INDIA SUNDARBANS MANGROVE RESTORATION

Document Prepared By NEWS & UNIQUE forestry and land use

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

This grouped project started in 2010 with the goal of restoring mangrove ecosystems in the Indian Sundarbans. The first project activity instances aimed to bring 4,404 ha under restoration over five years – from 2010 to 2015 – through planting and enhancing natural regeneration and restoration. At the time of this first verification, most of the project activities have been implemented as described in the PD. These include:

1. Site and species selection;

2. Seed selection and raising seedlings and saplings in tree nurseries;

3. Planting by communities and NEWS, and the maintenance of the planted seedlings;

4. Training in raising of seedlings, and maintenance/tending of restored sites.

For a detailed description of activities, please refer to the Project Description. The restoration campaigns planned and undertaken for the first instances are summarized in the table below. The areas subject to this verification have been planted and restored within a 5-year period from 2010 to 2014. The areas are stratified into two baseline strata and 4 monitoring strata. The baseline strata distinguish one stratum without pre-existing biomass during the year of plantation whereas the so-called dwarf mangrove baseline stratum is characterized by pre-existing shrubby (dwarf) mangroves and some scattered pre-existing trees which were restored through gap plantation and protection by NEWS. The monitoring stratum 4 is synonymous to this dwarf baseline stratum. Monitoring strata 1-3 reflect different growing conditions with stratum 1 being the best performing plantations and stratum 3 reflecting either very young plantations or relatively insignificant growth performance. For stratum 3, no carbon from tree biomass is accounted during this verification.

Table 1 5-year NEWS plantation and restoration campaigns encompassing the first project activity instances

Year of plantation/ restoration start	Areas of 1st project instances	
	Zero baseline stratum and monitoring strata 1-3 (ha)	Dwarf mangrove baseline stratum and monitoring stratum 4 (ha)
2010	190.2	160.4
2011	371.9	64.9
2012	718.2	218.7
2013	937.9	243.6
2014	1108.4	389.8
Sub-total	3,326.5	1,077.4
Total first activity project instance	4,404	

In addition, a fifth stratum is incorporated into the general NEWS project management and implementation, however, this stratum is excluded from the carbon project areas being not

eligible under the VCS ARR project activity since these areas are already established mangrove forests at project start which are further protected by NEWS (in fact many of these forests will only survive because NEWS is working in the surrounding areas creating larger mangrove forest corridors).

The total GHG emission reductions or removals generated in this monitoring period 28-09-2010 to 28-02-2015 are 88,331.7 tCO2-e.

1.2 Sectoral Scope and Project Type

The project falls under the VCS sectoral scope 14: "Agriculture, Forestry and Other Land Use" as Afforestation, Reforestation and Revegetation (ARR) AFOLU project category. The project is a grouped project.

1.3 Project Proponent

Organization name	Livelihoods Fund
Contact person	Mr. Jean-Pierre Rennaud
Title	General Manager
Address	15 rue de Helder; 75009; Paris; France
Telephone	+33 1 44 35 20 84
Email	jprennaud@livelihoods-venture.com

1.4 Other Entities Involved in the Project

Organization name	Nature Environment and Wildlife Society (NEWS)
Role in the project	Project development and implementation
Contact person	Ajanta Dey
Title	Joint Secretary and Project Director
Address	10, Chowringhee Terrace; Kolkata - 700020; West Bengal; India
Telephone	+91 33 22234148
Email	ajanta@naturewildlife.org

Organization name	UNIQUE forestry and land use GmbH
Role in the project	Carbon project development support
Contact person	Matthias Seebauer
Title	AFOLU carbon project development expert

Address	UNIQUE forestry and land use GmbH Schnewlinstraße 10 79098 Freiburg, Germany
Telephone	+49 7612085340
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1.5 Project Start Date

The start date of the project activity is 28-09-2010.

1.6 Project Crediting Period

Project crediting period: 28-09-2010 – 27-09-30

Total numbers of years: 20 years

1.7 Project Location

The grouped project is located in West Bengal district, India, in the South of the Dampier Hodges line, between the following coordinates:

Latitude: 21° 30´ - 22°45´ N

Longitude: 88°00´-89°05´ E

The project's outer boundary and the first project activity instances are shown in the map below (Figure 1).

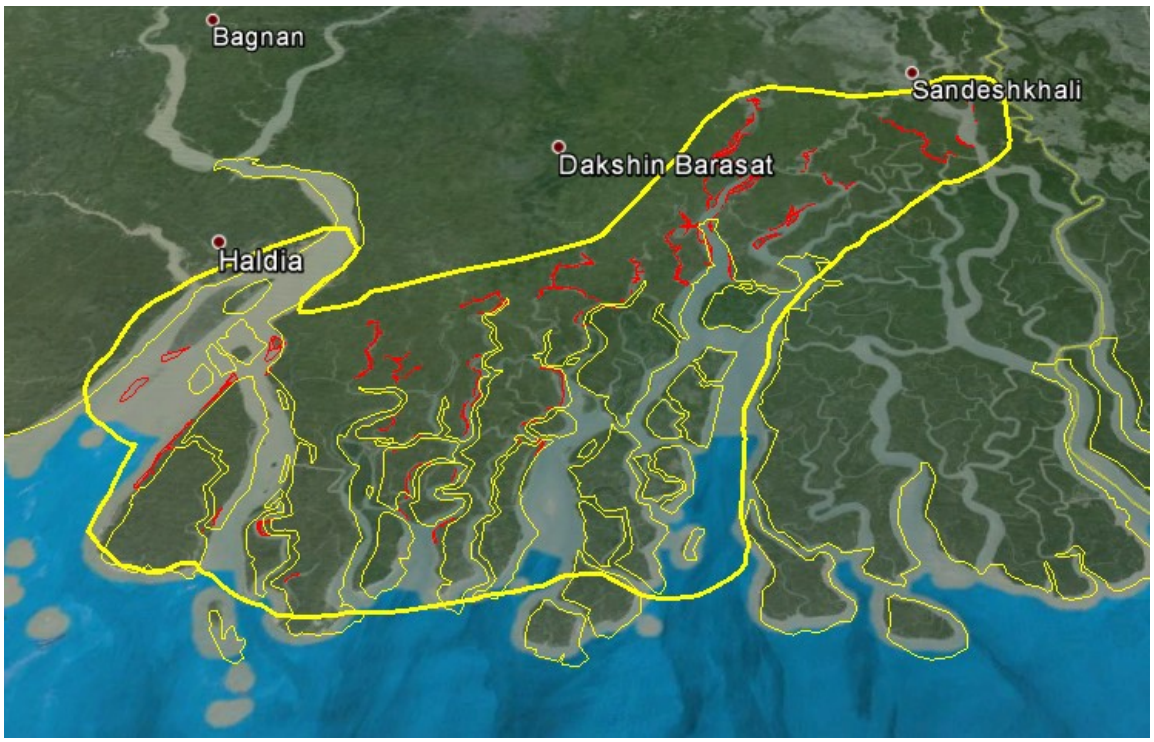


Figure 1 Outer project boundary in thick yellow line; first project activity instances in red

The project area for this monitoring period encompasses 342 plantation and restoration plots/sites. The project area is divided into different zones to organize the activities and NEWS field coordination. This is summarized in the table below.

Table 2 Zonal distribution of the NEWS project area (1st activity instances)

Zone	No of restoration plots/sites	Total area (ha)	Average size (ha)
Bidya	34	207.5	6.1
Matla	124	1,640.0	13.2
Raimongal	30	192.3	6.4
Sagar	29	1,386.9	47.8
Saptamukhani	125	977.2	7.8
Total	342	4,403.9	12.9

The geographic locations and boundaries of each discrete site/parcel is determined using a GPS, and are identified with a unique number and geographic coordinate. An example is shown in the Google Earth Map below (Figure 2).

Figure 2 Plot M 44 (red outline)

The details of each plot of land subject to planting/restoration are enclosed in the supporting documentation. The location of the planting plots/sites in each village with detailed information are contained in Google Earth image (kml file) or shapefiles.

1.8 Title and Reference of Methodology

AR-AM0014: Afforestation and reforestation of degraded mangrove habitats (Version 3.0[1]).

A/R methodological tools:

- "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities" (Version 01)
- "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0)
- "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities" (Version 03.0)

[1] https://cdm.unfccc.int/methodologies/DB/KMH6O8T6RL3P5XKNBQE2N359QG7KOE

- "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" (Version 04.1)

- "Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity" (Version 02.0)

Other methodological A/R CDM tools which are applied:

- Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities (Version 01.0.0)

- Calculation of the number of sample plots for measurements within A/R CDM project activities (Version 2.1.0)

1.9 Other Programs

This project started validation process under A/R CDM. Then the project proponent decided to switch from the CDM process to the validation and verification process under the VCS. Hence, the project is listed as 'unvalidated' project on the UNFCCC website[2] since the validation was not completed.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The NEWS plantation and restoration campaigns started in September 2010. As detailed in tables 1 and 2 above the implementation status is 4,404 ha. The project activities are implemented as described in the PD, which has been prepared after project start. Both the monitoring report and the Non-Permanence Risk assessment report have also been prepared simultaneously with the PD, assuring congruence among the different documents.

2.2 Deviations

2.2.1 Methodology Deviations

There are no deviations from the methodology.

2.2.2 Project Description Deviations

Project Description deviations have not occurred in this first verification period.

2.3 Grouped Project

This project is a grouped project. The first project activity instances, which is the subject of this first verification, has 4,404 ha as outlined in section 2.1.

[2] http://cdm.unfccc.int/Projects/Validation/DB/OHBNWZ0ZO8WGG9LNQM6R28S8OQSPIO/view.html

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	$\Delta C_{BSL,t}$
Data unit	t CO2-e
Description	Baseline net GHG removals by sinks in year t
Source of data	Calculated
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	The project area is stratified into zero baseline and dwarf mangrove baseline stratum considering as shrubs according to the AR CDM tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities". Based on this, no removals by sinks are assumed
Purpose of Data	Calculation of ex-ante and ex-post baseline emissions
Comments	-

Data / Parameter	CF_{TREE}
Data unit	t C (t d.m.)-1
Description	Carbon fraction of tree biomass
Source of data	Default value of AR CDM tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" is applied.
Value applied:	0.47
Justification of choice of data or description of measurement methods and procedures applied	According to AR-TOOL14, the above default value (0.47) should be used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Determination of project emission/removals
Comments	-

Data / Parameter	R_j
Data unit	Dimensionless
Description	Root-shoot ratio for tree species *j*
Source of data	Application of the following equation from the AR-TOOL14:

	R_j=exp[-1.085+0.9256*ln(AGB)]/AGB Where AGB is the above-ground tree biomass per hectare (in t d.m. ha^{-1})
Value applied:	See database
Justification of choice of data or description of measurement methods and procedures applied	According to AR-TOOL14, root-shoot ratio for tree species shall be calculated with the formula: Rj=exp[-1.085+0.9256*ln(AGB)]/AGB
Purpose of Data	Calculation of project emission removals
Comments	-

Data / Parameter	$f_j(x_{1,I},x_{2,I},x_{3,I},...)$
Data unit	t d.m (tone of dry matter).
Description	Above-ground biomass of the tree returned by the allometric equation for species *j* relating the measurements of tree *i* to the above-ground biomass of the tree.
Source of data	For ex-ante: Ray et al. (2011)[3] biomass allometric equation For ex-post: biomass allometric equation from Komiyama *et al.*, 2005 as cited in CIFOR, 2012 - based on the geographical location and the size of the trees.
Value applied:	For ex-ante: AGB = $1.3799*(H)^{0.687}*(DBH)^{0.955}$ Where: AGB = Above-ground biomass; t d.m DBH = Diameter at breast height; cm H = Height (m) For ex-post for trees: AGB = $0.251*\rho*DBH^{2.46}$ Where: AGB = Above-ground biomass; t d.m DBH = Diameter at breast height; cm ρ = wood density; g/cm^3 For ex-post for saplings: $Ln(AGB)=b_0+b_1*Ln(D_{30})$ Where: AGB = Above-ground biomass; t d.m D = Diameter at height of 30cm from the ground; cm b_0 = 4.310 b_1 = 1.124
Justification of choice of data or description of	Both allometric equations are appropriate as determined by the A/R Methodological Tool “Demonstrating appropriateness of

[3] Ray, R. Ganguly, D., Chowdhury, C., Dey, M., Das, S., Dutta, M.K., Mandal, S.K. (1011). Carbon sequestration and annual increase of carbon stock in a mangrove forest. Atmospheric Environment 45 (2011) 5016-5024.

measurement methods and procedures applied	allometric equations for estimation of aboveground tree biomass in A/R CDM project activities"
Purpose of Data	Calculation of project emission removals
Comments	-

Data / Parameter	$dSOC_t$
Data unit	t C ha^{-1} yr^{-1}
Description	The rate of change in SOC stocks within the project boundary, in year t.
Source of data	Default value obtained from project methodology: AR-AM0014
Value applied:	1.62
Justification of choice of data or description of measurement methods and procedures applied	Default value based on the"IPCC 2013 Supplement to the 2006 guidelines: Wetlands" [4]
Purpose of Data	Calculation of project emission removals
Comments	-

Data / Parameter	$EF_{CH4,i}$
Data unit	g CH_4 (kg dry matter burnt)$^{-1}$
Description	Emission factor for CH_4 in stratum *i*
Source of data	CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	A default value of 6.8 from the above CDM A/R Methodological Tool is used.
Justification of choice of data or description of measurement methods and procedures applied	A default value is used since values are not available from sources numbered a., b., and c. described below. According to the above CDM A/R Methodological Tool, values may be selected from the following sources, in order of preference: a. Regional/national inventories e.g. national forest inventory, national GHG inventory; b. Inventory from neighbouring countries with similar conditions; c. Globally available data applicable to the project site or to the region/country where the site is located;

[4] http://www.ipcc.ch/meetings/session37/Doc_8b_Rev_2_Accepted_Report_Wetlands.pdf

	d. Default values
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	$EF_{N2O,i}$
Data unit	g N_2O (kg dry matter burnt)$^{-1}$
Description	Emission factor for N_2O in stratum *i*
Source of data	CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	A default value of 0.2 from the above CDM A/R Methodological Tool is used.
Justification of choice of data or description of measurement methods and procedures applied	A default value is used since values are not available from sources numbered a., b., and c. described below. According to the above CDM A/R Methodological Tool, values may be selected from the following sources, in order of preference: a. Regional/national inventories e.g. national forest inventory, national GHG inventory; b. Inventory from neighbouring countries with similar conditions; c. Globally available data applicable to the project site or to the region/country where the site is located; d. Default values;
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	GWP_{CH4}
Data unit	Dimensionless
Description	Global warming potential for CH_4
Source of data	CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	21
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of ex-post project emissions

Comments	-

Data / Parameter	GWP_{N2O}
Data unit	Dimensionless
Description	Global warming potential for N_2O
Source of data	CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	310
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	$COMF_i$
Data unit	Dimensionless
Description	Combustion factor for stratum *i*
Source of data	CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	The corresponding default according to the age is used, unless transparent and verifiable information can be provided to justify a different value:

Mean age (years)	Default value
3-5	0.46
6-10	0.67
11-17	0.50
18 and above	0.32

Justification of choice of data or description of measurement methods and procedures applied	A default value is used since values are not available from sources numbered a., b., and c. described below. Default emission factor for tropical forest from the CDM A/R tool. According to the above CDM A/R Methodological Tool, values may be selected from the following sources, in order of preference: a. Project-specific calculation, regional/national inventories

	e.g. national forest inventory, national GHG inventory; b. Inventory from neighbouring countries with similar conditions; c. Globally available data applicable to the project site or to the region/country where the site is located d. Default values
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	*E*
Data unit	t d.m. (or t d.m. ha^{-1})
Description	Acceptable margin of error (i.e. one-half the confidence interval) in estimation of biomass stock within the project boundary
Source of data	AR-TOOL14
Value applied:	10% of the mean value of biomass stock
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	t_{val}
Data unit	Dimensionless
Description	Two-sided Student's t-value at infinite degrees of freedom for the required confidence level
Source of data	AR-TOOL14
Value applied:	According to the student's t-distribution table, 1.645 for confidence level 90% and infinite degrees of freedom
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of ex-post project emissions
Comments	The value used is for the 90% confidence level for determination of biomass stock prescribed in the A/R CDM project activities since a different confidence level is not prescribed in the

	methodology.

Data / Parameter	DF_{DW}
Data unit	Percent
Description	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass
Source of data	A/R Methodological tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities
Value applied:	6%
Justification of choice of data or description of measurement methods and procedures applied	Default value depending on the biome, elevation and precipitation of the area. The tool recommended this value unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Calculation of ex-post project emissions
Comments	-

3.2 Data and Parameters Monitored

Data / Parameter	A_i
Data unit	Ha
Description	Area of tree biomass stratum *i*
Source of data	GIS and GPS
Description of measurement methods and procedures to be applied	Areas in project area is tracked in the field using the GPS. Each planting area is tracked as a standard procedure of the baseline and monitoring inventory.
Frequency of monitoring/recording	Before the start of the project (planting) and adjusted thereafter every three years since the year of the initial verification
Value applied:	See project database and project shape files
Monitoring equipment	GPS (Garmin), GPS Smartphones, QGIS software
QA/QC procedures to be applied	Field teams are trained in the proper use of GPS/GIS application, and they are all fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of data	Calculation of project emissions
Calculation method	Use of GIS tool
Comments	-

Data / Parameter	n_i
Data unit	Dimensionless
Description	Number of sample plots in stratum *i*
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	n_i is calculated for each monitoring event, at least every five years.
Value applied:	The following values are estimated from the first project activity instance:

Stratum	n_i
1	37
2	49
3	0 (no decrease stratum for biomass)
4	30

Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	The calculation method is described in the tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" (version 02.1.0)[5]
Comments	-

Data / Parameter	w_i
Data unit	Dimensionless
Description	Relative weight of the area of stratum i, the area of the stratum i divided by the project area.
Source of data	Calculated as the area of the stratum *i* divided by the project area.
Description of measurement methods	N/A

[5] Annex 15 of the Executive Board report at its 58th meeting.

and procedures to be applied	
Frequency of monitoring/recording	Calculated for each monitoring event, at least every five years
Value applied:	The following values are estimated from the first project instance:

Stratum	w_i
1	0.11
2	0.53
3	0 (no decrease stratum for biomass)
4	0.36

Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	Area of the stratum i divided by the project area
Comments	-

Data / Parameter	s_i
Data unit	t d.m. (or t d.m. ha^{-1})
Description	Estimated standard deviation of biomass stock in stratum i
Source of data	Inventory or default value
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	s_i is calculated for each monitoring event, at least every five years
Value applied:	The following values are estimated from the first project activity instance:

Stratum	s_i
1	23.8
2	14.5
3	0 (no decrease stratum for biomass)
4	24.1

Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	Excel or tool available to calculate standard deviation
Comments	-

Data / Parameter	$A_{PLOT,i}$
Data unit	Ha
Description	Size of sample plot in stratum i
Source of data	Field measurement
Description of measurement methods and procedures to be applied	After calculating the number of sample plots required to achieve the desired precision level (90/10) a stratified random selection is carried out. A circular plot design of 2m or 3 m radius are used – the plots sizes are varied with the aim to achieve 15 trees per plot.
Frequency of monitoring/recording	Every three years since the year of the initial verification
Value applied:	0.0028 (3m radius) and 0.0013 (2m radius)
Monitoring equipment	N/A
QA/QC procedures to be applied	Field teams are trained in all inventory procedures including layout of plots – as described in the Pilot Inventory, Sampling & Monitoring Plan. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible. Finally, a quality check is undertaken as part of inventory to identify and correct errors if any.
Purpose of data	Calculation of project emission removals
Calculation method	The estimate is size is based on the expected density (trees/ha) in each stratum, with the objective of having around 15 trees per sample plot.
Comments	-

Data / Parameter	$A_{BURN,i,t}$
Data unit	Ha
Description	Area burnt in stratum i
Source of data	Field measurement, remote sensing measurement or any other spatial information available

Description of measurement methods and procedures to be applied	The area is delineated on the ground using GPS, or georeferenced remote sensing data or from any other spatial information available.
Frequency of monitoring/recording	The area burnt is measured whenever forest fire has occurred.
Value applied:	N/A, wildfires did not occur in any mangrove forests in the Sundarbans in this monitoring period
Monitoring equipment	GPS
QA/QC procedures to be applied	Field teams are trained in the correct use of GPS. They are also made fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of data	Calculation of project emissions/removals
Calculation method	N/A
Comments	Applicable only if wild fires occurs.

Data / Parameter	X_i
Data unit	Variable
Description	Variables measured per tree for the calculation of above-ground biomass applying an allometric equation: DBH, height, D_{30},
Source of data	Measured
Description of measurement methods and procedures to be applied	DBH and D_{30} readings are taken from a caliper/ diameter tape at 1.3 m along the stem (for DBH) or at 30 cm from the ground for D_{30}. Height – readings are taken on calibrated pole placed along the longitudinal axis of the tree.
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value applied:	n.a.
Monitoring equipment	DBH and D_{30}, a caliper/ diameter tape is used. Height, a calibrated pole is used.
QA/QC procedures to be applied	Field teams are trained in all inventory procedures including correct measurement – as described in the Pilot Inventory, Sampling & Monitoring Plan. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible. Finally, a quality check is undertaken as part of inventory to identify and correct errors if any.
Purpose of data	Calculation of project emissions/removals

Calculation method	n.a.
Comments	D_{30}, only for the first verification

Data / Parameter	*T*
Data unit	Year
Description	Time period elapsed between two successive estimations of carbon stock in a carbon pool
Source of data	Recorded time
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	N/A
Value applied:	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emission removals
Calculation method	N/A
Comments	If the two successive estimations of carbon stock in a carbon pool are carried out at different points of time in year t_2 and t_1, (e.g. in the month of April in year t_1 and in the month of September in year t_2), then a fractional value will be assigned to *T*

3.3 Monitoring Plan

Organizational structure

Institutionally, a permanent NEWS Carbon Survey Team has been set up consisting of 4 field teams made of 2-3 zonal field officers – under the supervision of the project coordinator (Mrs Ajanta Dey) and carbon monitoring coordinator (Mr. Dibyajyoti Chatterjee). These teams will undertake all boundary demarcation surveys in the project to ensure consistency in measurements and will implement the carbon monitoring inventory of permanent sampling points (PSPs). Further, NEWS and Livelihoods have set up a stringent verification system with external tree audits including annual boundary verification and revision, if required.

The organizational structure of the monitoring is divided into two layers. The first layer is represented by the NEWS field staff who are trained to perform the forest inventory, boundary tracking with GPS, socio-economic monitoring and forest establishment monitoring (survival rate,

nursery monitoring, etc.). More than 20 field officers of NEWS are responsible for the different zones of the project areas ranging from the western region to the central parts of the Indian Sundarbans. Generally they are part of the communities and are well acquainted with the specific conditions within the different planting areas. The forest inventory and monitoring surveys are conducted by them in the field (as part of the carbon survey teams). All results are directly brought to the main office of NEWS in Kolkata - the second layer of the organizational structure of monitoring of the project. Ajanta Dey and the NEWS technical program coordinators are responsible for the technical implementation of the whole project. In the main office, the data are processed, analyzed and archived following standard operation procedures and good practice guidelines e.g. Pilot Inventory, Sampling & Monitoring Plan. To ensure reliability of the results, the NEWS technical program coordinators will periodically crosscheck the data in the field as an independent survey. It is envisaged to at least verify 10% of the data after each inventory or survey conducted.

Monitoring include the following aspects:

1. Establishment of survival counts and replanting

The establishment and management of the restored plots/sites will be monitored as part of the carbon monitoring plan. Regular plantation audits are conducted by NEWS and an external auditor. This include the following tasks:

- Selecting randomly and verifying the GPS location of at least 10% of the plots/sites planted during a particular planting season;
- Comparing the trees planted with the trees recorded in the planting plans;
- Assessing the survival (in %) of the mangrove seedlings and preparation of a report with the findings considering a minimum precision of 10% at the 90% confidence level. Replanting of mangroves is only necessary if the optimal tree density of 2,500 trees per ha is not achieved due to very high natural mortality. This has to be decided on a site-by-site basis due to the varying local tidal and ecological conditions.
- Area verification: the area of the restored plots/sites are verified using GPS in the field as well as through Google Earth imagery analysis.

Annual tree audit reports are provided as supporting documentation.

2. Livelihoods Standard Monitoring

The Livelihoods Fund has established a standard monitoring process for all Livelihoods projects. For this project, an extensive monitoring training was conducted in October 2013 – focused on Standard Operating Procedures (SOPs) for monitoring carbon in land based carbon projects. Generic SOP documents related to various procedures throughout the whole monitoring process were elaborated. From this a NEWS Pilot Inventory Sampling Monitoring Plan for this project has been compiled. The full monitoring SOP is available as supporting documentation; a short summary is illustrated in the Figure 3 below.

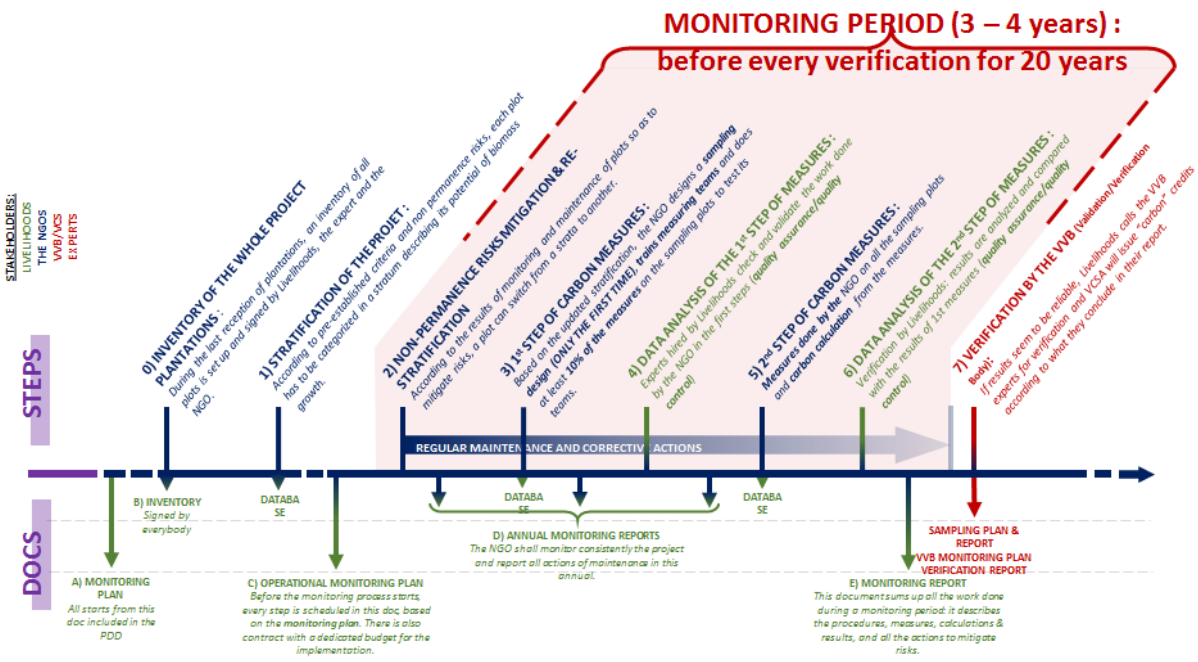


Figure 3 Standard monitoring process for Livelihoods projects

3. Geographic coordinates of the project boundary

All project areas subject to mangrove plantations and restoration under this project activity will be delineated using GPS tracking function. For this, an extensive training has been conducted and up-to-date GPS portable devices purchased (i.e. Garmin etrex). Each planting plot, having been assigned a unique ID, is tracked and the tracks are downloaded and recorded as Google Earth *kml* file, and as *gpx* file. This allows for further processing of the tracks in GIS.

Monitoring of the project boundary comprise the following activities:

- Review of entire project boundary to assess on-going afforestation/restoration activities, successes/failures – site by site.
- Geo-referencing (latitude and longitude) of each plot subject to planting/restoration as part of the NEWS project using GPS and GIS applications.
- Periodic checking that the project boundaries correspond to the defined boundaries and are consistent with the eligibility analysis.
- There will be periodic verifications of the project boundary during the crediting period. If there are boundary changes due to natural causes (pests, diseases, fire, etc.) or anthropogenic damages (harvests, or deforestation), these areas will be located and their extent determined to facilitate assessment of the carbon loss. Such areas will be treated as different strata from those initially established. The modified boundaries will be reported to the VVB during the subsequent verification.

- Areas where planting failed or the use of the land changed will also be documented.

- Ultimately, analysis of the field information obtained using a GIS system (QGIS) to calculate the areas subject to restoration/tree planting plan, and those affected by disturbances will be carried out.

All NEWS staff members have received a 3-days training in GPS boundary demarcation (GPS tracking), data processing, data analyzing and data archiving. During this training, a standard operating procedure in geographic boundary demarcation was elaborated. The resultant report: '*GPS data collection, downloading, processing and management report: Sundarbans mangrove project, NEWS, Kolkata*' is available upon request.

4. Identification and monitoring of strata

Initial stratification of the areas has been done ex-ante. It has to be kept in mind that the Sundarbans is a dynamic region, with short- and long-term changes in forest cover and biomass occurrence due to changes in hydrology, sedimentation, disease, and human factors. Thus, a stratification employed today may not be relevant in the future as vegetation communities and lands might have spatially shifted. Therefore, final factors considered for the stratification will be the differences in the estimated sinks for each mangrove species species/ species group as the project develops. For this reason, strata will be monitored periodically. If a change in the number and area of the project strata occurs, the sampling framework will be adjusted accordingly through the following procedure for strata monitoring and sampling framework:

The stratification is based on the initial baseline strata defined for the pre-project biomass stratification, and the growth and survival performance of mangroves after the first 4 years of project implementation as shown below (Figure 4):

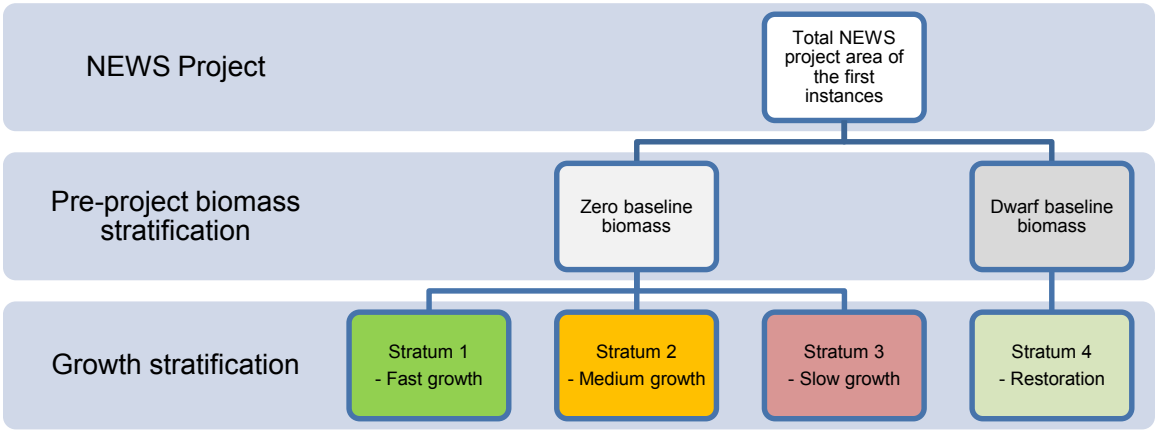


Figure 4 Stratification of the project area

The growth and survival performance was assessed during several tree audits and each plot/sites was categorized according to when the planted mangroves were established and the growth

performance (speed of biomass accumulation). Hence, four strata are defined from the two baseline strata as described below and in Table 1:

Stratum 1 – Fast growth: This stratum represents plantation areas with observed higher rates of growth, with plantation dated between 2010 and 2012, where significant growth began in the same year of planting. No baseline pre-project biomass was present at project start date.

Stratum 2 – Medium growth: This stratum represents plantation areas which were established within the first four years. However, due to higher mortality and replanting activities growth significantly started between 2013 and 2014. No baseline pre-project biomass was present at project start date.

Stratum 3 – Slow growth: This stratum includes plantation areas with a slow rate of growth, where many of the planted trees did not initially survive well and the growth is slow in comparison with the first two strata. For the first verification, tree biomass in this stratum will be accounted as zero carbon, due the insignificant increase of biomass. No baseline pre-project biomass was present at project start date.

Strata 4 – Restoration: This stratum comprises all areas where NEWS is promoting and managing the regeneration and restoration of existing degraded mangroves patches. It includes both planting in gaps to create larger mangrove corridors as well as protection and management of natural regeneration and poorly surviving community plantations. For stratum 4, pre-project shrubby vegetation is included in the baseline (after exclusion of all areas already representing a mangrove forest).

Table 3 NEWS project area stratification

Stratum	Total area (ha)
Stratum 1 – Fast growth	331
Stratum 2 – Medium growth	1,562
Stratum 3 – Slow growth	1,433
Stratum 4 – Restoration	1,077
Total	4,404

A re-stratification might be necessary after each monitoring of the project, if changes that significantly affect biomass distributions occurs.

As this project activity is phased, i.e., the planting/restoration of multi-species mangrove trees is taking place over a period of 5 years, the NEWS project databases shall be updated periodically capturing the following information:

- Unexpected disturbance occurring during the crediting period;

- Unexpected disturbances occurring during the crediting period (changes in hydrology, sedimentation, disease, and human factors), which affect differently different parts of an originally homogeneous stratum;

- Forest establishment (planting, re-replanting) if implemented at different intensities, dates and spatial locations from those stated in the PD.

5. Mangrove carbon inventory

This is undertaken to determine carbon stock change for the verification of the project. Such inventory will be undertaken at each verification event. Below is a summary of the process; for details, refer to the inventory SOP: 'Pilot Inventory, Sampling & Monitoring Plan', which is available as supporting documentation.

Sampling design and sampling size

The sampling design aim to meet the precision requirements outlined in the methodology, i.e., the targeted precision level for biomass estimation shall be ± 10% of the mean at a 90% confidence level. The basic sampling design is chosen in light of the high within-plot variability along a typical gradient in the area from lower to upper mudflats. This necessitates use of a cluster sampling approach.

The Mangrove Forest Management Guidelines (FAO 1994)[6] and the Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forest (CIFOR, 2012) [7] have been used as a guidance to establish the sampling design. The mangrove forest inventory applies permanent sample plots with 3 sub-plots. Each sub-plot has either a 2 m or 3 m radius. The plots are randomly laid out within the NEWS mangrove restoration sites.

The sampling approach used is stratified random sampling. Random sampling is recommended as a good practice in forest inventory when land parcels involved in a project are small, irregularly shaped, or narrow. These conditions exist is this project.

In the first stage, all planting plots subject to monitoring are assigned to the project specific strata. In the second stage from each stratum a representative number of sample plots is picked randomly. Once established, the sample of planting plots is permanent throughout the lifetime of the project.

The survey sample size is determined based on the variability of biomass within the samples and the precision level required in the methodology: 10% error with 90% level of statistical confidence. In other words, the sampling strategy aim to achieve an error with a mean value of 10% or less and that there is a 90% level of statistical confidence that the true amount of carbon sequestered is the claimed amount.

[6] http://www.archive.org/details/mangroveforestma034845mbp
[7] http://www.bluecarbonportal.org/wp-content/uploads/2012/08/USDA_Protocols_measurement-monitoring-reporting_carbon-stocks_2011.pdf

The AR CDM Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" (Version 01)[8] as well as the Winrock Sampling Calculator (Walker et al. 2007) is used to estimate the number of permanent sample plots needed. This applies to project total as well as number of plots per stratum for monitoring changes in carbon pools at a desired precision level and to determine the plot locations. The sample size follows method I, i.e. samples drawn without replacement of the tool, and considers no information on costs is available or the costs are assumed as constant for all strata.

Plot design

The size of the circular plots is determined with the aim of finding an optimal size so that the plot contains an average of 15-25 sample trees for a reliable statistical analysis. The estimation of the plot size is based on the latest tree audit which documents the planting densities in the project. Based on this, the average area occupied per tree is calculated (m²/ha), from which the area for 15 trees required in a sample plot of 3 sub-plots is calculated.

Due to the large variability in tree density in the project, two circles have been defined. The first circle with 2 m of radius is selected for measurement if more than 15 trees are found inside that radius. If the tree number is less than 15, the circle of 3 m radius around is measured. This is illustrated in Figure 5, and the detailed plot layout is illustrated in Figure 6.

[8] http://cdm.unfccc.int/EB/031/eb31_repan15.pdf

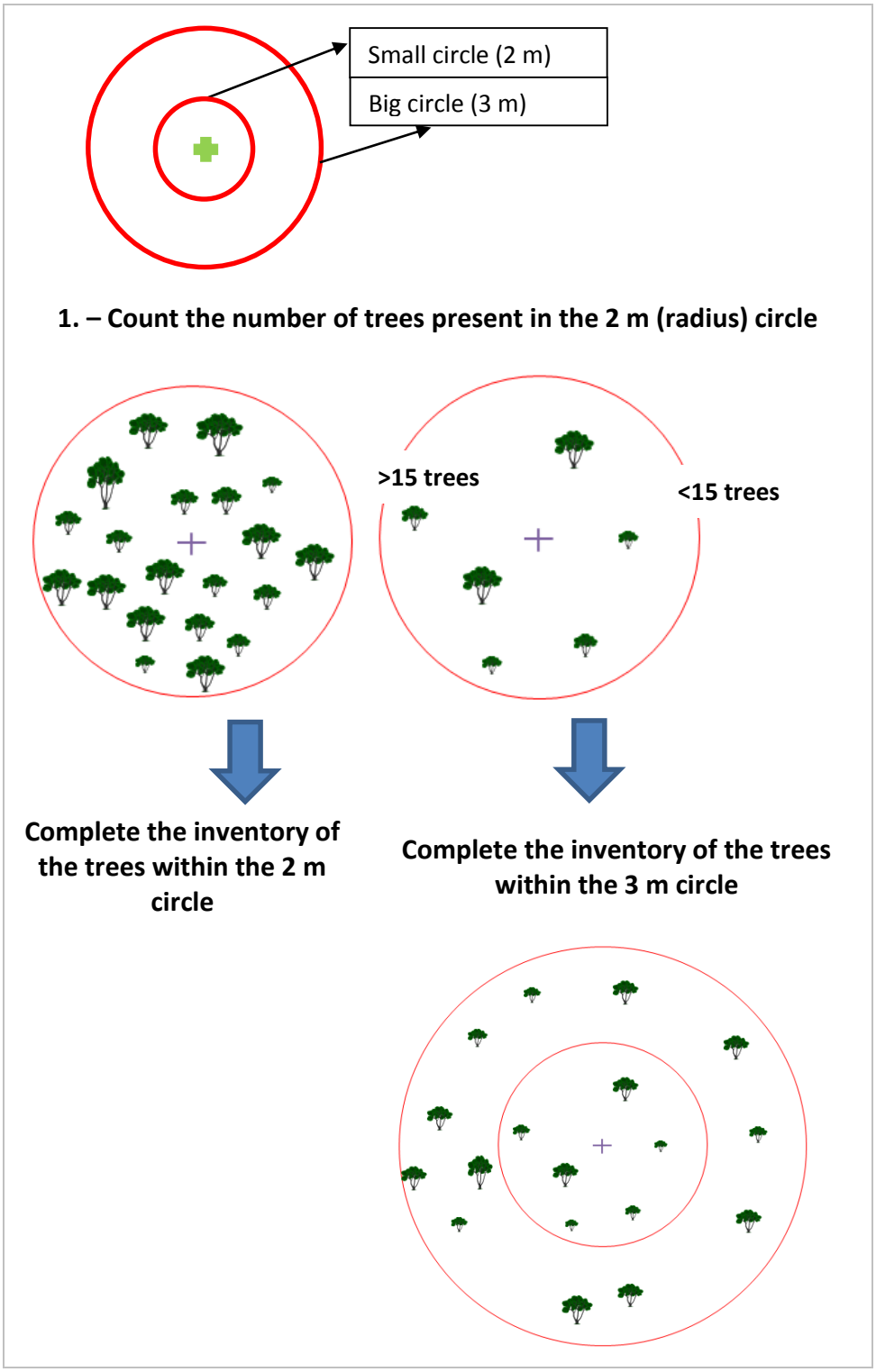


Figure 5 Procedure to determine circle radius of each sub-plot

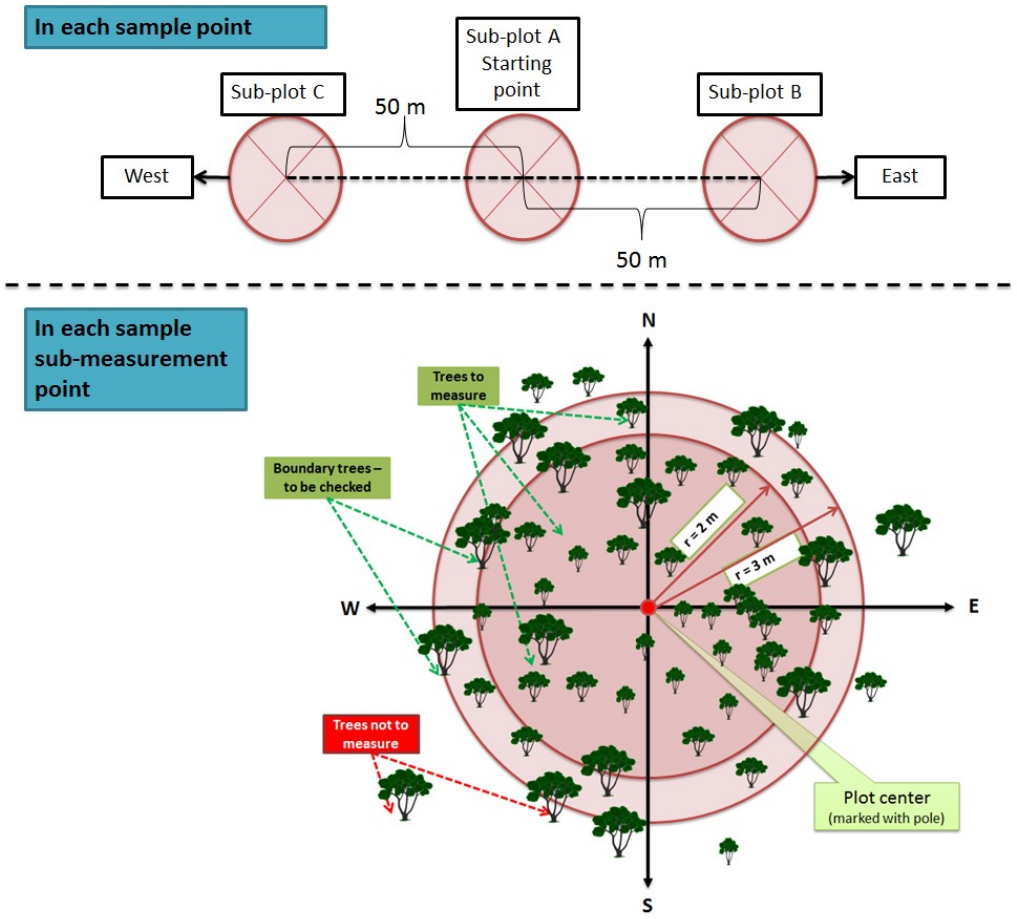
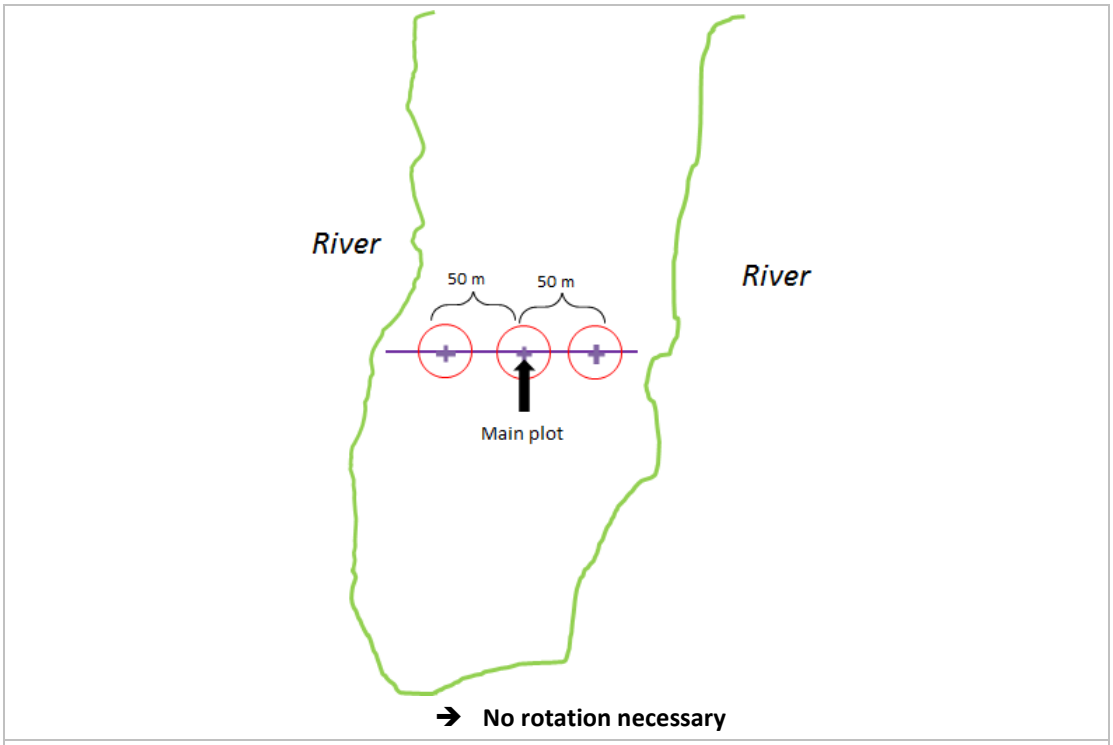
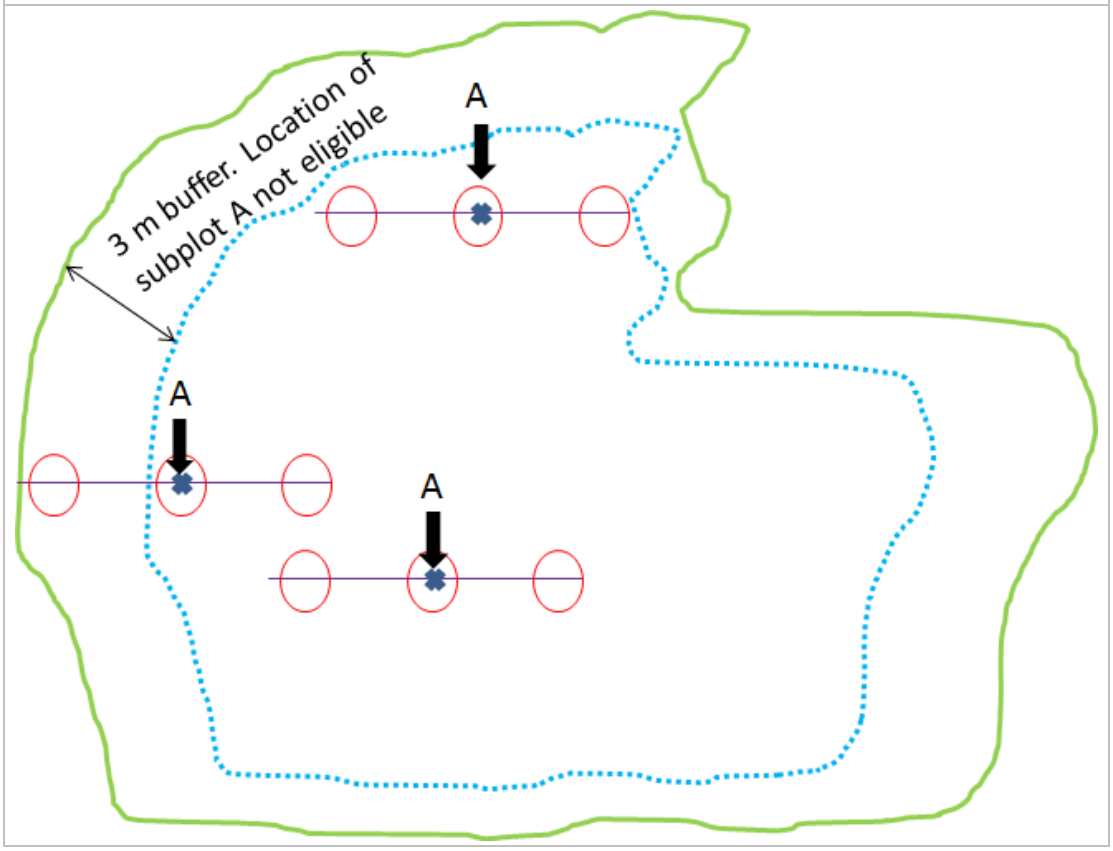


Figure 6 NEWS Carbon inventory plot layout

The starting point for the measurement is sub-plot in the centre (denoted as C), i.e., Sub-plot A in the figure above. The distance between the sub-plots is 50 m.The default orientation of the three sup-plots is west to east as show above. Rotation of any of the sub-plots on both sides of the centre sub-plot is undertaken around the centre sub-plot if the plot falls outside the plantation/restored site. This is shown illustrated in Figure 7 below.



➔ **No rotation necessary**



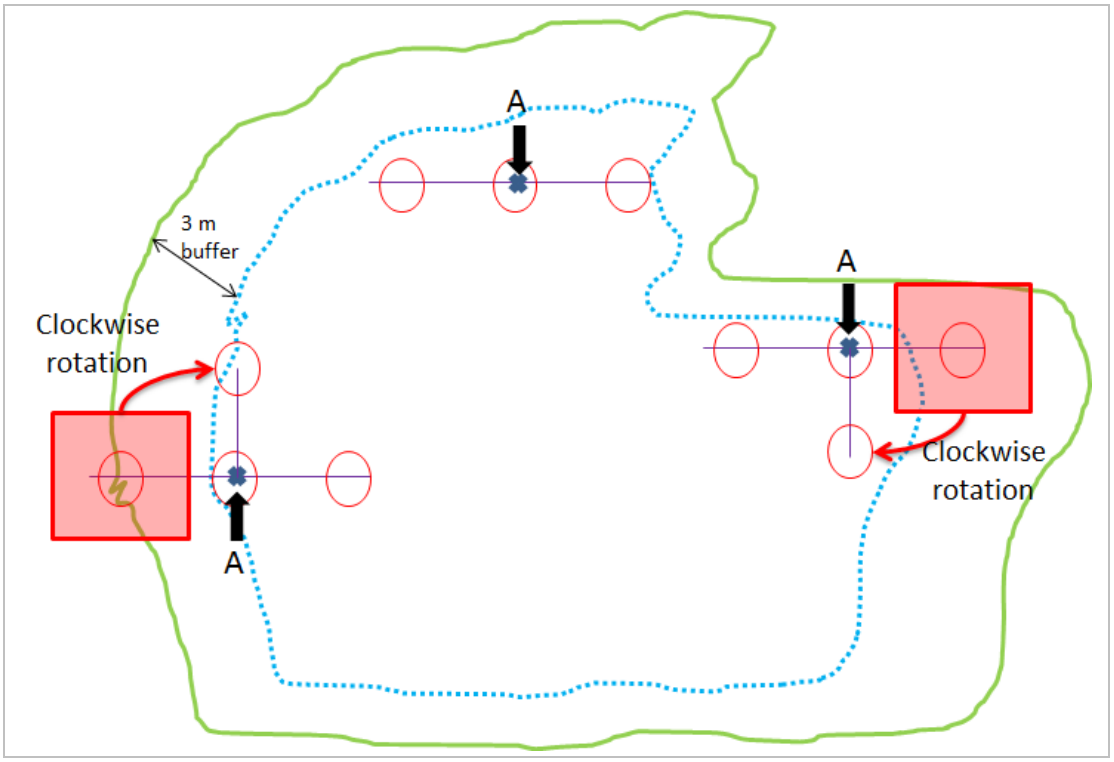


Figure 7 Different conditions of sample plot layouts in the field

Plot selection & location

The locations of the layout of the point centers of each sub-plots (W-E direction) is randomly selected using GIS software, e.g. Quantum GIS. Also coordinates of W-E and N-S points at 50 m from the centre sub-plots are generated using computer/GIS software. This way, the efforts of measuring 50 m distance at certain azimuth in field is reduced. Figure 8 and 9 shows an example of location and layout of plots including the case where rotation is required.

Figure 8 Example of the sub-plots directly selected (W-C-E)

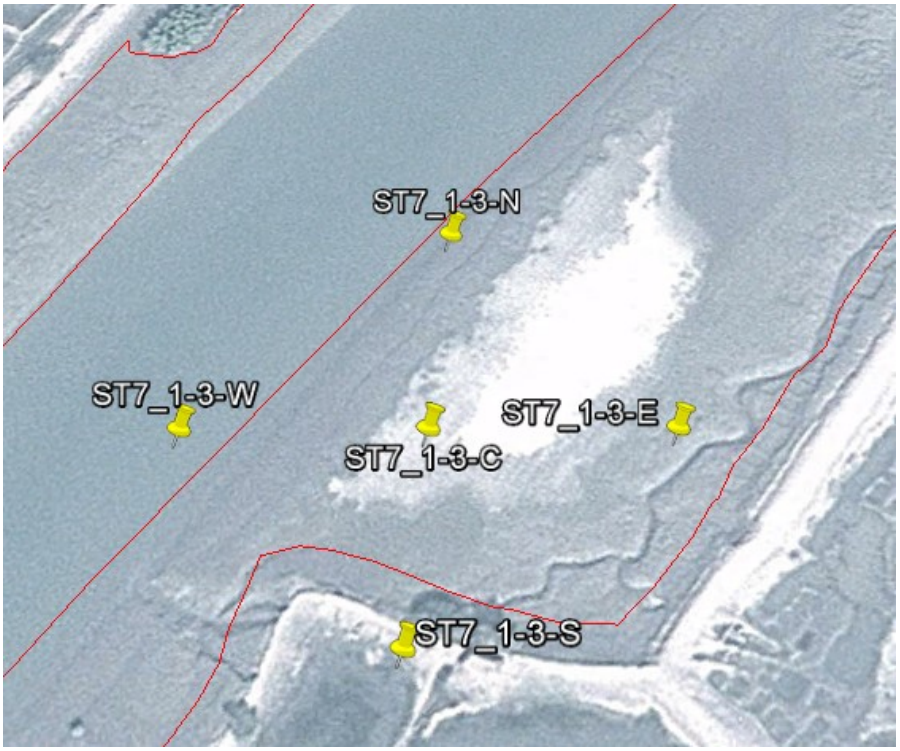


Figure 9 Example of sub-plot with a non-eligible western plot

The sample plot selection and location equally follows the guidance of the “Calculation of the number of sample plots for measurements within A/R CDM project activities” (Version 01) to ensure that

- The planting plots assigned as permanent sample plots are evenly distributed in the stratum. This is done by weighting the sample plots according to the shares of that stratum compared to the total project area, and

- The sample plots will be located randomly in each stratum. To ensure that the process of random selection is unbiased, GIS software is used to randomly select the location of sample plots in each plantation area.

Data collection

A detailed description of the NEWS carbon inventory procedures can be found in the SOPs (supporting documentation) including standard operating procedures on work safety, field measurement planning and organization, navigating in the field, and tree measurement procedures, etc.

In the field, several parameters were assessed/measured. The parameters relevant for the carbon monitoring are the following:

- Species code

- Origin: Classification of the tree according to the origin of the tree: Pre-existen tree, Planted tree or Natural regeneration.

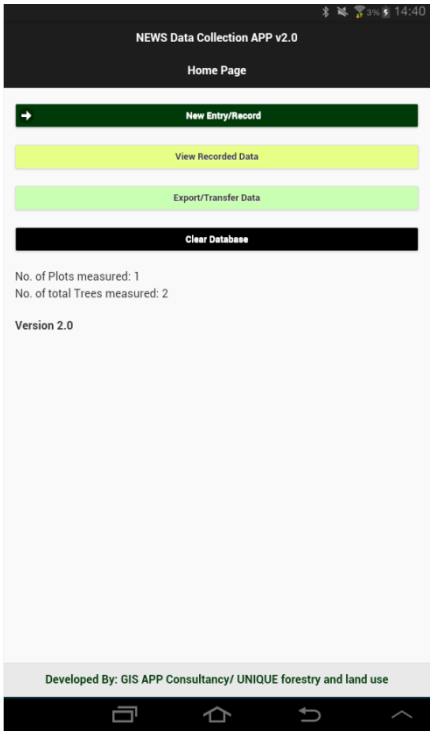
- Size: Classification between trees and saplings.

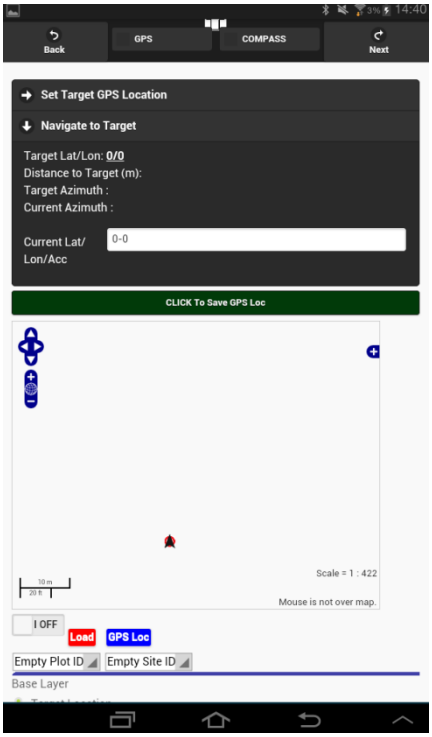
- DBH: Diameter at breast height (1.3). Only measured in trees.

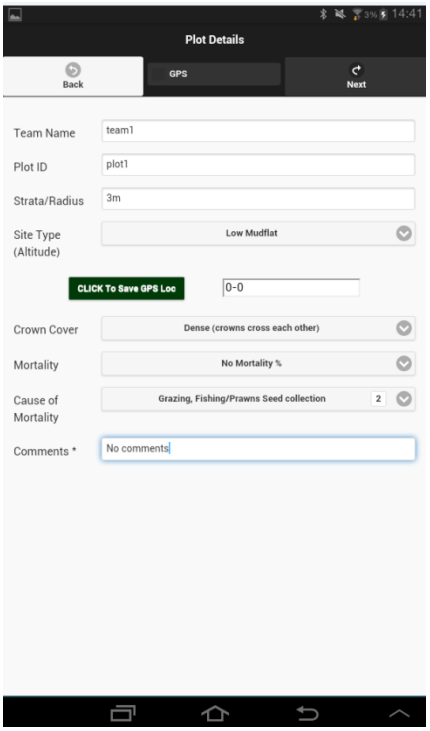
- D_{30}: Diameter of stem at 30 cm aboveground level: Only measured in saplings.

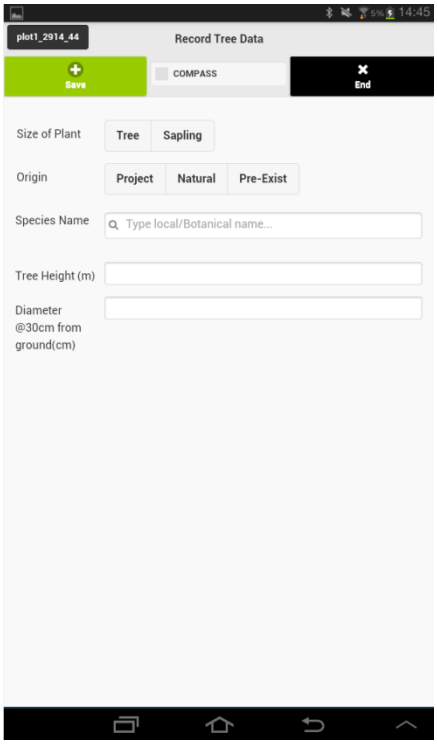
- Total Height: Total tree height of the tree or sapling.

For navigation and data entry of tree and plot variables, a smartphone based inventory application was specifically designed for this project. A snapshot of the interface of the mobile application is shown below:


NEWS Data Collection APP v2.0
Home Page
New Entry/Record
View Recorded Data
Export/Transfer Data
Clear Database
No. of Plots measured: 1
No. of total Trees measured: 2
Version 2.0
Developed By: GIS APP Consultancy/ UNIQUE forestry and land use


Back
GPS
COMPASS
Next
Set Target GPS Location
Navigate to Target
Target Lat/Lon: 0/0
Distance to Target (m):
Target Azimuth :
Current Azimuth :
Current Lat/ Lon/Acc
0-0
CLICK To Save GPS Loc
Scale = 1 : 422
Mouse is not over map.
OFF
Load
GPS Loc
Empty Plot ID
Empty Site ID
Base Layer


Plot Details
Back
GPS
Next
Team Name
team1
Plot ID
plot1
Strata/Radius
3m
Site Type (Altitude)
Low Mudflat
CLICK To Save GPS Loc
0-0
Crown Cover
Dense (crowns cross each other)
Mortality
No Mortality %
Cause of Mortality
Grazing, Fishing/Prawns Seed collection
2
Comments *
No comments


plot1_2914_44
Record Tree Data
Save
COMPASS
End
Size of Plant
Tree
Sapling
Origin
Project
Natural
Pre-Exist
Species Name
Type local/Botanical name...
Tree Height (m)
Diameter @30cm from ground(cm)

Procedures for internal auditing and Quality Assurance/Quality Control

As stated in the IPCC GPG for LULUCF (page 4.111) monitoring requires provisions for quality assurance (QA) and quality control (QC) to be implemented via a QA/QC plan. For this project, QA/QC procedures cover the following aspects:

- Collecting reliable field measurements;
- Verifying methods used to collect field data;
- Verifying data entry and analysis techniques; and
- Data maintenance and archiving.

Procedures to ensure reliable field measurements

Collecting reliable field measurement data is an important step in the quality assurance plan. Those responsible for the measurement work will be trained in all aspects of the field data collection and data analyses. It is good practice for all Livelihoods Projects to develop Standard Operating Procedures (SOPs) for each step of the field measurements, which should be adhered to at all times. These SOPs describe in detail all steps to be taken of the field measurements and contain provisions for documentation for verification purposes so that future field personnel can check past results and repeat the measurements in a consistent manner. The following are measures to ensure the collection and maintenance of reliable field data:

- Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible;
- Field teams install test plots if needed in the field and measure all pertinent components using the SOPs to estimate measurement errors;
- Field teams are trained in all aspects of field measurements including correct application of tools and recording. Documentation is provided to show that field team are trained. The document will list all names of the field team and the project leader will certify that the team is trained;
- New staff adequately trained.

A monitoring training where all relevant monitoring SOPs have been introduced and extensively trained was held as part of the pilot inventory. A standard training agenda was used which can be found in the annex of the SOPs.

Procedures to verify field data collection

To verify that plots have been installed and the measurements taken correctly, it is good practice to re-measure independently 10% of the originally measured plots to compare the measurements. The following quality targets should be achieved for the re-measurements compared to the original measurements:

- Missed or extra trees: no error within the plot
- Tree species or groups: no error
- DBH of tree measurements: < ± 0.5 cm or 3 % whichever is greater
- Height measurements: < ± 10%

At the end of the field work 10% of the plots is independently checked. Field data collected at this stage is compared with the original data. Any errors found will be corrected and recorded. Errors discovered will be expressed as a percentage of all plots that have been re-checked to provide an estimate of the measurement error.

Data maintenance and storage

Because of the relatively long-term nature of the project activities, data archiving (maintenance and storage) will be an important component of the work. Data archiving should take several forms and copies of all data should be made readily available/accessible to project participants.

Copies (electronic) of all field data, data analyses, and models; estimates of the changes in carbon stocks and corresponding calculations and models used; any GIS products; and copies of the measuring and monitoring reports should all be stored in a dedicated and safe place, preferably offsite.

Given the time frame over which the project activity will be implemented, and the pace of production of updated versions of software and new hardware for storing data, it is recommended that the electronic copies of the data and report be updated periodically or converted to a format that could be accessed by any future software application. Copies of all raw data, reports of analysis and supporting spreadsheets will be stored in a dedicated long-term electronic archive for at least 2 years after the end of the last crediting period in 2030.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The baseline net GHG removals by sinks are therefore calculated using Equation 1 of the methodology AR-AM0014:

$$\Delta C_{BSL,t} = \Delta C_{TREE-BSL,t} + \Delta C_{SHRUB-BSL,t} + \Delta C_{DW-BSL,t}$$

Where:

$\Delta C_{BSL,t}$ = Baseline net GHG removals by sinks in year t; t CO_2-e

$\Delta C_{TREE\_BSL,t}$ = Change in carbon stock in baseline tree biomass within the project boundary in year t; t CO_2-e

$\Delta C_{SHRUB\_BSL,,t}$ = Change in carbon stock in baseline shrub biomass within the project boundary in year t; t CO_2-e

$\Delta C_{DW\_BSL,t}$ = Change in carbon stock in baseline dead wood biomass within the project boundary, in year t; t CO_2-e

As indicated in Section 3.1 of the PD, there are two baseline strata distinguished in this project: zero baseline biomass and dwarf mangrove baseline biomass.

Zero Baseline Biomass (project strata 1-3):

The carbon stocks and carbon stock changes of trees and shrubs in the baseline is estimated as zero following the conditions outlined in chapter 5 of the A/R Methodological tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" (Version 04.1). The existence of baseline trees is monitored throughout the crediting period of the project activity consistent with the baseline scenario.

Dwarf mangrove baseline biomass (project stratum 4):

Apart from establishing new mangrove plantation, a core activity in this project is to restore degraded mangrove 'chars' through community based protection and management. Therefore, a large share of the project areas is characterized by pre-existing vegetation prior to project start. The origin of this pre-project biomass is either from natural regeneration or community plantation with poor survival rates. Most of this vegetation is characterized as shrubby or dwarf mangroves which normally occur in degrading areas where nutrients, freshwater, and inundation by tides are all limited. Any mangrove species can be dwarfed, with trees generally limited in height to approximately 1 meter or less. Apart from this, also scattered pre-existing mangrove trees are present on such areas.

Therefore, a classification method for the year 2010 was applied to first identify and conservatively exclude 'normal' mangrove forest patches from these areas (which are classified as stratum 5 and excluded from this carbon project) and then further assess the crown cover of the dwarf (shrub) vegetation as well as the crown cover of any scattered pre-existing mangrove trees. See PD, section 3.1 for further description of the baseline classification method.

Shrub baseline biomass

Shrub carbon stock changes in this stratum have been estimated as zero as explained in PD. Baseline carbon stocks in shrubs are calculated following the equation of the AR-TOOL14 "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" (Version 4.1):

$$C_{SHRUB;T} = \frac{44}{12} * CF_s * (1 + R_s \sum_i A_{SHRUB}, * b_{SHRUB,i})$$

$$b_{SHRUB,t} = BDR_{SF} * b_{forest} * cc_{SHRUB}$$

Where:

$C_{SHRUB,t}$ = Carbon stock in shrubs within the project boundary in the baseline; t CO2e

CF_S = Carbon fraction of shrub biomass, tC (t d.m.)-1

R_s = Root-shot ratio for shrubs; dimensionless

$A_{SHRUB,i}$ =Area of shrub biomass estimation stratum i, ha

$b_{SHRUB,i}$ = Shrub biomass per hectare in shrub biomass estimation stratum i, t d.m.ha-1

BDR_{SF} = Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 and the default above-ground biomass content per hectare in forest in the region where the project is located.

b_{FOREST} = Default above-ground biomass content in forest in the region/country where the A/R CDM project activity is located, t d.m.ha-1

CC_{SHRUB} = Crown cover of shrubs in shrub biomass estimation stratum i at the time of estimation, expressed as a fraction

Crown cover (CC_{SHRUB}):

Following the shrub classification (see PD), 72.43% of the stratum 4 project areas are covered with shrubs.

b_{FOREST}:
There are 14 research sites distributed across the Indian Sundarbans (Western, Central and Eastern zone) which are subject to various scientific studies on mangrove vegetation and soil carbon (see *Mitra et al.*, 2014)[9]. The average value of aboveground biomass of these stations is used, i.e.:

b_{FOREST} = 116.8 t d.m. ha^{-1}

For the following parameters, default values taken from the tool AR-TOOL14 are applied:

Parameter	Denotation	Value
Carbon fraction of shrub biomass	CF_s	0.47
Root-shot ratio for shrubs	R_s	0.4
Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0	BDR_{SF}	0.1

[9] Mitra, A.; Zaman, S (2014). Carbon sequestration by coastal Floral Community. Teri

Pre-existing tree baseline biomass

The estimation of carbon stock in pre-project tree biomass was done following equation 20 and 21 of the methodological tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities (Version 04.1):

$$C_{TREE\_BSL} = \sum_{i=1} C_{TREE\_BSL,i},$$

$$C_{TREE\_BLSi} = \frac{44}{12} \times CF_{TREE} \times b_{FOREST} \times (1 + R_{TREE}) \times CC_{TREE\_BLSi} \times A_i$$

Where:

C_{TREE_BSL} = Carbon stock in pre-project tree biomass; t CO_2-e

$C_{TREE\_BSL,i}$ = Carbon stock in pre-project tree biomass in stratum i; t CO_2-e

CF_{TREE} = Carbon fraction of tree biomass (tC (t.d.m.)$^{-1}$

b_{forest} = Mean above-ground biomass in forest in the region orcountry where the A/R CDM project is located; t d.m.ha^{-1}

R_{TREE} = Root-shoot ratio for trees in the baseline; dimensionless

$CC_{TREE\_BSL,i}$ = Crown cover of trees in baseline stratum i, at the start of the A/R CDM project activity, expressed as a fraction; dimensionless

A_i = Area of baseline stratum i, delineated on the basis of tree crown cover at the start of the A/R CDM project activity; ha

Crown cover (CC_{tree})

According to the crown cover analysis, the crown cover of pre-existing trees in baseline represents 2.63% of the area in stratum 4.

b_{FOREST}:

The same value as for the shrubs baseline was applied.

b_{FOREST} = 116.8 t d.m. ha^{-1}

For the following parameters, default values taken from the tool AR-TOOL14 are applied:

Parameter	Denotation	Value
Carbon fraction of tree biomass	CF_T	0.47
Root-shot ratio for tree	R_T	0.25

Dead wood of pre-existing trees in the baseline

According to the methodological tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in AR CDM project activities (Version 03.00), when there are pre-existent trees in the baseline, dead wood carbon shall be accounted as baseline carbon.

The baseline carbon in dead wood is calculated using the conservative default-factor based method included in AR-TOOL12. The following equation is applied:

$C_{DW,i,t} = C_{TREE,i,t} * DF_{DW}$

Where:

$C_{DW,i,t}$ = Carbon stock in dead wood in stratum *i* at a given point of time in year t; t CO_2-e;

$C_{TREE,i,t}$ = Carbon stock in trees biomass in stratum *i* at a point of time in year t; t CO_2-e;

DF_{DW} = Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; per cent.

As stated in the PD, the conservative default factor for dead wood biomass for this project according to the corresponding biome, elevation and annual precipitation is 6% of carbon stock of pre-existing tree biomass. Hence, this value is applied.

As result of all calculations, the pre-existing baseline carbon estimation for the first project activity instances is summarized in the table below:

Table 4 Calculation of pre-existing bassline carbon stocks in trees and shrubs

Year	Areas planted/ restored per year (ha)	C_{TREE_BSL} Pre-existing biomass of trees (t CO_2-e)	C_{DW_BSL} Dead wood pre-existing trees (t CO_2-e)	C_{SHRUB_BSL} Pre-existing shrub biomass (t CO_2-e)	C_{BSL_TOTAL} Total biomass baseline (t CO_2e)
2010	350.5	1,143.66	69	3,527.6	4,740
2011	436.8	372.62	22	1,149.3	1,544
2012	936.8	1,332.56	80	4,110.2	5,523
2013	1,181.6	1,150.54	69	3,548.8	4,768
2014	1,498.2	3,132.81	188	9,663.1	12,984
2015	0	0	0	0.0	0

Changes in the carbon stocks in baseline dead wood biomass ($\Delta C_{DW\_BSL,t}$)

As demonstrated in PD, baseline of living biomass is accounted as zero in the zero baseline stratums. Consequently, changes in carbon stocks in dead wood in the baseline are also accounted for as zero.

Change in carbon stocks in the Stratum 4 baseline tree and shrub biomass including dead wood within the project boundary in this stratum can be estimated as zero for the same reasons as described for the zero baseline stratum (see PD).

4.2 Project Emissions

The actual net GHG removals by sinks have been calculated using equation 2 of the methodology: AR-AM0014: Afforestation and reforestation of degraded mangrove habitats (Version 03.0), as described below.

$\Delta C_{ACTUAL,t} = \Delta C_{P,t} – GHG_{E,t}$

Where:

$\Delta C_{ACTUAL,t}$	= Annual actual net greenhouse gas removals by sinks at time *t*; t CO_2-e yr^{-1}
$\Delta C_{P,t}$	= Change in carbon stocks in project, occurring in the selected carbon pools, at time *t*; t CO_2-e yr^{-1}
$GHG_{E,t}$	= Increase of non-CO_2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity, in year t, t CO_2-e

Change in the carbon stocks in project have been calculated using equation 3 of the methodology:

$\Delta C_{P,t} = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{SOC\_PROJ,t}$

Where:

$\Delta C_{P,t}$	= Change in carbon stocks in project, occurring in the selected carbon pools, at time *t*; t CO_2-e yr^{-1}
$\Delta C_{TREE\_PROJ,t}$	= Change in carbon stock in tree biomass in project in year t, as estimated in AR-TOOL14; t CO_2-e yr^{-1}
$\Delta C_{SHRUB\_PROJ,t}$	= Change in carbon stock in shrub biomass in project in year t, as estimated in AR-TOOL14; t CO_2-e yr^{-1}
$\Delta C_{SOC\_PROJ,t}$	= Change in carbon stock in the soil organic carbon (SOC) pool within the project boundary, as estimated in AR-AM0014, in year t; t CO_2-e yr^{-1}

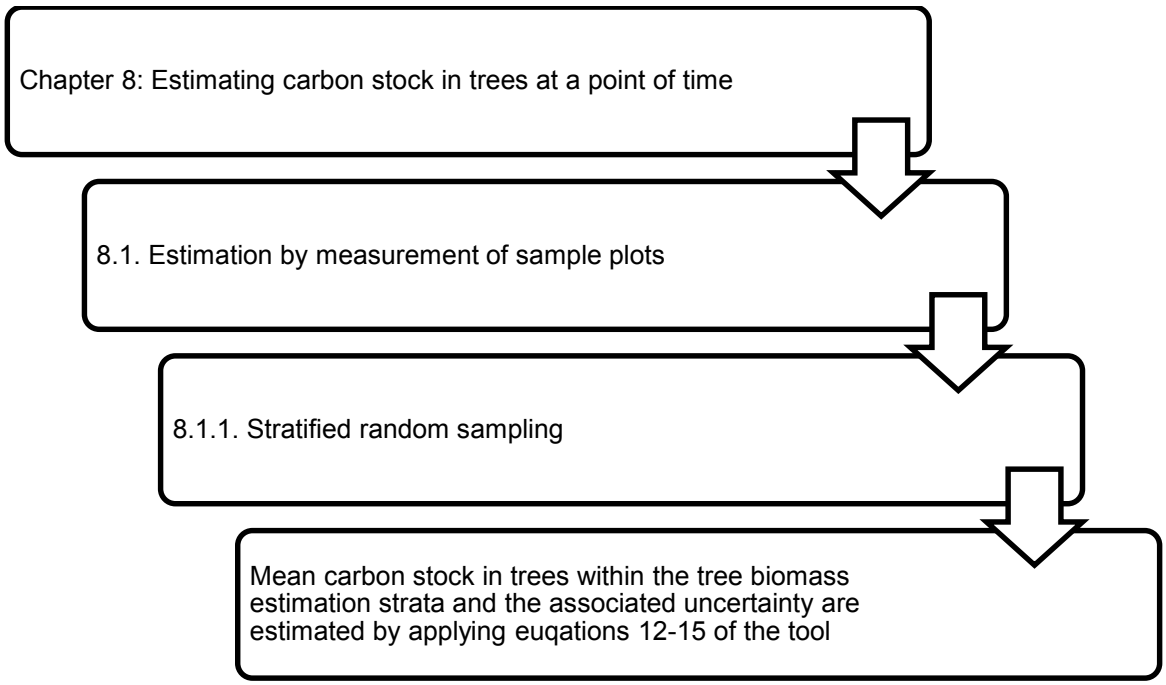
Estimation of carbon stock changes in trees and shrubs

Carbon stock changes of trees and shrubs are estimated applying the AR-Tool 'A/R Methodological tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities' (Version 04.1)[10].

Estimation of carbon stock change in trees

The following sections and equations of the tool are applied:

[10] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v4.1.pdf



The following equations of the methodology have been applied:

$$C_{TREE,t} = \frac{44}{12} * CF_{TREE} * B_{TREE,t}$$

$B_{TREE,\,t} = b_{TREE,\,t} * A$

$$b_{TREE,t} = \sum_{i=1}^{M} w_i \times b_{TREE,t,i}$$

Where:

Where:

$C_{TREE,\,t}$ = Carbon stock in tree biomass within the project boundary at a point in time in year *t*; t CO2-e.

CF_{TREE} = Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$.

$B_{TREE,\,t}$ = Total tree biomass within the project boundary at a given point in time in year *t*; t d.m.

$b_{TREE,\,t}$ = Mean tree biomass per hectare within the project boundary at a given point in time in year *t*; t d.m. ha^{-1}

A = Project area; ha

w_i = Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata (A_i/A), dimensionless

$b_{TREE,t,i}$ = Mean tree biomass per hectare in stratum *i* at a given point in time in

year *t*; t d.m. ha^{-1}

Determination of tree biomass

Therefore, the following allometric equations have been selected and applied for trees and saplings respectively for this monitoring period:

Size	Equation	R^2	N (sample trees used to derive the equation)	Source
Tree	$AGB = 0.251*\rho*DBH^{2.46}$	0.98	104	(Komiyama *et al.*, 2005 as cited in CIFOR, 2012)[11]
Sapling (A. Germinans)	$Ln(AGB)=b_0+b_1*Ln(D_{30})$ $b_0 = 4.310$ $b_1 = 3.960$	0.984	21	Ross *et al.*, (2001)
Sapling (R. Mangle)	$Ln(AGB)=b_0+b_1*Ln(D_{30})$ $b_0 = 3.960$ $b_1 = 1.481$	0.925	52	Ross *et al.*, (2001)

Where:

AGB = Above ground biomass (kg)

ρ = Wood density, g/cm^3

DBH = Diameter at Breast Height, cm

D_{30} = diameters of the sapling measured at 30 cm from the ground

b_0 = Intercept of the regression equation

b_1 = slope of coefficient

Ross et al (2001) presents different coefficients of intercept and slope depending on the three different species they take into consideration. According to the tool “Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities” (version 1.0.0), an allometric equation is appropriate if the equation was derived from a data set of at least 30 sample trees, and the value of coefficient of determination (R2) obtained was not less than 0.85. Both of the allometric equations used have a higher coefficient of determination, but the sample trees of the A. germinans equation is lower than 30. Therefore,

[11] Zinne et al (2011), 2012. Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forest: http://www.cifor.org/library/3749/protocols-for-the-measurement-monitoring-and-reporting-of-structure-biomass-and-carbon-stocks-in-mangrove-forests/

for the final biomass calculation of saplings in the project, the average of the results of the two species most used was applied (see Excel 2015-04-15 NEWS_ex-post carbon calculations)

Wood density, ρ

Specific values for several species of planted genus were applied in order to get a higher accuracy in the calculations. Zanne et al (2011) 12presented a table with different examples of densities of mangroves, with a classification based on four priorities:

1. Specie from India
2. Specie from Asia
3. Genus from India
4. Genus from Asia

Taking this list as basis, wood density of the species of the project has been calculated. All values used for this project were priority 2. When the species matched, the corresponding value was directly taken. In the cases of matching genus, wood density was calculated as an average value of the individuals of the genus. A site average of all the values was taken if species could not be matched.

Table 5 Wood density of project relevant mangrove species (Zanne et al (2011))

Scientific name	Wood density (gcm^{-3})
Aegialitis rotundifolia	0.51
Aegiceras corniculatum	0.51
Avicennia Alba	0.587
Avicennia Marina	0.585
Avicennia Officinalis	0.59
Bruguiera Gymnorrhiza	0.71
Bruguiera Parviflora/Cylindrica	0.747
Ceriops Decandra	0.77
Excoecaria Agallocha	0.38
Heritiera Fomes	0.816
Rhizophora Apiculata	0.85
Rhizophora Mucronata	0.78
Soneratia Apetala	0.52

[12] Zanne et al (2011) Global wood density database.

Soneratia caseolaris	0.389
Soneratia Griffithii	0.689

Root-to-shoot ratio, R_j:

The default equation from Appendix 1 of the Tool AR-TOOL14 is applied:

Rj: $\frac{e^{(-1.085+0.9256\times lnb)}}{b}$

Where,

b is the AGB tree biomass in t d.m. ha^{-1}

CF_{TREE}:

A default value of 0.47 for CF_{TREE} is applied – taken from AR CDM tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities".

Carbon stock change in shrubs
The project area will be reforested with mangrove trees only. Due to the small size of overall vegetation in the project area, shrub vegetation is conservatively not estimated in this first verification. It may be included in subsequent verifications if it becomes significant.

Carbon stock change in dead wood

The change in carbon stock in dead wood is calculated using the conservative default-factor based method included in AR-TOOL12. The following equation is applied:

$C_{DW,i,t} = C_{TREE,i,t} * DF_{DW}$

Where:

$C_{DW,i,t}$ = Carbon stock in dead wood in stratum *i* at a given point of time in year t; t CO_2-e;

$C_{TREE,i,t}$ = Carbon stock in trees biomass in stratum *i* at a point of time in year t; t CO_2-e;

DF_{DW} = Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; per cent.

As stated in the PD, the conservative default factor for dead wood biomass for this project as influenced by the biome, elevation and annual precipitation is 6% of carbon stock in tree biomass. Hence, this value is applied.

The actual net GHG removals by sink have been calculated based on the forest inventory data, which were collected as described in section 3.3. The change in the carbon stocks in project were calculated using equation 3 of the methodology as described in the preceding sections. The calculation is available in the Excel file "NEWS Inventory Database".

Trees (B_{TREE})

Stratum	Area (ha)	w_i	$b_{TREE.t2}$ t d.m. ha^{-1}	$B_{TREE.t2}$ t d.m.	$C_{TREE.t2}$ t CO_2-e
1	330.90	0.11	15.62	46,389.35	79,944.32
2	1,562.25	0.53			
4	1,077.39	0.36			
TOTAL	2,970.54	1			

Calculation of uncertainty

This was done following the guidance of Appendix 2 of the A/R Methodological Tool. The values are presented in the table below:

Stratum	s_i t d.m. ha^{-1}	n_i	u_c %	u_c mean t CO_2-e	u_c Discount t CO_2-e
1	23,84	37	20.9	16,682.1	12,511.6
2	14,46	49			
4	24,13	30			
Total	21,23	116			

Total $\Delta C_{TREE\_PROJ,t}$ for this monitoring period: 67,433 t CO_2-e.

Estimation of changes in soil organic carbon stocks

Changes in carbon stocks in the SOC pool is calculated as indicate in the Methodology AR-AM0014:

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

Where:

$\Delta SOC_{PROJ,t}$ = Change in SOC stock within the project boundary, in year t; t CO_2-e

$A_{PLANT,t}$ = Area planted in year t, ha

$dSOC_t$ = The rate of change in SOC stocks within the project boundary, in year t, $tCha^{-1}yr^{-1}$.

Following the same criteria as outlined in the PD for ex-ante calculations, 1.62 $tCha^{-1}$ has been applied as dSOC. This value is published in 2013 for mangroves by the IPCC in a specific supplement for wetlands to the 2006 guidelines (see PD).

As indicated in the IPCC supplement for wetlands, where activity results in patchy or patches of biomass, the emission factor of 1.62 $tCha^{-1}$/yr. can only be applied when the mangrove cover is at least 10% of the overall area.

For the NEWS project strata 1-3, annual tree audits provides a good basis to assess the specific plantation plot survival rates upon which the stratification into these three strata was made; stratum one represents the best performing plantations, stratum 2 medium conditions and stratum 3 poor growth conditions. This assessment is used to identify all plots where the survival rate is below 10% which implies to be excluded from the IPCC dSOC default value. The table below shows the areas excluded from the first project instances for the first monitoring period.

Table 6 Derivation of eligible project areas for SOC accounting

Year of inclusion of project area	Area under plantation (ha)	Area excluded (ha)	Corrected SOC area (ha)
2010	190.2	23.8	166.4
2011	371.9	46.5	325.4
2012	718.2	89.8	628.4
2013	937.9	117.2	820.7
2014	1108.4	138.5	969.8

For this monitoring period, a 4-year and 5 months period is used to calculate the actual soil organic carbon stock changes of the project.

Table 7 Calculation of SOC change for this monitoring period

Year	Corrected SOC area strata 1-3 (ha) (months accounted)	Cumulative SOC area strata 1-3 (ha)	ΔSOC strata 1-3 (t CO_2-e)	SOC area stratum 4 (ha) (months accounted)	Cumulative SOC area stratum 4 (ha)	ΔSOC stratum 4 (t CO_2-e)	Total ΔSOC strata 1-4 (t CO_2-e)
2010	166.4 (3)	166.4	247.1	160.4 (3)	160.4	238.1	485.2
2011	325.4 (6)	491.8	1,954.9	64.9 (6)	225.3	1,145.3	3,100.1
2012	628.4 (6)	1120.2	4,787.7	218.7 (6)	443.9	1,987.6	6,775.2
2013	820.7 (6)	1940.9	9,091.5	243.6 (6)	687.6	3,360.6	12,452.1
2014	969.8 (6)	2910.7	14,409.3	389.8 (6)	1077.4	5,241.9	19,651.2
2015	- (2)	2910.7	2,881.6	- (2)	1077.4	1,066.6	3,948.2
Total							46,412.1

Change in carbon stocks of trees

According to paragraph 16 of the tool AR-TOOL14 A/R Methodological tool 'Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities' (Version 04.1) at the first verification $C_{TREE, t1}$ is set equal to the carbon stock in the pre-project tree biomass, i.e. $C_{TREE,t1} = C_{TREE\_BSL,t1}$. Based on this, the following table shows the change in carbon stock during the period between two points of time t1 (pre-existing tree and shrub biomass) and t2. The Excel sheet NEWS_ex-post carbon calculation details the full calculation of emission reductions for this monitoring period and is available upon request.

Table 8 Change in carbon stocks during the period between two points of time t1 (pre-existing tree and shrub biomass) and t2

Year of inclusion of project areas	Area strata 1,2 and 4 included in year t (ha)[13]	$C_{TREE,t1} = C_{TREE\_BSL,t1}$ (t CO_2-e)	$C_{DW\_BSL;t1}$ (t CO_2-e)	$C_{SHRUB\_BSL,t1}$ (t CO_2-e)	$C_{TREE\_PROJ\_DISCOUNT;t2}$ (t CO_2-e)	$C_{DW\_PROJ;t2}$ (t CO_2-e)	$\Delta C_{TREE+DW\_PROJ;(t2-t1)}$ (t CO_2-e)
2010	350.3	1,143.7	68.6	3,527.6	7,952.6	477.2	3,689.9
2011	332.0	372.6	22.4	1,149.3	7,537.6	452.3	6,445.5
2012	692.4	1,332.6	80.0	4,110.2	15,717.9	943.1	11,138.2
2013	609.3	1,150.5	69.0	3,548.8	13,830.5	829.8	9,892.0
2014	986.5	3,132.8	188.0	9,663.1	22,394.2	1,343.7	10,754.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2,971	7,132.2	427.9	21,999.0	67,432.7	4,046.0	41,919.6

[13] Project stratum 3 is not considered for accounting of biomass for this monitoring period.

Next, the actual net greenhouse gas removals by sinks for the different years of the monitoring period are summarized below, separately for trees (including dead wood) and soil organic carbon as well as totals. In addition the cumulative months of project implementation are shown, starting with 3 months in 2010 and ending with 2 months in 2015 until the end of this monitoring period 28-02-2015.

Table 9 actual net greenhouse gas removals by sinks for the different years of the monitoring period

Year	Project implementation (cum. months)	Actual tree net GHG removals by sinks, in year t; (t CO_2-e)	Actual SOC net GHG removals by sinks, in year t; (t CO_2-e)	Actual total net GHG removals by sinks, in year t; (t CO_2-e)
2010	3	208.9	485.2	694.1
2011	15	2,659.6	3,100.1	5,759.8
2012	27	7,969.0	6,775.2	14,744.2
2013	39	12,095.7	12,452.1	24,547.7
2014	51	17,404.5	19,651.2	37,055.8
2015	53	1,581.9	3,948.2	5,530.1
Total	53	41,919.6	46,412.1	88,331.7

4.3 Other project emissions

GHG project emission from burning of biomass does not occur in any of the mangrove systems in the Sundarbans.

4.4 Leakage

As demonstrated in section 3.3 of the Project Description, leakage due displacement of agricultural activities in the areas of this project can be accounted as zero.

Table 10 GHG emissions due to leakage, in year t

Project year	LK_t t CO_2-e
2010	0
2011	0
2012	0
2013	0
2014	0
2015	0
Total	0

4.5 Net GHG Emission Reductions and Removals

The net anthropogenic GHG emission reductions and removals are calculated using equation 6 of the methodology AR-AM0014:

$$\Delta C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t$$

Where:

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

The net change in carbon stocks for the first project activity instances are shown below.

Table 11 Total NEWS project net change in carbon stocks for this monitoring period

Year	$\Delta C_{BSL,t}$ (t CO_2-e)	$\Delta C_{ACTUAL,t}$ (t CO_2-e)	LK_t (t CO_2-e)	$\Delta C_{AR-CDM,t}$ (t CO_2-e)
2010	0	694.1	0	694.1
2011	0	5,759.8	0	5,759.8
2012	0	14,744.2	0	14,744.2
2013	0	24,547.7	0	24,547.7
2014	0	37,055.8	0	37,055.8
2015	0	5,530.1	0	5,530.1
Total	0	88,331.7	0	88,331.7

Therefore, the total GHG emission reductions or removals generated in this monitoring period 28-09-2010 to 28-02-2015 are 88,331.7 t CO_2-e. The non-permanence risk rating is 15% – as assessed and documented in the AFOLU non-permanence risk report (provided as a separate document). Therefore, the total number of buffer credits that need to be deposited into the AFOLU pooled buffer account is 13,250 t CO_2-e. The number of GHG credits eligible to be issued as VCUs for the first project instances of this monitoring period is 75,082 t CO_2-e.

APPENDIX X: <TITLE OF APPENDIX>

Use appendices for supporting information. Delete this appendix (title and instructions) where no appendix is required.