10 - The net anthropogenic GHG removals by sinks per stratum in 2014 (date of verification)

Stratum <i>i</i>	Baseline emissions or removals ΔC_{BSL} (tCO ₂ e)	Project emissions or removals ΔC_{ACTUAL} (tCO ₂ e)	Leakage emissions LK (tCO ₂ e)	Net GHG removals by sinks C_{AR_VCS} (tCO ₂ e)
Planting year 1995	0	73,219	0	73,219
Planting year 1996	0	118,337	0	118,337
Planting year 1997	0	45,096	0	45,096
Planting year 1998	0	72,335	0	72,335
Planting year 1999	0	86,409	0	86,409
Planting year 2000	0	50,611	0	50,611
Planting year 2002	0	1,701	0	1,701
Planting year 2003	0	2,243	0	2,243
Planting year 2004	0	8,093	0	8,093

Planting year 2005	0	20,976	0	20,976
Planting year 2006	0	9,175	0	9,175
Planting year 2007	0	6,648	0	6,648
Planting year 2008	0	4,710	0	4,710
Planting year 2009	0	3,845	0	3,845
Planting year 2010	0	4,697	0	4,697
Natural Regeneration	0	503,098	0	503,098
Total				1,011,194

4.5 Calculation of VCUs

To estimate the VCUs at time $t^* = t_3$ (the date of verification in 2014) for the monitoring period $T = t_3 - t_2$, the CDM methodology AR-ACM0001/Version 05.0.0 uses the equation as the follows:

$$VCUs = C_{AR\_VCS,t_3} - C_{AR\_VCS,t_2} \quad (14)$$

where:

$VCUs$ Number of Verified Certified Carbon Units

C_{AR_VCS,t_1} Net anthropogenic GHG removals by sinks, as estimated for $t^* = t_2$ = date of verification 2011; t CO₂-e

C_{AR_VCS,t_2} Net anthropogenic GHG removals by sinks, as estimated for $t^* = t_3$ = date of verification 2014; t CO₂-e

The results for the number of VCUs per stratum i for the monitoring period $T = t_3 - t_2$ (2011-2014) are presented in Table 11. A detailed elaboration of the results can be found in the excel spreadsheet attached as separate file (Appendix 3).

Table 11 - Number of VCUs per stratum for monitoring period 2011 - 2014

Stratum i	Area 2011 (ha)	Area 2014 (ha)	Net GHG removals 2011 C_{AR_VCS,t_2} (tCO ₂ e)	Net GHG removals 2014 C_{AR_VCS,t_3} (tCO ₂ e)	Number of VCUs 2011 - 2014
Planting year 1995	689	689	59,756	73,219	13,463
Planting year 1996	592	592	100,474	118,337	17,863
Planting year 1997	169	169	37,576	45,096	7,520
Planting year 1998	360	360	56,008	72,335	16,326
Planting year 1999	565	565	71,540	86,409	14,869
Planting year 2000	339	340	38,628	50,611	11,982
Planting year 2002	16	16	1,470	1,701	230

Planting year 2003	21	21	2,024	2,243	219
Planting year 2004	98	98	5,192	8,093	2,901
Planting year 2005	285	285	18,000	20,976	2,977
Planting year 2006	80	80	7,220	9,175	1,956
Planting year 2007	90	90	2,897	6,648	3,752
Planting year 2008	116	116	6,343	4,710	-1,633
Planting year 2009*	-	105	2,013*	3,845	1,832
Planting year 2010*	-	100	1,908*	4,697	2,790
Natural Regeneration	2,593	2,592.92	399,010	503,098	104,088
Dead Wood correction**			-20,068**	-	20,068**
Total	6,011	6,217	789,991	1,011,194	221,203

*New compartments added to project area during monitoring campaign 2014, therefore the initial baseline carbon stock value of 19.1 t CO₂-e/ha is used as carbon stock in t₂ (see section 4.2).

** As described in the monitoring report of 2011 (Banda, 2011), the monitoring results in t₂ (2011) need to be corrected since dead wood was mistakenly included as carbon pool in monitoring results. The total value of the dead wood carbon pool in the compartments in t₂ (2011) was 20,068 t CO₂-e. To correct this error, the total value for dead wood carbon in 2011 is subtracted from total results for 2011.

The total number of VCUs for the monitoring period $T = t_3 - t_2$ (2011-2014) is:

$$\text{VCUs} = 1,011,194 - 789,991 = 221,203$$

The percentage of VCU's to be deposited in the AFOLU Pooled buffer account is 10% = 22,120 (see Non-Permanence Risk Report 2015).

NET VCUs after buffer subtraction = **199,083**

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APPENDIX 1: DBH-HEIGHT MODEL PARAMETERS

<Attached as excel spreadsheet in separate file>

APPENDIX 2: FRESH WEIGHT TO AIR-DRY WEIGHT CONVERSION COEFFICIENTS

<Attached as excel spreadsheet in separate file>

APPENDIX 3: MONITORING RESULTS 2014

<Attached as excel spreadsheet in separate file>

APPENDIX 4: QC RESULTS 2014

<Attached as excel spreadsheet in separate file>