

REFORESTATION OF DEGRADED FOREST RESERVES IN GHANA



Project Design Document

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LIST OF ABBREVIATIONS

ARR	Afforestation, Reforestation and Revegetation
AFOLU	Agriculture, Forestry and Other Land Uses
ANR	Assisted Natural Regeneration
CDM	Clean Development Mechanism
CITES	Convention on International Trade in Endangered Species
CFMP	Community Forest Management Project
FC	Forestry Commission
FD	Forestry Department
FR	Forest Reserve
FSC	Forest Stewardship Council
FSD	Forest Services Division
ER	Emission Reduction
GIS	Geographic Information System
GHG	Greenhouse gas
GPS	Global Positioning System
HIPC	Heavily Indebted Poor Countries (program)
IPCC	Intergovernmental Panel on Climate Change
ITTA	International Timber Trade Agreement
ILO	International Labour Organisation
IY	Invasive York
LK	Leakage
LTA	Long Term Average
MDF	Mixed Degraded Forest
MTS	Modified Taungya System
NFPDP	National Forest Plantation Development Program
NTFP	Non Timber Forest Product
PDD	Project Design Document
PP	Project Proponent
PSP	Permanent Sample Plot
RIL	Reduced Impact Logging
RIT	Remnant Indigenous Trees
RT	Remnant Teak
SEIA	Social and Environmental Impact Assessment
SOC	Soil Organic Carbon
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit
WHO	World Health Organisation

1 PROJECT DETAILS

1.1 Summary Description of the Project

The proposed ARR VCS project aims at reforestation of 15,000 ha in degraded forest reserves in Ghana. Currently, 1,506 hectares in the Asubima Forest Reserve in the north of the Ashanti region are realized, forming the first project instance of this grouped project. The project foresees an average expansion of 1000 hectares per year, adding new project areas and instances.

The Asubima forest reserve used to be a productive reserve covered with high, semi-deciduous forest. However, the reserve has been severely degraded by overexploitation, bush fires and conversion to agricultural land, particularly between 1980 and 2000 and has been declared degraded by the Government of Ghana. Without the reforestation project the area would remain degraded and degrade even further due to illegal farming, bushfires and logging of the last remaining trees.

Project proponent (PP) FORM Ghana Ltd. has a land lease agreement with traditional land owners and the Government of Ghana for reforestation of the project area to restore productive forest in the degraded forest reserves. This lease construction is part of the presidential policy to restore degraded forest reserves in Ghana, which is a strong policy instrument showing the commitment of the Government of Ghana to conserve, restore and promote the sustainable use of forest resources in the country.

FORM Ghana is a company limited under Ghanaian law, established in 2007. It has been certified according to the principles and criteria of the Forest Stewardship Council (FSC) since January 2010. The FSC certificate demonstrates the commitment and adherence of FORM Ghana to the highest sustainability standards of both social and ecological aspects. The VCS carbon project will be implemented according to the same high operational standards.

Project activities comprise CO₂ sequestration in tree plantations with exotic and indigenous tree species, natural forest restoration in riparian buffer zones and harvesting of high quality timber. Project activities are carried out and monitored according to approved project methodology AR-ACM0001 version 05.2.0 for a project period of 40 years.

1.2 Sectoral Scope and Project Type

The project is classified as a grouped project because new areas will be included in the future.

The sectoral scope of this project is Agriculture, Forestry and Other Land Uses (AFOLU). Within this category the project is of the Afforestation, Reforestation, Revegetation (ARR) type, more specifically Reforestation and Revegetation.

1.3 Project Proponent

Proponent: FORM Ghana Ltd.
P.O. Box 8597 .
Ahensan Estate, Kumasi, Ghana

Contact: Managing Director: Mr. Willem Fourie
Tel: +233544 441440
E-mail: w.fourie@formghana.org

FORM Ghana is responsible for plantation establishment and maintenance. This includes, but is not limited to terrain preparation, plant propagation, planting, thinning, pruning, weeding, clear cutting, security and fire management

1.4 Other Entities Involved in the Project

Project development: Form international B.V.
Bevrijdingsweg 3, 8051 EN, Hattem, The Netherlands

Contact: Mr. Rik Sools and Mr. Remi de Wilde
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Form international is contracted by FORM Ghana to deliver management support and technical assistance. This includes, but is not limited to developing and managing the VCS certification and is as such responsible for all technical aspects of the VCS certification. This includes mapping and GIS, managing of the monitoring and analysis of data, training of FORM Ghana personnel and managing the FSC certificate. In table 16 below the different roles of the monitoring staff are elaborated. The monitoring manager and quality control officer are part of Form international staff, while the rest of the team is part of the FORM Ghana staff.

Sustainable Forestry Investments B.V. (SFI)
Owner and shareholder of FORM Ghana, but has no active role in VCS implementation.
Contact: Mr. Paul Hol
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E-mail: info@forminternational.nl

1.5 Project Start Date

01-March-2008

1.6 Project Crediting Period

Start date: 01 - March - 2008
End date: 01 - March - 2048

Total number of years: 40

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project	x
Mega project	

Table 1: Summary of the estimated GHG emission removals

Years	Estimated GHG emission reductions or removals (tCO ₂ e)
2008	0
2009	0
2010	1,155
2011	7,360
2012	24,477
2013	45,267
2014	50,839
2015	33,673
2016	47,108
2017	49,265
2018	27,484
2019	4,398
2020	37,984
2021	7,999
2022	2,005
2023	1,916
2024	1,838
2025	1,770
2026	1,710
2027	945
2028	1,362
2029	1,063
2030	1,024
2031	795
2032	762
2033	732
2034	703
2035	678
2036	653
2037	631
2038	610
2039	591
2040	572
2041	555
2042	539

2043	523
2044	509
2045	495
2046	482
2047	470
2048	458
Total estimated ERs	360,943
Total number of crediting years	40
Average annual ERs	8,815

1.8 Description of the Project Activity

GHG emission removals are achieved by establishing tree plantations of exotic and indigenous tree species and by restoring natural forest in riparian buffer zones. We therefore identify four reforestation types, teak plantation, indigenous plantation and two types for riparian forest restoration as illustrated in table 2. The different reforestation types are elaborated on below. All these project activities are carried out and monitored according to approved project methodology AR-ACM0001 version 05.2.0 'afforestation and reforestation of degraded land'. PP aims at an ecologically sustainable plantation with a maximum of 90% of Teak (*Tectona grandis*) and 10% native tree species. The amount of indigenous plantation and forest restoration of the first 1506 hectares is 14% as shown in table 2.

Table 2: Areas and percentage of the different reforestation types

Reforestation type	Area (ha)	Percentage
Teak Plantation (I)	1,290	86
Indigenous Tree Plantation (II)	43	3
Buffer restoration (III+IV)	173	11
Total	1,506	100

1.8.1 Teak Plantation (reforestation type I)

Tectona grandis, commonly known as 'teak', is the principle species planted in Asubima Forest Reserve. It is a deciduous hardwood tree that can reach heights up to 40 meters. Its white flowers are small and fragrant and the leaves have a papery feel with hairs on the bottom. The tree species originates from South-Asia but is currently widespread in plantations all over the world. The main reasons for its success are outlined below.

The wood is both weather-, termite- and pesticide-resistant because of the natural oils that are contained within its fibers. This makes the wood extremely suitable for outdoor use, such as furniture or boat decks, even without treatment with oils or varnish. The attractive

appearance however, makes teak desired for interior use as well. Teak flooring, cutting board and veneer remain popular throughout the world.

In West-Africa the production of teak has also been adopted successfully. In comparison to indigenous as well as other exotic tree species, teak performs best economically (1) (2) (3) (4).

Experience with the silviculture of teak plantations started in the 19th century (4) and this longstanding practice has resulted in sound management guidelines and good yield prognoses. This provides a solid technical basis for plantation establishment.

As an exotic tree species in Ghana, teak does not suffer much from diseases, which reduces the risk of plantation failure. Disease risk can be further reduced significantly by careful site selection. (3)

The environmental impact of sustainable teak production is low. It is planted on deep, fertile and level soils which are relatively insensitive to erosion and not planted in the buffer zones or other ecologically valuable areas. No chemical treatments are required for pest control because of the low susceptibility of teak to diseases. Therefore, no ecological damage is caused to the environment. Also, the spread of teak outside the plantation can easily be controlled, since dispersal distance of teak seeds is limited. Teak cannot invade areas with dense (high grass) vegetation without human interference because it is a high light demanding species. The presence of buffer strips and fire outbreaks around the plantation inhibits the spread of teak outside plantation boundaries. Most areas surrounding the plantation are in agricultural use for which teak poses no threat.

Teak plantations are managed as even-aged stands with a rotation cycle of 20 year and three intermediate thinnings. This choice is based on economic and silvicultural considerations. Following AFOLU requirement 4.5.4, carbon removals due to harvesting are appropriately accounted for by claiming a maximum amount of sequestered carbon equal to the project's long term average CO₂ sequestration and by the guarantee of immediate reforestation in the year following the harvest.

Coppices of teak trees that are cut by PP (see chapter 3 of this PD) and teak wildlings are included in carbon accounting. This is justified since this regeneration is only possible, because fires are kept out of the plantation by PP.

1.8.2 Indigenous plantation (reforestation type II)

In addition to teak, a number of tree species native to Ghana are planted. These species are introduced to enhance biological diversity of the forest estate, diversify the number of commercial tree species and restore ecological functions of the area. These indigenous tree species are planted mainly, but not exclusively, near buffer zones along rivers, near natural forest remnants and areas where the soil conditions are not favourable to teak. A list of utilized species is presented in table 3, which may be expanded later in the project.

Table 3: Indigenous species planted as plantation and in the buffer zones

Scientific name	Local name
Albizia ferruginea	Awiemfosamin
Antiaris toxicaria	Kyenkyen
Blighia sapida	Akyi
Ceiba pentrandra	Onyina

Cola gigantea	Watapuo
Erythroleum ivorense	Potrodum
Hildegardia barteri	A.Kyewewa
Khaya anthoteca	Mahogany
Mansonia altissima	Mansonia
Nauclea diderrichii	Kusia
Pericopsis elata	Kokrodua
Pteleopsis hylodendron	Kwae-Kane
Rhodognaphalon brevisuspe	Bombax
Terminalia ivorensis	Emeri
Terminalia superba	Ofram
Triplochiton scleroxylon	Wawa

Indigenous plantations are planted with indigenous tree species to form even-aged, mixed forest stands. These stands will be managed to eventually form mixed and uneven-aged forest stands with permanent forest cover. To that end natural regeneration is conserved and thinning is done when needed to improve stand quality, diversity and growth. Commercial thinning will take place. As there is little peer reviewed data available on this type of plantation the exact harvesting schedule cannot yet be decided as it will depend on stand performance. Therefore the most conservative scenario, clear felling after 40 years, is followed and the long term average calculation based on this scenario.

Wildlings of indigenous trees are included in carbon accounting. This is justified since this regeneration is only possible, because fires are kept out of the plantation by PP and remnant indigenous trees are protected in the project area.

1.8.3 Forest restoration in riparian buffer zones and degraded forest remnants (reforestation type III and IV)

Riparian areas and forest remnants need protective cover of native vegetation to prevent erosion and pollution of water courses. Forest conservation strips of at least 30m wide are required to separate rivers from productive plantations. Apart from the prevention of erosion, sedimentation and water pollution, the buffer zones are developed to restore and maintain an ecological network of natural forest supporting a wide range of plant and animal species. No harvesting is allowed in the buffer zones, allowing for considerable carbon stock enhancement and maintenance. At the start of the project (baseline situation), the buffer zones are highly degraded and not homogeneous. There are patches of fallow grassland with remaining indigenous trees, agricultural land, and patches of degraded forest. This heterogeneity requires the application of various techniques to achieve the desired forest restoration and CO₂ sequestration.

In the areas where virtually no trees are left (grassland and farmland) CO₂ removal is achieved in the same way as for the indigenous tree plantations, only without commercial thinning or harvesting. This is considered as the planted buffer and is reforestation type III.

In degraded forest areas with more remaining tree cover, PP prevents further degradation by the prevention of further logging, conversion to agricultural land and wildfires in these areas. Besides these protective measures, assisted natural regeneration (ANR) is applied to increase the speed of forest restoration in these areas. ANR techniques include:

- Liberation of indigenous seedlings and saplings by removing invasive species such as the woody *Broussonetia papyrifera* (York), the herbaceous *Chromolaena odorata* (Akyeampong) and grasses.
- Climber cutting.
- Enrichment planting with indigenous tree species.

The restoration of degraded forests is considered as reforestation type IV.

1.8.4 Nursery practices and silvicultural practices

The nursery and silvicultural practices explained below apply for both teak and indigenous plantations.

1.8.4.1 Tree nursery

The FORM Ghana Nursery has as a mission to produce high quality seedlings for the establishment of 1000ha of plantations per year in Ghana. This is realized through:

1. A yearly production of 1.500.000 (genetically) high quality teak (*Tectona grandis*) seedlings
2. A yearly production of 200.000 seedlings of indigenous species.

Important components of the nursery are:

- Nine hectares for teak stump production
- Shade shed of 1600 m² for indigenous seedling production, capacity of +- 500.000 plants in polybags
- Water pump station near the pond
- A garage



Figure 1 Nursery of indigenous species

Teak stumps are produced and transported to the plantation. Indigenous seedlings on the other hand are grown in polybags under shade nets. Planting material is selected by high genetic and phenotypical quality to suit the local conditions. Systematic selection during production and before planting will assure the transfer of only the best material to the field.

1.8.4.2 Silvicultural treatments

Silvicultural treatments are executed from the plantation establishment till the final harvest. This paragraph describes general aspects of technical plantation management practises. Detailed technical plantation management procedures are worked out in specific protocols.

Site preparation

First, the site has to be prepared to facilitate planting and create optimal conditions for the seedlings. The area to be planted is cleared to remove weeds. This is mainly done by ploughing, depending on present vegetation. Slashed vegetation is burned. Where necessary, herbicides (Roundup) are sprayed to control weeds. Roundup (glyphosate) is a permitted herbicide by FSC and not hazardous when applied correctly. The intention is to use Roundup just once for soil preparation prior to planting. Employees that apply herbicides receive proper training and equipment to minimise health and environmental risks. Site preparation takes place between January and April. During site preparation damage to remnant indigenous trees is minimized following PP protocol P17 Protected plant species.

Plantation establishment

The planting density varies depending on the quality of planting material and soil because canopy closure is reached earlier under higher quality conditions. Under lower quality conditions 2x3m spacing is chosen (1667 plants per ha), under higher quality conditions 3x3m is chosen (1111 plants per ha), Planting takes place from April till June. Planting

commences in the second half of April when the rainy season has really set in, to avoid the risk of drought stress.

Beating up

A few months after planting, a balance is made of the mortality rate of the planted material. If more than 10% of all planted seedlings has not developed or died, the 'gaps' need to be filled in. This is done in the short rainy season after initial planting, in September.

Weeding

Due to the degraded state, weed pressure before canopy closure is severe. Weeding is therefore very important to prevent weeds from restraining the performance of the seedlings. Weeding is carried out at least three times per year until canopy closure. The method applied is grass cutting completed with strip or circle weeding. Circle weeding takes place around a planted tree, strip weeding along the planting lines.

Climber cutting

Forest stands are checked every year to determine whether climber cutting is necessary to prevent the planted stock from being smothered by climbers. If this is the case, climber cutting is carried out.

Thinning

Wood distribution between stem and branches can be influenced by thinning and pruning. By timely thinning and pruning the trees can be directed to have optimal height growth and well-formed crowns, with little biomass going into the branches in early life stages. The moment and the intensity of thinning are dependent on the growth performance and canopy closure of a stand, which is determined in permanent sample plots. The right timing is checked by comparing measured basal area (G) with the yield tables. Stumps of thinned trees are cut off low to the ground and covered with soil and leaves. This will prevent the stump from coppicing, because of a lack of light. Coppicing is not desired because of root competition. Thinning intensity will be much higher in the teak plantation than in the indigenous plantation.

Pruning

Pruning is undertaken mainly to clean part of the stem from branches, which leads to higher timber quality and better machine ability. One year after each thinning, the stand is pruned.

Final harvesting

After 20 years, all remaining teak trees are harvested with the final harvesting. Stumps are treated with round-up, because establishment of the new plantation is done by planting new seedlings/stumps, not through coppicing. Expected rotation time of indigenous trees is 40 years. During final harvest of teak and indigenous plantations remnant indigenous trees will not be felled.

1.9 Project Location

The Asubima Forest Reserve is situated in the dry, semi-deciduous forest zone at about 100 km north of Kumasi in the Ashanti region in Ghana (figure 2). It falls under the authority of the Offinso Forest District.

The project location is in the south-eastern corner of the Asubima forest reserve.

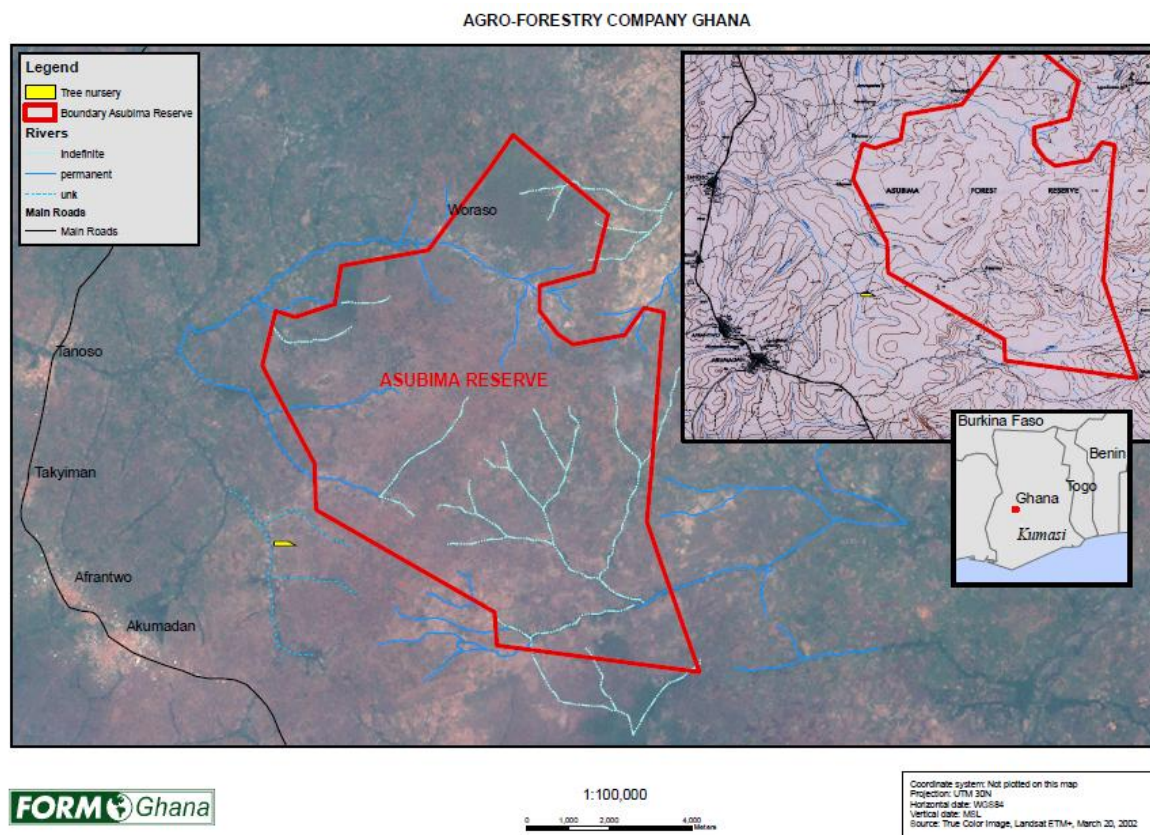


Figure 2: Area of Asubima forest reserve. The project area lies in the south eastern corner of the reserve

1.10 Conditions Prior to Project Initiation

The project has not been implemented to generate GHG emissions for the purpose of their subsequent reduction or removal, since the area has been degraded subsequent to the project start. The conditions prior to project initiation are described below.

Climate

The Asubima forest reserve lies at the northern fringes of the semi-deciduous forest ecological zone of Ghana. The zone has a tropical monsoon climate with alternating wet and dry seasons. The long wet season starts around mid-March and ends in mid-July. It is followed by a short dry season until the end of August. From September till the end of October there is a short rainy season, followed by a long dry season from November till mid-March. Temperatures are generally high and uniform throughout the year. Mean annual temperature is about 26°C. February and March are the warmest months. The total average annual rainfall is 1227 mm (5).

Soil

The soils in the area have developed in weathered sandstone. As a result they generally have a sandy loam to sandy clay loam texture. Deeper horizons have a clay loam to clay texture due to illuviation of clay particles.

The well-drained soils, the Bediesi series, are dusky red to reddish brown at the surface, and red in deeper horizons. The moderately drained soils, the Sutawa series, are dark brown to brown at the surface to dark brown in deeper horizons. The Pimpimso series are soils which are found in places where sandstone is at or near the surface. These soils are quite shallow and have highly weathered rock or rock fragments within 50 cm from the surface (6).

Topography

The topography of the area is undulating. Some rocky outcrops can be found in the forest reserves.

Hydrography

Forest degradation in the forest reserves of Ghana is so extensive that it has affected the existing water bodies. Analyses of samples of the water bodies at project commence showed severe reduction of water quality, measured in quality parameters such as pH, turbidity, dissolved oxygen, conductivity and nitrate content. There was also severe reduction of water volume/level due to siltation and evaporation due to slopes near the streams (7).

Vegetation

The vegetation of the reserve was mostly of the dry semi-deciduous forest type, containing valuable timber trees such as Wawa, Odum, Sapele and Kokrodua. Savannah conditions are observed in large areas of the reserve which are the result from human-induced land degradation. Due to intensive farming and reported annual wild-fires very little of the original forest remains and what is left are vast areas of grasslands, where climbers and weeds are abundant. In the past, farmers protected big trees on their farms but the majority has been logged so very few remain today (8).

An inventory, conducted as part of a social and environmental impact assessment (SEIA) carried out for FORM Ghana, demonstrated that there is virtually no stretch of land within the project area covered with natural forest (7). Like most degraded forest reserves in Ghana, the area has been degraded by a number of activities such as farming, fire damage, over-exploitation and illegal logging (7). Without the proposed reforestation project the area would remain degraded or degrade even further due to illegal farming, bushfires and logging of the last remaining trees. Figure 3 below illustrates the degradation over time.



Figure 3: Satellite images showing the history of the project area. Pictures from Google Earth.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

1.11.1 Following legislation in Ghana

FORM Ghana adheres to strict compliance with all laws, statutes and regulatory frameworks in Ghana that apply to the company. Changes in legislation are registered and the company

makes sure that legal compliance is maintained. The original articles entered in the register are kept in the FORM Ghana office as well as legislative texts and conventions.

Table 4: Overview of relevant laws in Ghana

Law	Specific issue	Compliance by PP
Act 43 Wild Animals Preservation Act, 1961	All types of hunting and collection of animal products (eggs etc.) within forest reserve boundaries are prohibited	PP has a patrol team that controls outsiders and workers. Any illegalities will be reported to the police and documented by PP
Act 47 Economic Plants Protection Act, 1979	Destruction of economic plants and timber within forest reserve boundaries is prohibited.	Thinning and harvesting is only done after written approval by Forestry Commission.
S.M.C.D 128 Timber Industry And Ghana Timber Marketing Board (Amendment) Act, 1977	Permit of Ghana Timber Marketing Board required for export of timber or timber products.	PP will get the relevant permit before export of timber.
Pesticide Control And Management Act, 199, Act 528.	Section 21 describes safety measures that should be taken.	Handling pesticides is done according to prescriptions, with necessary protective facilities and clothing
		Intercroppers should comply with prescribed pesticide use on foodstuff
	Section 27 prescribes that rules for containers and packaging should be followed	Keep pesticides in original containers, with unchanged labels
	Section 28 requires for importers to record pesticide quantities imported for a duration of 10 years	FORM records imported pesticides
	Section 31 states that inspectors may at any given time inspect all premises, except residence areas, for pesticide use/storage/pollution etc.	FORM will give full cooperation to inspectors
Act 229 Control And Prevention Of Bush Fires Act, 1990	Prescribed burning allowed with permission & bushfires should be reported to authorities	Fire is prohibited on the plantation. Combated fires are recorded.
Act 273 Trees And Timber Act, 1974	Register property mark at Forestry Commission before felling trees for export.	Form Ghana will get property mark at FC before export
Act 308 Abandoned Property(Disposal) Act, 1984	Logs, which are not under lawful forestry operation, scrap metal and road signs within 50 feet of public land or roads may have to	Keep logs, scrap metal and signs at least 50 feet away from public land and roads to prevent any problem. For forestry operations,

	be removed	logs are no problem.
Act 624 Forest Protection (Amendment) Act 2002 Ghana	All activities such as farming or tree felling in forest reserves is prohibited without written consent by competent forest authority.	PP has a land lease contract which specifically entitles PP to reforest and also harvest trees. All farming activity in the project area was and will be illegal by law. Felling of trees is only allowed after getting a written consent by Forestry Commission
National Health Insurance Act, 2003	No implications for PP	Workers in contract with PP are all in a national health insurance scheme which is partly paid by PP.
Act 651 Labour Act, 2003		As the project is FSC certified, this demonstrates that all sections on employees' rights and health and safety procedures are being followed.

1.11.2 Following the international conventions

Regarding the international conventions, the approach chosen by FORM Ghana is to research all the relevant texts related to FORM's activities which are ratified by Ghana. The relevant international conventions are mentioned in the table below. This list will be updated yearly.

Table 5 Overview of relevant international agreements and conventions

Convention	Subject	Ratification	Implications for FORM Ghana
RAMSAR Convention	Convention on the preservation of wetlands	Yes	Respect buffer zones around watercourses. (The only RAMSAR site in Ghana is the Keta Lagoon complex)
ILO Convention 87,98	Freedom of association and collective bargaining	Yes	Employees must have the right to adhere to a union
ILO Convention 29, 105	Elimination of forced and compulsory labour	Yes	Employees must have the right to a labour contract with clear terms which was freely negotiated
ILO Convention 111	Elimination of discrimination in respect of employment and occupation	Yes	Men and women of all religions and racial origins (also

			tribe) have equal opportunities when applying for job openings
ILO Convention 138,182	Abolition of child labour	Yes	Child labour (children younger than 18 years) is prohibited
ILO Convention 97	Migration for Employment (Revised) Convention 1949	Yes	Only Ghanaian workers are employed at the moment, but the convention will be respected when hiring migratory workers
ILO Convention 100	Equal Remuneration Convention	Yes	Men and women of all religions and racial origins (also tribe) have equal remuneration when doing similar work
ILO Convention 131	Minimum Wage Fixing Convention	Yes	The wages of employees will be equal to or higher than the Ghanaian minimum wage
ILO Code of Practice	ILO Code of Practice on Safety and Health in Forestry Work	Yes	The ILO Code of Practice is taken into account in the risk assessments of forestry work and the applied health and safety measures
Convention on Biological Diversity	Maintaining biological diversity	Yes	Prevent introducing new species which may become pests
CITES	Convention on International Trade in Endangered Species: listing species not to be traded, or to be traded with special documentation	Yes	Trade in species mentioned in appendices I, II and III is subject to regulations or prohibited.
ITTA	International Tropical Timber Agreement	Yes	No consequences
Stockholm Convention	International Convention on the ban of persistent organic pollutants	Yes	All toxic substances to be used by FORM Ghana must be

			approved by both the Ghanaian government and FSC regulations.
Rotterdam Convention	To promote shared responsibility and cooperative efforts among parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm; to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to parties.	Yes	All pesticides to be used by FORM Ghana must be approved by both the Ghanaian government and FSC regulations.
Convention on the conservation of Migratory species of Wild Animals Bonn. 1979. (CMS)	Migratory species shall not be hampered in their movement.	Yes	The management of the plantations should be such that any migratory species which may use the forest are not hampered in their movement
International convention to combat desertification.	Desertification shall be combated where possible	Yes	The project itself is combating desertification through plantation establishment.

1.12 Ownership and Other Programs

1.12.1 Proof of Title

FORM Ghana holds a legal title to the project area in the form of land lease agreements with the Government of Ghana and the traditional land owner, accompanied by an official benefit sharing agreement. The lease has a duration of 50 years and is renewable.

1.12.2 Emissions Trading Programs and Other Binding Limits

Not applicable.

1.12.3 Participation under Other GHG Programs

The project has not been registered or is seeking registration under any other GHG program.

1.12.4 Other Forms of Environmental Credit

Since the project involves reforestation, no other credits than the VCU are aspired by project proponent. The project's FSC certification will not generate environmental credits.

1.12.5 Projects Rejected by Other GHG Programs

The project has not been rejected by any other GHG program.

1.13 Additional Information Relevant to the Project

1.13.1 Project description for grouped projects

This project proposes the reforestation of degraded forest reserves in Ghana, by means of four different types of reforestation, as described in section 1.8 of this PDD. PP aims at 15,000 hectares of sustainable reforestation in Ghana with an average expansion of 1000 hectares per year. The first project instance for validation (this document) covers an area of 1506 ha of degraded forest and is geographically described in section 1.9 and 2.3.3 of this PDD. The baseline scenario and demonstration of additionality described in section 2.5 of this document are based on this area, but future project areas will closely resemble this case. PP will manage the GHG information systems and monitoring of the proposed project in the first project area as well as in future project areas. All future project instances will conform to the following eligibility criteria:

- All new instances shall lie within Ghana, as shown in the polygon in the figure below.



Figure 4: Polygon of Ghana. All future instances of the project activity will be in degraded forest reserves in Ghana. National borders are depicted in yellow. Source: Google Earth

- Project activity shall be on degraded lands (determined with applicable CDM tool).

- Project activity shall not be on organic and/or drained soils.
- Project area shall not be a wetland.
- Litter shall remain on site.
- Ploughing/ripping/scarification as part of the A/R CDM project activity, is:
 - o Done in accordance with appropriate soil conservation practices, (e.g. following the land contours); and
 - o Limited to the first five years starting from the year of initial site preparation; and
 - o Not repeated, if at all, within a time period of 20 years.
- Shall apply one or more of the project activities and reforestation types defined in section 1.8.
- Shall have the baseline scenario as identified in section 2.4.
- Shall be additional following the applicable CDM tool as applied in section 2.5.
- A non-permanence risk buffer assessment shall be performed for each new project area and applied for buffer determination.
- Leakage shall be assessed for each new project area following the applicable CDM tool.
- PP shall have the right of use for each new project area.
- Shall be managed according to the same sustainability principles as described in this PDD.

1.13.2 Leakage Management

Activity shifting leakage occurs as farmers move to an area outside of the project boundary and continue pre-project agricultural activities there. To reduce the increase of GHG emission due to displacement of pre-project agricultural activities, PP has a strong policy for leakage management: Part of the farmers are employed by PP, a system of intercropping is developed where intercroppers have legalised access to land and can benefit from prepared soils and plant permitted crops around the planted trees. This intercropping is possible until canopy closure. Since the PP plants new areas every year, intercroppers can also rotate together with the planting years. Leakage can unfortunately not be completely avoided and is further quantified in section 3.3 of this PDD.

1.13.3 Commercially Sensitive Information

- Yield tables teak
- Net Present Value calculations FORM Ghana

1.13.4 Further Information

Not applicable

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The CDM consolidated methodology “Afforestation and Reforestation of Degraded Land” AR-ACM0001 version 05.2.0 is applied.

2.2 Applicability of Methodology

This section provides evidence that AR-ACM0001 version 05.2.0 is applicable. According to the methodology's section I.4: *Applicability*, the methodology is applicable if five conditions (a, b, c, a, b) are met. Each of the conditions is provided and answered in the following text:

CDM methodology, section I.4: *"(a) The A/R CDM project activity is implemented on degraded lands, which are expected to remain degraded or to continue to degrade in the absence of the project, hence the land cannot be expected to revert to a non-degraded state without human intervention;"*

To determine what a degraded land is, PP should follow the CDM *"Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities."*

According to this tool section III, it suffices if PP demonstrates the following:

"(a) Provide documented evidence that the area has been classified as "degraded" under verifiable local, regional, national or international land classification system or peer-review study, participatory rural appraisal, satellite imagery and/or photographic evidence in the last 10 years. If the documented evidence of degradation is older than ten years then:

(i) Provide evidence that the natural or anthropogenic degradation drivers and pressures that led to the land becoming "degraded" are still present and/or that there are no insufficient land management interventions to reverse degradation."

All the forest areas PP operates in are degraded. The satellite images in figure 3 show that the forest was still in a good state in 1973. However on the image from 2003 it can be clearly seen that the forest reserve is degraded. Forest Reserve conditions in Ghana were mapped in 1995 by the IUCN. The results show that at that time, Asubima Forest Reserve was 'mostly degraded' (9). The most important causes of this degradation are intense logging conversion to agricultural land and subsequently fire in the semi-deciduous zones. In the 1998-2002 National Forest Management Plan Asubima Forest Reserve was marked as degraded and open for investment in commercial tree growing (10). Additionally, the director of Forestry Commission has given a signed statement in 2009 that Asubima Forest Reserve has been degraded for two and a half decades and is still degraded today (11). Subsistence farming and wild fires were still present within the project scenario boundaries until the start of project activities (7) (12). Fire is now strictly forbidden, but this does not prevent that fire outbreaks still have to be combated regularly. In the fire season of 2011 (January till April) 60-80 fires outside the plantation had to be combated to prevent them from entering the project area.

CDM methodology, section I.4: *"(b) If at least a part of the project activity is implemented on organic soils, drainage of these soils is not allowed and not more than 10% of their area may be disturbed as result of soil preparation for planting;"*

The soils of the project area consist predominantly of sandy loams over sandy clay loams and belong to three well-described soil series. Amongst the encountered soil series no organic soils are present within the project boundary (6).

CDM methodology, section I.4: *"(c) The land does not fall into wetland category;"*
There are no wetlands within the project boundary.

PP wishes to include SOC as a carbon pool, so also the following requirements a and b need to be met.

CDM methodology, section I.4: *“(a) Litter shall remain on site and not be removed in the A/R CDM project activity;”*

In the FORM Ghana management plan it is stated that dead wood, yearly shedding of leaves, and branches and leaves after thinning and felling are left in the plantation.

“(b) Ploughing/ripping/scarification attributable to the A/R CDM project activity, if any, is:

- i. Done in accordance with appropriate soil conservation practices, e.g. follows the land contour; and*
- ii. Limited to the first five years from the year of initial site preparation; and*
- iii. Not repeated, if at all, within a period of 20 years.”*

Ploughing is done to prepare the land where possible and is done in accordance with appropriate soil conservation practices following the land contour where relevant. About one third of the land is ploughed. Ploughing is only done before planting and is therefore not repeated, if at all, within a period of 20 years, since the rotation period is at least 20 years.

2.3 Project Boundary

2.3.1 Land eligibility

The project's eligibility of land is determined following the CDM Methodology section II: *Baseline Methodology Procedure*.

To demonstrate the eligibility of the project area CDM tool: *“Procedures to demonstrate the eligibility of lands for afforestation and reforestation cdm project activities”* is applied. With this tool, land eligibility shall be demonstrated through step 1a:

Step 1a: *“Demonstrate that the land at the moment the project starts does not contain forest by providing transparent information that:*

- Vegetation on the land is below the forest threshold*
- All young natural stands and all plantations on the land are not expected to reach the minimum crown cover and minimum height chosen by the host country to define forest;*
- The land is not temporarily unstocked, as a result of human intervention such as harvesting or natural causes.”*

The current Ghanaian definition of forest is “A piece of land with a minimum area of 0.1 hectares, with a minimum tree crown cover of 15% or with existing tree species having the potential of attaining more than 15% crown cover, with trees which have the potential or have reached a minimum height of 2.0 meters at maturity in situ” (13). Looking at the satellite image in figure 3 and figure 5, it is clearly seen that there is no forest in the project area, apart from the buffer zones where degraded forest patches persist. As elaborated above and in section 2.5, the situation without proposed project activities is expected to worsen and therefore the land is not expected to reach crown cover and the land is not just temporarily unstocked as a result of human intervention. Rather, degradation is a continuous process. Approximately 3 indigenous trees per hectare have been left standing and in addition ~50 immature teak and yorke trees/ha (trees up to 5 years old). These trees do not reach the minimum crown cover of 15% to be defined as forest. Given the current land use practice these trees will be cut before they can reach 15% forest cover.

Part of the buffer zones is considered forest according to the definition stated above. The AFOLU eligibility requirement 4.2.1 for ARR projects states that: *“Eligible ARR activities are those that increase carbon sequestration and/or reduce GHG emissions by establishing, increasing or restoring vegetative cover (forest or non-forest) through the planting, sowing or human-assisted natural regeneration of woody vegetation”*. According to this requirement, the degraded forests are within the ARR definition and can be included in proposed project and GHG emission removals are further quantified in chapter 3.2.

Step 2b of the CDM tool does not apply as VCS AFOLU requirement 3.1.5 states instead that: *“Project activities that convert native ecosystems to generate GHG credits are not eligible under the VCS Program. Evidence shall be provided in the project description that any ARR, ALM, PRC or ACoGS project areas were not cleared of native ecosystems to create GHG credits (e.g., evidence indicating that clearing occurred due to natural disasters such as hurricanes or floods). Such proof is not required where such clearing or conversion took place at least 10 years prior to the proposed project start date. The onus is upon the project proponent to demonstrate this, failing which the project shall not be eligible.”*

There is ample evidence that no native ecosystems are converted for this reforestation project. The satellite images in figure 3 show that the forest was still in a good state in 1973. However on the image from 2003 it can be clearly seen that the forest reserve is degraded. Forest Reserve conditions in Ghana were mapped in 1995 by the IUCN. The results show that at that time, Asubima Forest Reserve was ‘mostly degraded’ (9). The most important causes of this degradation are intense logging, conversion to agricultural land and subsequently fire in the semi-deciduous zones. In the 1998-2002 National Forest Management Plan Asubima Forest Reserve was marked as degraded and open for investment in commercial tree growing (10). Additionally, the director of Forestry Commission has given a signed statement in 2009 that Asubima Forest Reserve has been degraded for two and a half decades and is still degraded today (11).

2.3.2 Selected carbon pools and emission sources

The selected carbon pools and emission sources in the project methodology and the justification or explanation for the inclusion or exclusion of different pools are outlined in table 6.

Table 6: Selected carbon pools

Pool/Source		Gas	Included?	Justification/Explanation
Baseline	Above-ground biomass	CO ₂	Yes	Major carbon pool in the baseline and project activity.
	Below-ground biomass	CO ₂	Yes	Major carbon pool in the baseline and project activity.
	Soil Organic Carbon	CO ₂	No	This is estimated as an annual increase over 20 years according to the applicable tool and therefore only included in the project and not in the baseline.
	Dead Wood	CO ₂	No	Since degraded lands are reforested, dead wood can be expected to increase in the project scenario compared to the baseline scenario. However, this carbon pool is conservatively neglected.
	Litter	CO ₂	No	Since degraded lands are reforested litter can be expected to increase in the project scenario compared to the baseline scenario. However, this carbon pool is conservatively neglected.
Project	Above-ground biomass	CO ₂	Yes	Major carbon pool in the baseline and project activity.
	Below-ground biomass	CO ₂	Yes	Major carbon pool in the baseline and project activity.
	Soil Organic Carbon	CO ₂	Yes	Independent research showed a significant increase in this carbon pool due to project activity (14).
	Deadwood	CO ₂	No	Conservatively neglected.
	Litter	CO ₂	No	Conservatively neglected.
Emission source		Gas	Included?	Justification/Explanation
Project	Burning woody biomass	CH ₄	Yes	Fire is used as a management tool for land preparation. Felled woody biomass is partially burned.
		N ₂ O	Yes	Fire is used as a management tool for land preparation. Felled woody biomass is partially burned.
	Leakage	CO ₂	Yes	Increase of GHG emission due to displacement of pre-project agricultural activities.
	Fossil Fuel	CO ₂	No	The use of fossil fuels is not included following VCS AFOLU guideline 4.3.3

2.3.3 Geographic project boundary

The first project instance is the FORM Ghana concession which is located in the Asubima Forest Reserve. The map below shows the instance boundaries. The current size of the concession is 1675 hectares. An established pilot plantation of 53ha in 2001 and a patch of farmer's teak of (117ha) are excluded from the scope because they have been established before the project starting date. Therefore the project size for the initial validation is 1506 hectares as shown in figure 5 below.

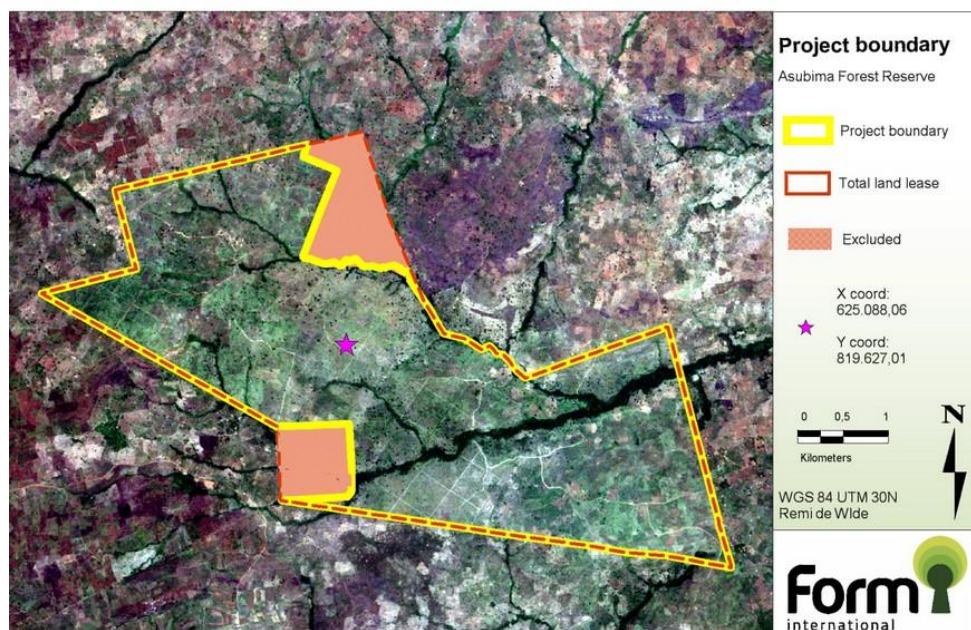


Figure 5 Outline of VCS project boundary. GPS coordinate in UTM Zone 30, Northern Hemisphere (WGS 84). The southern excluded square is the 64 ha pilot plantation and the north-eastern area is a patch of farmer's teak.

2.4 Baseline Scenario

The selected baseline approach is chosen based on paragraph 22 of the A/R CDM modalities and procedures as:

'(c) Changes in carbon stocks in the pools within the project boundary from the most likely land use that the time the project starts.'

The baseline scenario is land encroachment forming a mosaic of illegal subsistence farming, grassland with scattered trees and patches of remnant forest.

The rationale for this approach and scenario is provided in section 2.5 and the quantification of carbon stocks is further elaborated in section 3.1.1.

2.5 Additionality

Following the CDM methodology AR-ACM0001, the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities" is used to demonstrate the additionality of the proposed VCS project.

The tool has two *Applicability Conditions*, which are met:

- The proposed project activities do not lead to the violation of any applicable law, see section 1.11.
- The proposed project is not a small-scale project. The expected GHG sequestration is more than 8 kiloton per year and the project is not a low income community project.

Following the tool's section II.6, a few steps must be applied to demonstrate additionality:

STEP 0. Preliminary screening based on the starting date of the A/R project activity

The project activity started in 2008, which is proven by the land lease agreement signed on the 14th of November 2008 (15) and the plantation establishment that started in March 2008. This is documented in the annual monitoring reports of FORM Ghana.

From the project start in 2008, the PP has aimed for a sustainable reforestation project combining high quality timber production with carbon crediting for revenue generation. PP has set up the commercial reforestation project as an example for sustainable plantation establishment and management, thus attracting new investors in the sub sector. PP implements the project according to the highest technical, social and environmental benchmarks available, notably by certifying the plantation to international FSC and Carbon Certification standards (16). Carbon credit sales have always been an important part of the business plan to ensure diverse and early revenues and attract future investors. Therefore, in January 2009, an independent auditor determined the carbon balance of the plantation company taking into account the amount of GHG emitted and sequestered during the process. The results from the 64 hectares pilot plantation established in 2011 showed that carbon sequestration is substantial (14).

STEP 1. Identification of alternative land use scenarios to the proposed A/R CDM project activity

Sub-step 1a: Identify credible alternative land use scenarios to the proposed CDM project activity

Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.

Prior to 1993, the forests of Ghana were poorly managed. Due to an unclear forestry policy from the government, no long term vision and the lack of enforcement of existing regulations there was a widespread malpractice in timber trade; forest fees were not paid, illegal trading flourished and concessions were illegally sublet to unlawful timber operations. These malpractices led to the overexploitation of the most marketable timber species, which caused severe degradation of forests throughout Ghana. Local communities were generally not involved in forest resource protection, leading to uncontrolled agricultural encroachment. Measures were taken to end these deficiencies, such as the 'Forest and Wildlife Policy' in 1994, the 'Forestry Development Master Plan' in 1996 and the 'National Forest Plantation Development Policy' in 2001 (17) (18). Nevertheless, 94% of the Forest Reserve area is still in a deplorable condition today (7).

In the project forest reserve, timber has also been overexploited since the 1980's. Subsequently, natural and anthropogenic fires ravaged the remaining forest and illegal farming became rampant. The Asubima Forest Reserve was already considerably degraded in 1995 (9) (19), figure 3 chapter 1.10. Despite recently developed regulations, social surveys conducted amongst farmers of the Asubima forest reserve and surrounding communities showed that little has changed until now. Customary and legal rules allow local people within forest reserve boundaries to collect non timber forest products (NTFPs) for their subsistence only, but farmers admitted in interviews that they farmed illegally in the forest reserve (7).

As a consequence of these unsustainable farming practices and of the human-induced fires that occur in the area, both soil fertility and water quality are still further reducing (8). Today, the herbaceous shrub *Chromolaena odorata* (Akyeampong), the invasive tree *Broussonetia papyrifera* (York) and *Pennisetum purpureum* (Elephant grass) are dominating the forest reserve, fueling wild fires.

Some patches of standing degraded forest remain on soils that are unsuitable for farming or in wet areas, where the wild-fires have little effect. However, almost all commercial timbers species have also been harvested from these forests. Without the activities proposed by the project proponent this situation is expected to continue, leading to further degradation of the forest and disappearance of the last remaining indigenous trees.

Land use scenario B: Conventional commercial reforestation/ plantation without VCS certification.

The 'National Forest Plantation Development Policy' was launched by the government in 2001 to promote sustainable plantation development in degraded forest reserves. The policy consists of three strategies: subsidize more government-owned plantations, attract private investors for plantation management and promote community forest management. The last strategy is regarded as a different scenario and will therefore be discussed below. The first two strategies are considered 'conventional commercial plantations'.

This policy made it possible for private actors to acquire a well-defined and carefully negotiated land lease for commercial reforestation on Forest Reserve land. A total of 15.032 ha were planted by private parties between 2002 and 2008. These plantations are mostly developed by smallholders, are often inactive due to a lack of funding, their performance is under expectation and developers are expecting financial support from the government (20). The Government Plantation Development Program (GPDP) in this period was funded with money from the Highly Indebted Poor Countries (HIPC) program, launched by IMF and the World Bank in 1996 to ensure that poor countries do not face a debt burden they cannot manage (18). The GPDP made use of hired labor and contracted supervisors for the establishment of industrial plantations. By 2008, a total of 33.652 ha was planted with funding from HIPC (19).

In general, both government-owned and private forest plantations in Ghana are often poorly managed and environmental and social laws are not always respected. Effective management of wild-fires and illegal activities as well as appropriate and timely silvicultural interventions in the plantation, such as weeding, pruning and thinning are often lacking, leading to low stocking levels, poor tree quality and losses due to fire and illegal logging. Labor conditions can be poor, with a lack of safety equipment and training, and employees are often underpaid (personal communication with Mans Vroom).

Land use scenario C: Modified Taungya system (MTS) and community forest management.

The conventional Taungya system is a specific type of agroforestry, applied worldwide in plantation forests. After clearance of the land, food crops are intercropped with the tree seedlings. This generates income in the first years of a plantation, reducing the establishment costs, but also benefits the seedlings because of the control of weeds on the bare land.

In Ghana, the Taungya system has been practiced for centuries as solutions for the restoration of degraded land. Since 1984 however, use of the system was discontinued because of problems related to inequity between communities and forest managers on the level of ownership and benefits. This led to the development of the Modified Taungya System (MTS) in 2002, in which financial benefits and decision-making power were not just reserved for government officials and land-owners but also included farmers and local communities (21).

The implementation of MTS is part of the National Forest Plantation Development Program (NFPDP). The design of MTS within this program involves a partnership between the Forest Services Division, which provides knowledge and equipment, and local farmers, that provide the labor. The returns from the investments are divided between the farmers (40%), government (40%), landowner (15%) and community (5%). By 2008, 78,569 ha of land had been allocated to MTS practices (19). In addition to MTS, the NFPDP also includes the implementation of the Community Forest Management Project (CFMP), funded with money from the African Development Bank. The objective of CFMP is to rehabilitate degraded forest reserves and at the same time increase agricultural, wood and non-wood forestry production (22). In 2008, 9,095 ha were allocated to CFMP (19). The barrier analysis will concern the entire CFMP, without distinguishing between MTS and other community forestry schemes included in the program, because the barriers are to a large extent the same.

Land use scenario D: Sustainable commercial reforestation without VCS certification.

PP definition of sustainable commercial reforestation: a reforestation activity that commits to the enhancement of environmental, social and economic values in the project area. The project proposed by the PP has committed to the sustainability principles stated in table 7.

FSC certification independently demonstrates compliance with international sustainability standards. Currently, the plantation of PP is the only FSC certified timber plantation in West and Central Africa and FORM strives to certify all future project instances with FSC certification.

Table 7: Sustainability principles as applied to project proposed by PP.

Category	Sustainability principle	Management activity
Environmental	Increase biodiversity on the plantation	- Establishment of wildlife corridor network - Native flora and fauna protection 10% of the trees planted are indigenous species. - Indigenous and rare tree species are protected and planted - Buffer zones are planted with indigenous species - High Conservation Value (HCV) monitoring
	Minimize pollution	The use of pesticides, biodegradable only, is reduced to a minimum
	Erosion control	Erosion channels and respecting buffer zones
	Wild-fire control& Water quality protection	The construction of buffer zones along streams of at least 30m wide
	Reduced Impact Logging (RIL)	- Adequate planning of forestry operations - Best practice forestry operations (e.g. harvesting, road building) - Provision of training to the employees
Social	Maximum safety for employees	- An active fire patrol team and security force are employed for the prevention/control of wildfires and other illegal activities - Purchase of safety equipment - Providing safety training
	High standard working conditions	- Fair wages (above national minimum) - Health insurance provided
	Education	Training provided to the employees
	Empowerment	A benefit sharing agreement

		signed with the local communities. • Possibilities to collective bargaining through unions
Economic	High-value species	• A viable mix of indigenous and exotic species
	Ensuring optimal growth of the plantation	• Skilled management for: - Weeding - Thinning - Pruning
FSC Certification	Compliance with international sustainability standards	• Annual in- and external audit • Monitoring (plantation, flora/fauna)

Outcome of Sub-step 1a: List of credible alternative land use scenarios that would have occurred on the land within the project boundary of the A/R CDM project activity.

- Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.
- Land use scenario B: Conventional commercial reforestation without VCS certification.
- Land use scenario C: Modified Taungya system (MTS) and community forest management.
- Land use scenario D: Sustainable commercial reforestation without VCS certification.

Sub-step 1b: Consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations.

Land use scenario A: Mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.

Since the project areas are all in degraded forest reserves all farming activities are illegal. However, this is the prevailing land use practice, as can be observed from interviews with local farmers and satellite images of the area (7)(figure 5). Hence, the law is currently not sufficiently enforced to prevent encroachment of the forest reserve.

Land use scenario B: Conventional commercial reforestation without VCS certification. Reforestation is not mandated by any enforced law or regulatory framework.

Land use scenario C: Modified Taungya System (MTS) and community forest management. The MTS is implemented by the Plantations Department (PD) of the Forest Services Division (FSD) of the Forestry Commission (FC) as part of the National Forest Plantation Development Program, as part of the national forest policy.

Land use scenario D: Sustainable commercial reforestation without VCS certification. Reforestation is not mandated by any enforced law or regulatory framework. There are laws concerning some of the social and environmental issues discussed in table 7 above, but these are also not enforced. There is no law to be FSC certified.

Outcome of Sub-Step 1b:

- Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.
- Land use scenario B: Conventional commercial reforestation without VCS certification.
- Land use scenario C: Modified Taungya system (MTS) and community forest management.
- Land use scenario D: Sustainable commercial reforestation without VCS certification.

STEP 2. Barrier analysis

This step serves to identify barriers and to assess which of the land use scenarios identified in the sub-step 1b are not prevented by these barriers.

Sub-step 2a. Identification of barriers that would prevent the implementation of at least one alternative land use scenarios

The project scenario and other land use scenarios face several barriers. The barriers discussed in this section are categorized as follows:

- Social barriers
- Investment barriers
- Institutional barriers
- Technological barriers
- Barriers due to prevailing practice
- Barriers to local ecological conditions

Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees.

This land use scenario is not constrained by any barriers and is therefore the prevailing land use practice.

Land use scenario B: Conventional commercial reforestation without VCS certification

As mentioned above about 15,000 ha were planted by 300 private developers between 2002 and 2008, implicating that the average size is only 50 hectares per developer. As the Forestry Commission reports, many developers are inactive, they lack funds and technical expertise, suffer from poor roads and expect financial support from the government (19)(20). Despite earlier mentioned policy initiatives, no large-scale commercial reforestation projects exist in Ghana because these projects face large barriers. Developments in the private sector have not survived without external support (17). Experience shows that initiatives to establish large private plantations are of short duration, run out of funds, and therefore stop or cannot scale up. The total size of plantations that have been established is very limited and insignificant at national level.

Social barriers

Illegal logging, farming, poaching and human-induced wild-fires for the preparation of agricultural land, pose substantial barriers to sustainable forest management and reforestation. These activities originate from rational economic behavior of the local farmers to generate food and income, but are also caused by ambiguous tenure of trees and the

limited availability of labor and capital (17). These activities stand in the way of a healthy cooperation with the government or private plantation developers, but also mean that real options and incentives for rural communities to start reforestation are scarce. In order to successfully manage a plantation, illegal activities have to be mitigated or stopped completely. This requires continuous dialogue and collaboration of companies with the local communities, prohibition of illegal activities and law enforcement, effective fire management through planning of fire belts, firefighter teams, and the education, engagement, employment and training of local people. To successfully achieve these changes structural social adjustments are needed. Since local people usually work as farmers and lack formal education, the skilled labor necessary for these adjustments is often lacking in the area. Additional training is therefore essential. The complexities of the required social adjustments and additional training pose significant barriers for successful reforestation.

Investment barriers

For the establishment of a forest plantation, several investment barriers have to be overcome. First of all, there is a large initial investment required to set up a teak plantation; costs for plantation establishment and maintenance range from €1500 to €3000 per hectare for the first four years only.

Secondly, it takes a long time before the returns on investment are received. The first commercial thinning can take place twelve years after planting. According to (17), there are no medium- or long-term loans available in the country and commercial bank lending rates are very high, interest base rates of 20-30% are normal in Ghana (23). In addition, Odoom concludes that the illegal lumbering and timber trade activities cause price distortions in the domestic timber trade market. This is worsened by the Forestry Department (FD) selling plantation timber below the market price.

Another factor hampering investments in Ghana is the poor investment climate. The credit rating for Ghana is B, which is five steps below investment grade with a stable outlook (24). Because of these investment barriers, complex financial strategies are needed to finance a large scale reforestation plantation, such as making use of multiple investors and combining public and private funding. This is difficult to achieve. Hence, there is a lack of funding for these projects and no large-scale plantations, other than government-owned, exist in Ghana.

Institutional barriers

Commercial reforestation in forest reserves requires a land lease contract with the Forestry Commission. A Benefit Sharing Agreement should be signed with the Forestry Commission (FC) and the traditional land owner. This process can be lengthy and related costs are a significant hurdle for some developers.

Since large teak plantation are not common practice, equipped sawmills and process facilities to handle teak are not yet present in Ghana. The establishment of more teak plantations would promote the establishment of more sawmills, thereby creating a more efficient industry altogether. However, this requires significant expansion and maturation of the forest plantations sector in Ghana.

Technological barriers

As evidenced by (19), existing infrastructure often cannot support proposed scenario activities so roads and bridges will have to be built upon the initiation of project activities. Plantation developers often lack the technical expertise for good quality plantation development, which leads to poor implementation and maintenance practices (17)(19)(20).

Ecological barriers

Due to the severe degradation, persistent invasive weeds such as *Broussonetia papyrifera* (York) and *Pennisetum purpureum* (Elephant grass) require initial clearing before planting is

possible. These weeds are extremely difficult to eradicate in an environmentally friendly way and cause a significant competition pressure on the growing trees, which requires intensive additional weeding in the first 4 years to maintain the preferred growth scenario. Also, the presence of especially Elephant grass creates high fuel loads and thus fire risks in and around the plantation, which makes fire prevention and firefighting an intensive and costly operation.

Compared with environments with less weed pressure and fire risk this ecological environment poses a high barrier.

Land use scenario C: Modified Taungya system (MTS) and community forest management.

Social barriers

An essential part of the NFPDP implementation is the cooperation with farmers. Problems have been reported concerning this cooperation, for example when preparation of land appointed for plantation establishment does not happen at the agreed time (NFPDP). This relatively small incident can have big consequences in case the juvenile trees can no longer profit from the rainy season. From a farmers point of view on the other hand, the choice to delay tree planting can be explained as follows: they tend to lend priority to the nursing of their food crops as they are they provide them with an immediate means of existence (25). Farmers may also be hesitant to cooperate because of bad experiences they had with the previous Taungya system, when the FD failed to provide seedlings or appropriate advice (17).

Another issue that farmers cope with is that of illegal activities of cattle herdsman in plantations, such as setting off wild-fires within the plantation, as was reported in the Begoro, Kumawu and Juaso plantation areas. This not only threatens the survival of seedlings by trampling and browsing of cattle, but also affects the safety of the people working on the plantations. Incidents have been reported in the Fulani regions. The field staff generally lacks capacity for proper surveys to prevent these events in the future (20).

Investment barriers

Both on the side of the farmers and on the side of the government there are challenges to be faced in financing the implementation of MTS. The program depends mainly on government funding, which is often delayed or insufficient. Hence, when funding is released, a large amount is used to disburse outstanding payments and not to finance new projects.

Communities are often kept waiting for their payments and they are unsure about the distribution of revenues (19). These practices hinder project implementation.

Farmers on the other hand also lack capital to invest in equipment like Wellington boots or to cover the costs of tending the (large) plantation areas (26). They have been reported to abandon their land because of financial shortcomings. For example in 2007 it was reported that only 14% of the MTS plantations received maintenance (20). The situation is so severe that the authors of the Annual Report of 2008 call for 'a revision of the roles and benefit sharing ratio for the participating Taungya Groups' (19).

Technological barriers

Despite efforts of the Sector Ministry and the Forestry Commission, still a lack of transportation vehicles was reported (19). A number of stations had to share vehicles, limiting the transport capacity of the plantation staff, for instance on field work or plantation assessments. According to the Annual Report of 2008, a minimum of 28 pick-ups, 5 station wagons and 16 tractors were said to be necessary in order to fully support the plantation activities. Other tools like GPS receivers, prismatic compasses, clinometers and pruning saws were also insufficiently present (19).

Ecological barriers

As in scenario B, reforestation under this scenario suffers from high weed pressure and fires risks. The plantations are highly susceptible to wild-fires (12). Fire outbreaks are common in a large number of areas and as the staff lacks the capacity in numbers and knowledge to perform adequate surveying and fighting fires (see the 'social barriers' section), no action can be undertaken to prevent this from happening.

Barriers related to land tenure, ownership, inheritance, and property rights

Due to the fact that the farmers working on the plantations are not the owners of the land, they are constantly suffering from great uncertainty regarding the future of the plantation. Their sense of responsibility for the plantation is therefore a lot smaller than in case the land would actually belong to them. The issue of long term investment is also problematic. The revenues from the timber plantation take a long time to reach the investing farmers. Farmers are therefore hesitant to invest, especially those above the age of 50, when you are not likely to reap the benefits (21).

Land use scenario D: Sustainable commercial reforestation without VCS certification.

The barriers mentioned for land use scenario B also apply to scenario D. The barriers discussed below are in addition and apply to sustainable reforestation specifically. PP reforestation project is the first plantation that is FSC certified ensuring environmental, social and economic sustainability (27). To ensure sustainability, additional barriers are faced.

Social barriers

Skilled management and staff is needed (for e.g. planning, logistics, thinning, pruning, RIL, and monitoring) to ensure feasible and technically sound management of a sustainable plantation and comply with all requirements for FSC. This can be realized by employing skilled professionals from within and from outside Ghana and constantly training the employees. Building the right set of skills and expertise adds costs and takes time. Also, working on the social adjustments and countering illegal activities (logging, poaching) requires constant efforts, surveillance and stakeholder consultation, posing additional barriers.

Investment barriers

Private investors will be withheld from investing in Ghana because of the high insecurity of the Ghanaian economy (24). Loans are not provided by the government for plantation establishment, and banks demand high interest rates (17). Investment for sustainable and commercial reforestation is therefore often tied to foreign investors, demanding high returns, extensive risk mitigation strategies and clear ecological and social co-benefits, including demonstrated positive contributions to climate change mitigation. These demands are difficult to bring together and efforts to mitigate risks and enhance co-benefits raise costs compared with conventional plantation development. This tension in the business case can be eased with the use of carbon finance. Without carbon finance, many of the additional goals that PP has set to ensure sustainability of the project could not be achieved.

Technological barriers

For the appropriate management of plantations with indigenous tree species insufficient (scientific) guidance and information is available at present. Therefore the company has to deal with a high degree of uncertainty regarding the expected growth and management regime of this plantation type. Additional monitoring of the plantations and development of improved management information and tools is therefore required.

Ecological barriers

The sustainability principles of FSC prohibit the use of conventional pesticides. Manual application is required for the ecologically friendly pesticides and this makes the control of weeds considerably more labor-intensive, hence more expensive.

Because of the management objective to have a positive impact on biodiversity and ecological values buffer zones and indigenous plantations are developed, also in areas that would under conventional plantation development be planted with teak. Profitability in these areas is lower than teak or even zero, while maintenance costs are higher for indigenous plantations.

Sub-step 2b. *Elimination of land use scenarios that are prevented by the identified barriers*

The proposed project area was partially forested since 1989 and the land was not a forest at the project start. This is because the land is officially a Forest Reserve, but due to increased population pressure in recent years and insufficient law enforcement, agricultural encroachment in the area has caused severe deforestation and soil erosion (17)(figure 3, chapter 1.10). Farmers still inhabit the area, using it for agricultural practices, which makes it highly improbable for the forest to return by means of natural regeneration.

Land use scenario B: Conventional commercial reforestation without VCS certification.

Many barriers hinder the implementation of this scenario. The most important ones are of a social and financial nature: there is a lack of skilled labor in the area, investment costs are too high and there is no option for obtaining loans for plantation establishment. In addition, the existing infrastructure cannot support the transport required under this scenario, which means the investment costs rise even further. The significance of these barriers is demonstrated by the absence of large-scale private reforestation sites in the country and small size and poor performance of private developers in the NFPDP (19)(20).

Considering these barriers, scenario B will be eliminated from further consideration.

Land use scenario C: Modified Taungya System (MTS) and community forest management.

A main barrier for implementation of scenario C is the cooperation between government and farmers. The government provides the funding of the program, but release of this funding is often delayed and outstanding payments have yet to be disbursed. This hampers the progress of the project and de-motivates the cooperating farmers. The farmers on the other hand do not perform as desired when it comes to attending the seedlings. They tend to lend priority to the nursing of their food crops, thereby delaying the planting of seedlings or neglecting the planted trees.

Considering these barriers, scenario C will be eliminated from further consideration.

Land use scenario D: Sustainable commercial reforestation without VCS certification.

This scenario meets with all the barriers that scenario B is met with. On top, investment, technological and ecological barriers of implementing the activities according to the sustainability principles that PP committed to are added. Abandoning these principles however, would significantly reduce ecological and social values of the project. To date no sustainable reforestation projects with FSC certification exist in Ghana.

Considering these barriers, scenario D will be eliminated from further consideration.

Outcome of sub-step 2b.

Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.

The identified barriers do not affect the continuation of the status quo: mosaic of illegal subsistence farming and grassland with scattered trees. Although this type of land use is technically illegal in a forest reserve area, it is the prevailing means of existence in the area since laws are not sufficiently enforced. Without interference, prevailing practice is therefore expected to continue, leading to further deterioration of the remaining vegetation, soil and water quality.

Sub-step 2c. Determination of baseline scenario (if allowed by the barrier analysis)

Forestation without being registered as an A/R (CDM) carbon project activity is not included in the list of land use scenarios that are not prevented by any barriers, listed at sub-step 2b. This list contains only one land use scenario:

Land use scenario A: Continuation of the pre-project land use; mosaic of illegal subsistence farming and grassland with scattered trees and patches of degraded forests.
This scenario is the baseline scenario.

STEP 4. Common practice analysis

In Ghana, large scale commercial plantations are not common practice. Teak, but also other timber species, are mostly produced by smallholders, the government or government-owned companies (17).

The project proponent commits itself to manage its plantations in a socially, environmentally and economically sustainable way according to the principles and criteria of FSC and even exceeding these requirements, as is detailed in table 7. This is a unique concept in Ghana, as no other company operates at this scale and with FSC certification.

The project proposed by the PP is the only FSC-certified plantation in West-Africa (28), but the PP has decided to add goals to the general FSC requirements. For example, at least 10% of the planted seedlings are indigenous, as opposed to the 5% required by FSC (27). In the buffer zones along the rivers in the area, natural regeneration of the standing degraded forest is assisted by reforestation and ANR techniques. In addition, the buffer zone is actively expanded in severely degraded patches and endangered species like the Kokrodua tree are being reintroduced in the area. In recent flora/fauna monitoring, sightings of endangered fauna species have been reported (29)).

Social research showed the project proponent is a large provider of work in the area (7). Whilst setting up the plantation, the project proponent aims to establish a healthy cooperation with the local communities living in the area. Farmers that have illegally farmed within the project boundaries are therefore invited to intercrop their food crops within the teak plantation until canopy closure. In addition, a benefit sharing agreement has been signed, ensuring that 10% of the revenues flow back to the Forestry Commission, traditional landowners and the local communities.

By adhering to all ILO conventions, PP ensures a safe working environment, pays more than the minimum wage, provides health care, free meals and transportation to the employees. Also, employees receive training in aspects such as firefighting, safety-regulations and reduced impact logging (RIL) practices. This extensive educational programme empowers local communities and promotes private initiatives. The targeted employees are local people, and therefore provide a boost to the local economy.

Because of the substantial barriers described in the barrier analysis, the proposed project does not yet exist in Ghana. VCS certification is essential in the pioneering business model to ensure a viable revenue stream to overcome these barriers and to substantially reduce the investment gap. This can pave the road for increased future investors to initiate more reforestation projects in Ghana.

2.6 Methodology Deviations

Not applicable

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

This chapter described the methodology, calculations and input variables for the quantification of GHG emission reductions and removals.

In case equations used in this chapter correspond to the CDM methodology, the equation number used in the CDM methodology is indicated behind the equation.

3.1 Baseline Emissions

Following the methodology carbon stock changes in dead wood, litter and soil organic carbon are not considered to determine baseline GHG removals by sink. Shrub biomass is neglected as they are hardly present in the area. The baseline net GHG removals are therefore determined as:

(eq. 1)

Parameter	Unit	Description
	t CO ₂ -e / ha	Baseline net GHG removals by sinks
	t CO ₂ -e / ha	Change in carbon stock in tree biomass in baseline within the project boundary in year t
t		1,2,3...t* years elapsed since the start of the project activity

is determined using the tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*”. According to this tool is determined as:

————— (CDM tool eq. 12)

Parameter	Unit	Description
	t CO ₂	Rate of change in carbon stock in tree biomass within the project boundary during the period between t1 and t2 for stratum i
	t CO ₂	Carbon stock in tree biomass within the project boundary at a point of time in year t2
	t CO ₂	Carbon stock in tree biomass within the project boundary at a point of time in year t1.. For the first year t1 is the baseline as stock as calculated in section 3.2
t	years	Time between two monitoring periods

must be determined for two different baseline carbon stock levels, because two clearly distinct strata have been identified with the use of satellite imagery (figure 6) and vegetation sampling. These baseline carbon stock strata are:

1. Stratum 1: Mosaic of agricultural land and degraded grasslands with some scattered trees remaining.
2. Stratum 2: Patches of degraded forest in the buffer zones along watercourses.

As can be observed in figure 6, stratum 1 has much lower woody biomass levels than stratum 2, with more remaining native vegetation. Table 8 shows the carbon pools and carbon content of these two baseline carbon stock strata. Calculation methods for the determination of the carbon values and for stratum 1 () and stratum 2 () are elaborated in the next two sections.

Table 8: Characteristics of two baseline carbon stocks.

Baseline carbon stock stratum	Relevant biomass pool	Mode of biomass calculation	Value (ton CO ₂ /ha)
1:	Remnant Indigenous Trees (RIT)	Representative plots to calculate an average per ha	8.9
	Remnant Teak (RT)	Representative plots to calculate an average per ha	5.9
	Invasive York (IY)	Representative plots to calculate an average per ha	0.9
	Total		15.7
2:	Mixed degraded forest (MDF)	Sample plots and satellite images	99.4
	Invasive York ()	Sample plots and satellite images	3.2
	Total (including deduction for precision)		102.5

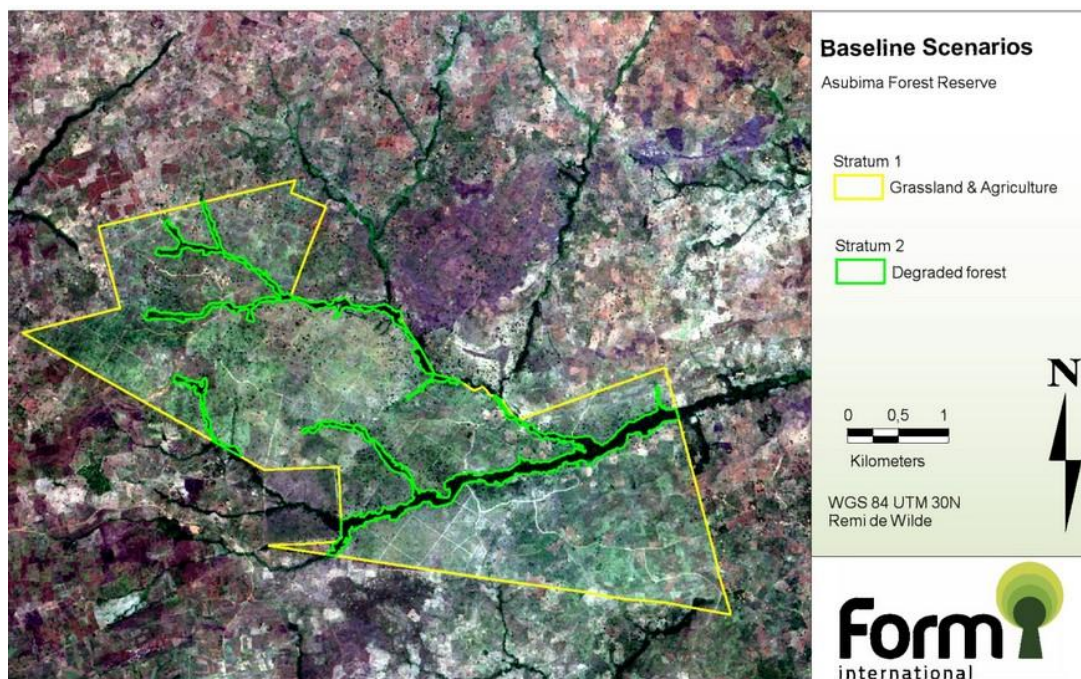


Figure 6: Satellite image of project area. The two baseline carbon stock strata are presented here. The area demarcated with the yellow line represents the mosaic of agricultural land and degraded grasslands with some scattered trees remaining (stratum 1). The green colour represents patches of degraded forest in the buffer zones (stratum 2). The scattered green dots are the remnant indigenous trees (RIT), which are now protected trees. Image from 24-02-2011, RapidEye 5m resolution.

3.1.1 Baseline carbon stock stratum 1: Carbon stock in living trees at the start of the project activity in degraded grassland ()

Carbon stocks in this baseline stratum are built up from two vegetation categories:

1. Remnant Indigenous Trees (RIT)
2. Remnant Teak (RT) & Invasive York (IY)

These two categories will be discussed separately in the section below because trees from the first category (RIT) are protected while trees from the second category (RT & IY) are felled in the project scenario.

Parameter	Unit	Description
	t CO ₂	Above and below ground tree carbon stock in baseline stratum 1
j	-	Species groups in baseline stratum 1. These are 1: Remnant indigenous trees (RIT) 2: Remnant Teak (RT) 3: Invasive York (IY)

Remnant Indigenous Trees (RIT) carbon stocks (Ctree_bsl1,1)

The CDM tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*” is used to calculate the amount of CO₂ storage in remnant indigenous trees per ha. The number behind the equation corresponds with the equation in the tool.

We do not use BEF in eq1 since Vtree_bsl1,1 is already total aboveground volume as described further below. An average wood density (D value: 0,447) is determined based on relevant literature (30) (31) (32) (33). Carbon fraction (CF, value: 0.5) and root to shoot ratio (Rmix, value: 0.22) were derived from Aalde et al. (2006) (33).

— (eq 1. CDM tool)

Parameter	Unit	Description
	t CO ₂ *ha ⁻¹	Above and below ground carbon stock in remnant indigenous trees
	m ³	Above ground tree volume in inventoried area i, estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (f) (f, value: 0,6) (34) as entry data into a volume calculation
	d.m. m ⁻³	Average wood density for indigenous species
	-	Root to shoot ratio for mixed tropical broadleaf trees
	-	Carbon fraction (assumed the same for all species)
A	ha	Total surface area of inventoried trees
44/12	m*m ₋₁	Ratio of molecular weight of CO ₂ to C

In order to determine Vtree_bsl1, PP inventoried all remnant indigenous trees (486 trees) in a representative part of the project area (179 hectares, 11% of the project area). Tree species, DBH and H of each tree were recorded. The average form factor (f, value: 0,6) for tropical broadleaf species used is derived from Cannell (1984) (34). The total surface of the inventoried area (A) was determined using a GPS and a GIS programme. Volume of aboveground biomass was calculated following:

$$V_{tree_bsl1,1} = \pi (DBH/2)^2 * H * F$$

Parameter	Unit	Description
	m ³	Above ground tree volume in inventoried area i, estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (f) as entry data into a volume calculation
DBH	m	Diameter measured at breast height
H	m	Height of the tree
F	-	Form factor for broadleaf tropical trees which converts DBH/height to total above ground biomass.

The outcome of this calculation can be seen in table 8 above.

Remnant Teak (RT) & Invasive York (IY) carbon stocks (Ctree_bsl1,2 & Ctree_bsl1,3)

York is the most common invasive tree in the area, hampering growth of teak and indigenous trees. In the plantation and in the buffer PP policy is to eradicate york. Some planted and regenerating teak is found in some parts of the project area. These trees are removed during land preparations as they are mostly of poor quality, unknown provenance and widely spaced. To provide a solid estimation of the carbon stocks in this pool, the amount of trees felled for land preparation were counted in 2011 and summarized in table 9. These values are based on data covering over 1,000 hectares and are representative for the whole project area. Many of these trees are coppices with multiple stems. All stems (also of the same tree) are separately included in the numbers presented in table 9. This is considered a relative conservative sample for the Asubima forest reserve the amount of remnant teak was less based on PP management. This is supported by the SEIA, which showed 87% of the land was already being farmed and 13% of the area was occupied with taungya or private teak plantation (7).

Table 9: Amount of York and Remnant Teak felled in 2011 & 2012

Species	Felling Date	Amount	CO2(t)
York	2 to 17 March	11,920	323
Teak	18 to 26 March	9,621	1,169
Teak	28 March to 2 April	11,468	1,394
Teak	4 to 9 April	9,232	1,122
Teak	10 April to 4 May	18,693	2,272
Total area (ha)	1,008	60,934	6,280
Ctree_bsl1,2 + Ctree_bsl1,3 (t CO₂/ha)			6.8

Remnant Teak (RT) calculation (Ctree_bsl1,2)

The biomass expansion factor (1,54) for Teak is derived from specific scientific literature (35). This factor converts stem biomass to total tree biomass and is therefore a combination of BEF and root to shoot ratio R. BEF related to teak calculations in the rest of this PDD are always including R and R is therefore not used in the equations.

The following equation is used to calculate the carbon stocks in remnant teak:

— (eq. 1 of the CDM tool)

Parameter	Unit	Description
Ctree_bsl1,2	t CO ₂ *ha ₁	Above and below ground carbon stock in remnant teak trees
	m ³	Merchantable timber volume in inventoried area i, estimated by using the FORM Ghana teak yield table combined with the number of inventoried trees
	ton* m ⁻³	Average wood density for teak (0,660)
	-	Biomass expansion factor converting stem biomass to total above and belowground biomass
	-	Carbon fraction for teak

A	Ha	Total surface area of inventoried trees
44/12	m ² m ₋₁	Ratio of molecular weight of CO ₂ to C

Input parameters used to determine C_{tree_bsl1,2} have been obtained through the fore mentioned inventory. The age of the trees was conservatively estimated at 5 years, based on expert judgement made by the FORM Ghana Management team. No tree measurement data is available. The evidence and supportive arguments for this age are as follows:

1. The tree size of a 5 year old teak tree in the yield table is 13.6 cm DBH and dominant height 12.6 meters. These sizes were considered to be upper limits for the felled trees based on observations in the field. Most trees were smaller than these limits.
2. Many of these trees were coppices with multiple stems. All stems (also of the same tree) are separately included in the numbers presented in table 9 above. This means that stem size in the ex ante calculations is overestimated, because the size of multiple stems of five year old coppices are smaller than those of single 5 year old stems, due to competition between individual stems of the coppicing tree.
3. Experience from managing the project area since 2008 shows that in general planted teak trees are cut down illegally before they reach 5 years. The tree sizes are then interesting for illegal loggers and hardly any trees are not harvested this way.

Based on the above arguments, the 5 year age and pertaining tree size are considered to provide a conservative figure, justified by direct and indirect evidence, which will rather underestimate than overestimate the net GHG benefit.

The volume of these trees () as well as the biomass were estimated following the FORM Ghana yield table for teak, which is also applied in the *ex ante* calculations for the teak plantation growth. Wood density, BEF and CF were derived from literature (35) (36). The outcome of this calculation can be seen in table 8 above.

Invasive York (IY) carbon stocks (C_{tree_bsl1,3})

The amount of york felled in 2011 was monitored and shown in table 9 above. York was sampled in buffer zone plots, which provided the best estimate of York densities and sizes in the area. York trees were not measured outside the buffers.

York density and sizes in the buffer zone plots were 40 trees/ha with an average tree height of 6.6 meters and 8.7 cm DBH. York density in the plantation areas was 12 trees/ha, based on the felled data presented in table 9 in the PD. The size of these trees was smaller than the buffer zone trees, based on field observation. These observations can be substantiated by understanding the land use dynamics in the area: Trees in the buffers are felled less frequently compared to areas outside the buffers, because these other areas were farmed intensively by illegal farmers with only 1 or 2 year fallow period. As explained in the leakage description in the PD: "Looking at the satellite photos in the baseline emission (Figure 3), all areas have been completely cleared for farming, except some patches of riverine forest. Most of the cleared areas consist of fallow land. Social surveys showed that an average farmer actively farms about 2,5 ha. In total, 54% of the degraded area was farmed actively and 33% was fallow land." During farm preparation, farmers cut down the York (a weed to farmers too). In practice this means that every 1 or 2 years an area is cleared for agriculture and York does not get the time to reach the tree sizes it has in the buffer. York grows slightly

faster than teak does, but will also need 3 to 4 years to reach the sizes found in the buffer areas. This is longer than the fallow period known in this area. In addition, these areas burned almost entirely each year, also severely damaging or killing the aboveground York biomass. The buffers were affected to a lesser extent by fires due to the higher vegetation cover and higher humidity near the rivers.

Another observation is that York performs better in the buffer areas than outside these areas. In the buffer site conditions are very good for York, with moist and light soils. Away from the buffers, soil moisture declines and there the York is seen mostly in association with better, moister soils. Orwa 2009 (one of the references in the PD) also describes the preference of York for moist and light soil types. This difference in performance between buffer areas and areas outside the buffers was not quantified, but is an expert observation, substantiated by the ecology of the species.

These arguments demonstrate that it is conservative to use the York tree sizes found in the buffer (Baseline carbon stock stratum 2) as a proxy for the York tree sizes in the areas outside the buffer (Baseline carbon stock stratum 1) based on field observations, the baseline land use dynamics (farming and fire) and the ecology of the York tree.

The following equation is used to calculate the carbon stocks in invasive yolk, the outcome of this calculation can be seen in table 8 above.

— (CDM tool eq. 1)

Parameter	Unit	Description
	t CO ₂ *ha ⁻¹	Above and below ground carbon stocks in invasive yolk trees
	m ³	York above ground volume in inventoried area, estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (f) (f, value: 0,6) (34) as entry data into a volume calculation and multiplying tree volume with the number of inventoried trees
	d.m. m ⁻³	Average wood density for York (0,506)
	-	Root to shoot ratio for mixed tropical broadleaf trees (0,22)
	-	Carbon fraction for York
A	ha	Total surface area of inventoried trees
44/12	m*m ₋₁	Ratio of molecular weight of CO ₂ to C

3.1.2 Baseline carbon stock stratum 2: Carbon stock in living trees at the start of the project activity in degraded forest ()

The CDM tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*” Carbon stocks in this baseline stratum 2 consist of mixed indigenous trees and invasive yolk in the following two categories:

1. Mixed degraded forest (MDF)
2. Invasive York

The tree carbon stock of baseline stratum 2 is determined as:

Parameter	Unit	Description
	t CO ₂ /ha	Above and below ground tree carbon stock in baseline stratum 2
j	t CO ₂ /ha	Species groups in baseline stratum 2. These are 1: Mixed degraded forest (MDF) 2: Invasive york

It is important to calculate the carbon stock of the two specie groups separately, because trees from the first category (MDF) are protected while trees from the second category (IY) are felled in the project scenario. The outcome of this calculation can be seen in table 8 above.

Mixed degraded forest (Ctree_bsl2,1)

To determine the carbon stocks of the mixed degraded forest at the start of the project activity in baseline carbon stock stratum 2, 21 sample plots of 200 m² each were laid out in this stratum. Tree height (H), tree diameter at breast height (DBH) and tree species were recorded, among other parameters. Over sixty different tree species were identified. An average form factor (f, value:0,6) was selected for tropical broadleaf species (34). Using this data, a total above ground tree volume of all trees in the sample plots was calculated and the total aboveground volume per hectare is derived from this number so that:

$$V_{tree_bsl2,1} = \pi (DBH/2)^2 * H * F / A$$

Parameter	Unit	Description
	m ³ * ha ⁻¹	Above ground tree volume per hectare in mixed degraded forest.
DBH	m	Diameter measured at breast height
H	m	Height of the tree
F	-	Form factor for broadleaf tropical trees which converts DBH/height to total above ground biomass.
A	ha	Total area of all sample plots

Wood density is determined when available from literature to calculate the average wood density (D, value: 0,467) of the entire buffer zone (30) (31) (33) (36). CF (value: 0,5) and Rmix (value: 0,22) is derived from Aalde et al (2006) (33). The form factor used to in the volume calculation above converts stem biomass to total aboveground biomass and therefore only R is used in eq1 below.

Total carbon stock in living trees in the degraded forest is then calculated using:

$$— \quad (CDM \text{ tool eq. 1 \&11})$$

Parameter	Unit	Description
	t CO ₂ *ha ⁻¹	CO ₂ in degraded forest indigenous trees left standing per hectare
	m ³	Above ground tree volume of indigenous trees in the inventoried area, estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (f) as entry data into a volume calculation
	d.m. m ⁻³	Average wood density for all species
	-	Root to shoot ratio for mixed tropical broadleaf trees
	-	Carbon fraction
44/12	m*m ₁	Ratio of molecular weight of CO ₂ to C
A	ha	Total surface area of all sample plots

The precision of the baseline carbon stock is estimated following equations 7 to 9 of the CDM tool. The result is a relative margin of error of 324%. This is larger than the 10% margin of error at a 90% confidence interval prescribed by the methodology and therefore a deduction is accepted. Following table 8 of the *“Estimation of carbon stocks and change in carbon stocks of trees and shrubs in AVR CDM project activities v3.0.0”* a deduction of 37% shall be applied. The calculation is shown in the “Guiding document calculations 20130114” and the result is presented in table 8. At the time of verification the uncertainty is calculated again and a confidence deduction will be applied according to this methodology in case the uncertainty is higher than allowed. This is adopted as the most conservative way to deal with variance in the mixed degraded forests.

Invasive York)

Part of the mixed degraded forest is invasive york. Tree carbon stocks for york are determined through the same sample plots as described above for Ctree_bsl2,1, but instead of including all tree species, carbon stock is determined only for york since these trees are felled as part of assisted natural regeneration. BEF is not relevant since volume is already aboveground volume. The volume calculation of is the same as for

The following equation is used to calculate the carbon stocks in invasive york:

— (adapted from CDM tool eq. 1 &11)

Parameter	Unit	Description
	t CO ₂ *ha ⁻¹	Above and below ground carbon stocks in invasive york trees
	m ³	York above ground volume in inventoried area i, estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (f, value: 0,6) (34) as entry data into a volume calculation and multiplying tree volume with the number of inventoried trees
	d.m. m ⁻³	Average wood density for York
	-	Root to shoot ratio for mixed tropical broadleaf trees
	-	Carbon fraction for York
A	ha	Total surface area of inventoried trees
44/12	m*m ₁	Ratio of molecular weight of CO ₂ to C

3.1.3 Baseline carbon stock changes in above and below ground tree biomass

Baseline carbon stocks are not assumed to be in steady state, since tree biomass is increasingly reduced due to cutting of trees and use of fire.

Because the methodology AR-ACM0001 does not provide further guidance to determine the CDM “guidance on conditions under which the change in carbon stocks in existing live woody vegetation are insignificant (v01)” is followed to determine the baseline carbon stock change.

According to section II.2 (procedure) of this guideline, the change in carbon stocks of existing woody vegetation sinks may be accounted as zero if at least one of the conditions (i) to (vi) is met. Below is stated how the project area meets several of the conditions:

(iii). Because of wild-fires, illegal logging of indigenous trees and continuous conversion to agricultural land, further degradation of the land is expected and it is expected that biomass in existing woody vegetation will decline in the baseline scenario (7) (9). The forest cover of Ghana reduced yearly by 2% over the last twenty years (37). In the project scenario, the remaining indigenous trees are protected and will not be felled, thus leading to reduced carbon emissions as opposed to the baseline scenario.

(v) Harvesting is expected to lead to declining biomass in existing woody vegetation. Harvesting of remaining indigenous trees is common practice. Teak planted either by the Forestry Commission or local communities is harvested illegally and/or prematurely.

(vi) Offinso district in Ghana is especially prone to annual bushfires since it lies in the northern drier part of the fire belt in Ghana (38) (39). Anthropogenic fires occur yearly as farmers apply slash and burn techniques to clear the land. Every year 2-3 fires a day in the fire season have to be extinguished to prevent damage to the plantation.

Because several of the guidelines’ conditions are met the change in carbon stocks in existing live woody vegetation are deemed to be insignificant. Therefore, baseline carbons stock change is conservatively assumed to be zero so that:

and

Therefore:

Parameter	Unit	Description
	t CO ₂	Baseline net GHG removals sinks for baseline strata 1 and 2

3.2 Project Emissions and Removals

3.2.1 Stratification

Reforestation typology

PP applies different ARR techniques to achieve GHG emission removals. This is shown in figure 7 and table 10.

The selected carbon pools mentioned in section 2.3 are applied in all reforestation types. However, different *ex ante* calculations for carbon storage apply, since there is difference in the management of certain areas. There are four identified types:

Table 10: Management of the different reforestation types

Reforestation Type	Baseline scenario	Clear felling	Selective harvesting	Thinning Pruning (management)	Planting	ANR
I: Teak plantation	1	Yes	No	Yes	Yes	No
II: Indigenous trees plantation	1	Yes	Yes	Yes	Yes	Yes
III: Planted buffer	1	No	No	No	Yes	Yes
IV: Degraded buffer	2	No	No	No	No	Yes

In the teak and indigenous trees plantation clear felling, thinning and pruning are part of the management and therefore a long term average is applied. Remnant indigenous trees will not be felled during harvesting operations. In the buffer zones there will be no harvesting, no pruning and no commercial thinning. The buffers are further divided into two areas; planted buffer and degraded forest buffer, which is further elaborated in section 3.2.2.3 of this PDD.

As the project expands gradually for all the different reforestation types, the project is further stratified by planting year as shown in table 11.

Table 11 Stratification

Stratum (i)	Year	Reforestation type	Size (ha)
1	2008	Teak Plantation	134
2	2009	Teak Plantation	514
3	2010	Teak Plantation	643
4	2010	Indigenous plantation	43
5	2010	Planted buffer	66
6	2010	Degraded forest buffer	106
Total			1,506

3.2.2 Actual net GHG removals by sinks

As described above, the project consists of four different reforestation types. The long term average shall be calculated following the AFOLU requirements 4.5.4 when harvesting is applied. As described in table 10 above clear felling is done in the teak plantation and selective harvesting could take place in the indigenous plantations, but no felling is done in the buffer zones. Since AFOLU requires all emissions such as leakage and all carbon pools to be included the project is first stratified per reforestation typology and then for plant year. For each reforestation typology the methodology ARR ACM-00001 version 05.2.0 is followed.

The estimated net GHG emission removals (t CO₂e) per year are therefore calculated as:

Parameter	Unit	Description
	t CO ₂ e*yr ⁻¹	Net anthropogenic removals by sink (from the CDM methodology eq 8)
	t CO ₂ *yr ⁻¹	Teak plantation emission removals
	t CO ₂ *yr ⁻¹	Indigenous trees plantation emission removals
	t CO ₂ *yr ⁻¹	Planted buffer zone emission removals
	t CO ₂ *yr ⁻¹	Degraded buffer zone emission removals

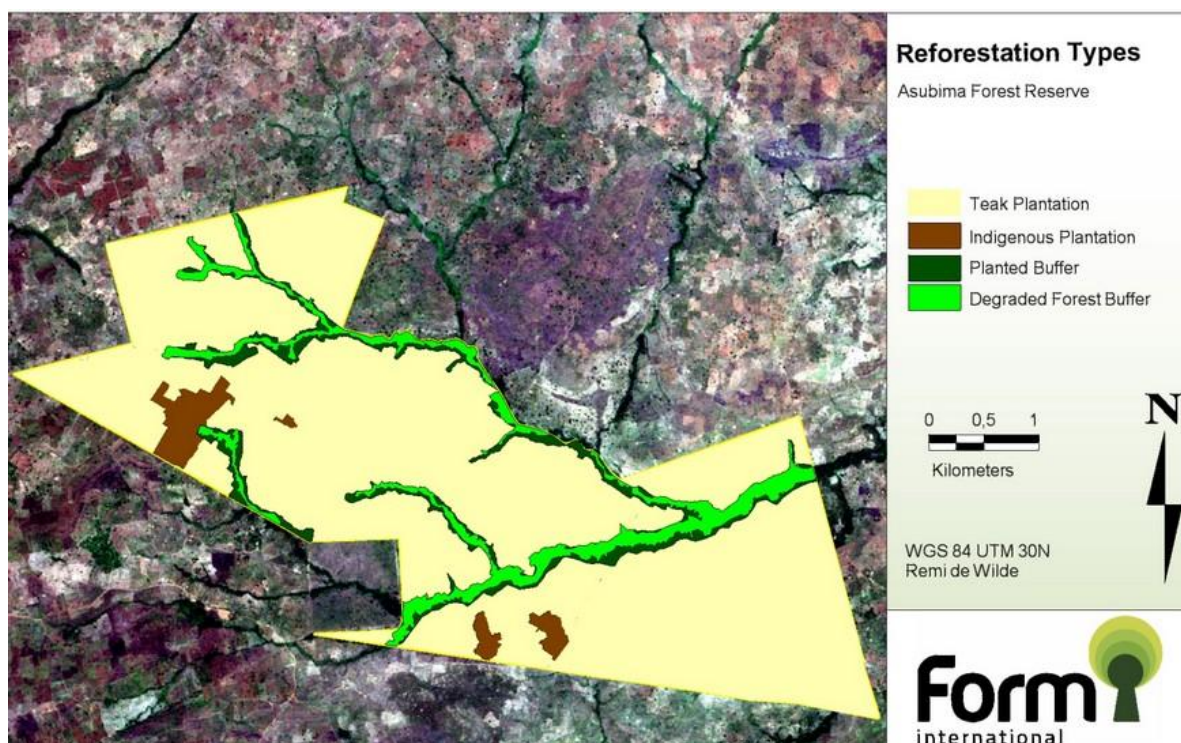


Figure 7 Reforestation types. The different colours represent the types accordingly. Yellow represents teak plantation, brown represents indigenous plantation, Light green represents the degraded forest buffer and dark green represents the planted buffer zone. The pink area represents the pilot plantation that was established in 2001. This area is outside the scope of the project area.

In the following sections, the actual net carbon emissions and removals per ha are explained per carbon pool and per reforestation type. Some of the emissions and removals of the selected carbon pools are calculated differently for different reforestation types and some are calculated in the same way for different reforestation types. For example, the calculations for *C_{tree}* are different for teak and indigenous forest areas, because different species have different growth. However, the change in e.g. soil organic carbon is assumed the same for teak and indigenous plantation. How different and same calculation methods are applied is visualized in table 12. Equal colours represent equal carbon calculations.

Following this table most carbon pools will be explained in the teak chapter below and only when a calculation is different will it be explained for other reforestation types.

Table 12 Selected carbon pools for the different reforestation types. Identical colours for different reforestation types imply that calculation method and the value for the selected pool are the same. X means that the pool is not included. *C_{soc}* is conservatively excluded for degraded buffer forests since the soil degradation is much less severe here. No agricultural activities exist in the degraded buffer forests and leakage is assumed zero.

	Carbon emissions and removals per hectare per reforestation type			
Carbon pool	Teak plantation ()	Indigenous plantation ()	Planted buffer zone ()	Degraded buffer zone ()
Above and belowground tree biomass (<i>C_{tree}_proj</i>)				
Soil organic carbon (<i>C_{soc}_al</i>)				X
Non CO ₂ GHG emissions (GHG _e)				
Leakage (LK _{agric})				X

3.2.2.1 Reforestation type I: Teak Plantation ()

Every year the plantation expands and additional teak is planted. In figure 8, the development over time is shown. The grouped project aims at planting 800 hectares teak per year. The plantation started in the most western corner of the original project area in 2008.

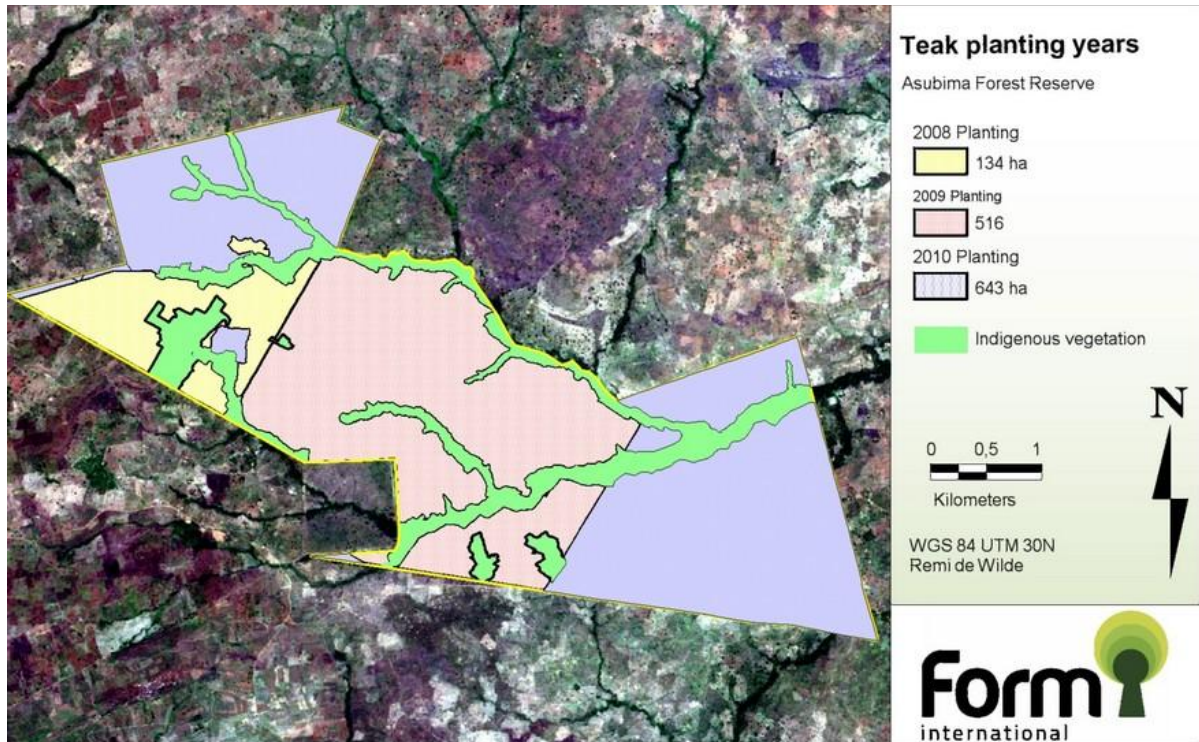


Figure 8: Teak planting years.

Since rotational harvesting will be done following AFOLU requirement, a long term average calculation is carried out over two rotation periods. The long term average should include at least one rotation period, which is for teak 20 years. The LTA is therefore calculated over 40 years.

Since each year additional areas are planted with teak, the long term average is calculated for one hectare. All teak plantation strata can only generate VCUs until the long term average is reached. This long term average is calculated following AFOLU requirement 4.5.4. Following this equation long term average is reached in year 11 after planting.

Parameter	Unit	Description
LA	t CO ₂ /ha	Long term average
PEt	t CO ₂ /ha	The GHG emission reductions and removals generated in the project scenario (tCO ₂ e) calculated over all relevant carbon pools.
BEt	t CO ₂ /ha	The GHG emission reductions and removals projected for the baseline scenario
n	y	Total number of years in the established time period (40 years)

All the calculations described in this document are done per hectare, following CDM guideline AR-ACM0001 v.05.2.0 for quantification of CO₂ emissions and removals. Multiplication with the amount of hectares then provides the net actual carbon emissions and removals by teak trees ().

The LTA for teak stands is 239 t CO₂/ha.

Actual net GHG removals by sinks (ΔC_{actual})

The actual net GHG removals equal the carbon stock increase in the relevant carbon pools minus the GHG emissions within the project boundary.

(eq. 3)

Parameter	Unit	Description
	t CO ₂ * yr ⁻¹	Actual net GHG removals by sinks
	t CO ₂ * yr ⁻¹	Sum of change in selected carbon pools within project boundary
	t CO _{2-e} * yr ⁻¹	Increase in non-CO ₂ GHG emissions within the project boundary as a result of project implementation
T	Years	Time between two monitoring periods

Sum of changes in selected carbon pools (ΔC_p)

(eq. 4)

Parameter	Unit	Description
	t CO ₂ * yr ⁻¹	Sum of changes in carbon stock in all selected carbon pools within project boundary since project start
	t CO ₂ * yr ⁻¹	Change in carbon stock in all selected carbon pools, in year t
t	Years	1,2,3 ... t* Time between two monitoring periods

The relevant carbon pools for ΔC_t are:

- Above and belowground tree biomass
- Soil organic carbon

Shrubs, litter and dead wood are conservatively excluded.
Therefore, equation five of the CDM methodology results as follows:

(eq. 5)

Parameter	Unit	Description
	t CO ₂ * yr ⁻¹	Change in carbon stock in all selected carbon pools, in year t
	t CO ₂ * yr ⁻¹	Change in carbon stock in above and below ground tree biomass
	t CO ₂ * yr ⁻¹	Change in carbon stock in soil organic carbon

Estimating change in carbon stock in tree biomass (ΔC_{tree} proj)

The change in tree biomass is calculated by estimating the biomass in each year. The tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*” is used to determine tree carbon stock changes. Because shrub biomass is very low this pool is conservatively excluded.

Following this tool, the stock change and BEF methods were applied to determine ΔC_{tree} in the teak strata. With the following equation ΔC_{tree} is determined:

————— (CDM tool eq. 12)

Parameter	Unit	Description
	t CO ₂ * yr ⁻¹	Rate of change in carbon stock in tree biomass within the project boundary during the period between t1 and t2 for stratum i
	t CO ₂	Carbon stock in tree biomass within the project boundary at a point of time in year t2
	t CO ₂	Carbon stock in tree biomass within the project boundary at a point of time in year t1.. For the first year t1 is the baseline as stock as calculated in section 3.2
T	years	Time between two monitoring periods

The tree biomass in the first year is the same as the baseline biomass in trees (remnant indigenous trees, remnant teak and invasive yorke) at the start of the project activity (). The tree biomass cleared (remnant teak and invasive yorke) during land preparation (), will be deducted from the baseline carbon stock and the increment of the planted teak trees (C_{tree_teak}) added.

Methods for determining have been discussed in section 3.1. The remnant indigenous trees is a constant figure of 8,9 t CO₂/ha. As discussed in the baseline, the amount of carbon in this pool is expected to decrease due to anthropogenic factors. These trees are protected in the project area and are therefore expected to grow. However, these

trees are conservatively assumed to reach a steady state in year zero and are therefore not monitored for ex post calculation, but added as a constant to the total C_{tree} of the relative stratum. Remnant indigenous trees will not be felled in the project scenario.

To determine the total above- and belowground biomass of teak trees, volume increments were calculated based on growth data for teak plantations provided by PP. These are adapted from existing growth tables (40) (2). In 2001, a pilot plantation of 64 hectares has been established in the project area. This plantation and its growth and performance serve as a model for the *ex ante* volume increments of the rest of the plantation.

To determine the amount of CO₂ removals originating from the teak trees the biomass expansion factor (BEF) method was used. BEF was multiplied with the carbon fraction (CF) and the wood density (D). The values for BEF, CF and D are based on peer reviewed scientific literature (35) (36). The following equation was used to calculate C_{teak} at a given time:

— (CDM tool adapted eq. 1)

Parameter	Unit	Description
	t CO ₂	Carbon removals by above- and belowground teak biomass
	m ³	Above ground tree volume in inventoried area <i>i</i> , estimated by using the diameter at breast height (DBH), tree height (H) and tree form factor (<i>f</i>) as entry data into a volume calculation
	d.m. m ⁻³	Basic wood density for teak
	-	Biomass expansion factor including roots
	-	Carbon fraction for teak
44/12	-	Ratio of molecular weight of CO ₂ to C

Soil Organic Carbon (ΔSOC)

In 2009, an independent auditor determined through soil samples that the soil organic carbon stock in the 64 ha pilot plantation increased from 10.1 (t C / ha) to 18.7 (t C / ha) in 8 years (1.07 t/ha/year). Because of this considerable increase this carbon pool is included as $\Delta SOC_{al,t}$ (part of equation 5 of the methodology).

CDM Tool: “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” is used to determine $\Delta SOC_{al,t}$.

Step 1: For the purposes of this tool, the areas of land shall be stratified:

ΔC_{soc} is relevant for reforestation types I, II and III (baseline stratum 1) since these are degraded areas. Where forest patches exist ΔSOC is conservatively neglected. The whole area has been cultivated and consisted of either fallow land, agriculture or taungya system (agriculture with teak) at the project start. No national inventory data is available for the amount of carbon that is stored in the soils. Therefore, the default figures from the tool are used to estimate the yearly increase in soil carbon. For the sake of simplicity the whole area is considered as one stratum. When a choice has to be made between two values, due to heterogeneity in the project area, the most conservative figure is chosen from the table 1-4 from the tool. It is assumed in the tool that SOC reaches a steady state after 20 years.

The following equations from the tool are used to estimate the yearly change in SOC.

Step 2: Initial SOC stock shall be estimated as follows:

$$SOC_{INITIAL} = SOC_{REF} * F_{LU} * F_{MG} * F_{IN}$$

Factor	Unit	Description
SOC_{REF}	$t\ C\ ha^{-1}$	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation . normally forest) by climate region and soil type applicable to stratum <i>i</i> of the areas of land;
F_{LU}	-	Stock change factor for land-use in stratum <i>i</i> of the areas of land
F_{MG}	-	Stock change factor for management regime in stratum <i>i</i> of the areas of land
F_{IN}	-	Stock change factor for input of organic matter in stratum <i>i</i> of the areas of land
$SOC_{initial}$	$t\ C\ ha^{-1}$	SOC stock at the beginning of an A/R CDM project activity in stratum <i>i</i> of the areas of land;

Step 3: For each stratum of the areas of land which is subjected to ploughing/ripping/scarification attributable to project activity within the first five years from the year of initial site preparation and for which the total area disturbed is greater than 10% of the area of the stratum, the following carbon loss shall be accounted:

$$SOC_{LOSS} = 0.1 * SOC_{INITIAL}$$

Over 10% of the area is ploughed and therefore SOCloss is accounted for.

Step 4: The rate of change in SOC stock in project scenario until the steady state in SOC content is reached (assumed in 20 years from the time of the initial site preparation) is estimated as:

$$SOC\ yr^{-1}\ ha^{-1} = (SOC_{REF} - SOC_{INITIAL} - SOC_{LOSS})/20$$

Parameter	Unit	Description	t C
SOC_{ref}	t C/ha	Tropical moist, low activity clay soils	41
f_{LU}	-	Average between short/longterm cultivation & dry/moist	0.82
f_{MG}	-	Severely Degraded	0.71
f_{IN}	-	Low input Tropical average dry/moist	0.935
$SOC_{initial}$	t C/ha	Estimated carbon stock at the start of project	22.2
SOC_{loss}	t C/ha	SOC carbon loss due to land preparation	2.2
$SOC_{cal,t}$	$t\ C\ yr^{-1}$	Carbon stock change in SOC for all strata in the project boundary in year t.	1.0
$SOC_{cal,t}$	$t\ C\ yr^{-1}$	"If $SOC > 0,8\ yr^{-1}$ then $SOC = 0,8/yr^{-1}$ "	0.8
$SOC_{cal,t}$	$tCO_2\ yr^{-1}$	SOC converted to CO_2	2.93

SOCref is chosen following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (33). The project area is classified as tropical moist deciduous forest according to these guidelines. However, Hall and Swaine classify the area as dry semi-deciduous forest, and therefore we choose conservative values between dry and moist deciduous forest (38). The soil texture is generally sandy loam to sandy clay loam. All the soils are classified as low activity clay.

Flu is conservatively chosen as an average of short term cultivation and long term cultivation because the pre-project land use ranges from long term cultivation (>20 years) to short term cultivation (between 0 and 20 years) and land degradation.

F_{MG} is chosen as severely degraded. The area previously consisted of forest.

F_{IN} is considered to be low since residues are removed via collection and the land is burned afterwards.

SOC, *t* is calculated per stratum for the first 20 years after plantation establishment. After that it is presumed SOC stock reaches steady state.

GHGe

It must be noted that PP as a means of site preparation, clears existing herbaceous vegetation and invasive woody vegetation is cut and burned. This woody vegetation is mainly remnant teak and invasive york. Indigenous trees are protected by PP and are left standing, which is quantified in chapter 3.1.

Following the CDM methodology and the “*tool for non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity (v04.0.0)*” under GHGe only the non-CO2 gases N₂O and NH₄ need to be quantified. CO₂ emissions due to biomass clearing and burning are accounted for under ΔC_{tree_proj} .

GHG emission is specified as resulting from forest fires and burning of biomass within the project boundary so that:

$$GHGe,t = GHGspf,t + GHGfmf,t + GHGff,t$$

Parameter	Unit	Description
GHGe, <i>t</i>	t CO2-	Emission of non-CO2 GHGs resulting from burning of biomass and forest fires within the project boundary in year <i>t</i>
GHGspf, <i>t</i>	t CO2-	Emission of non-CO2 GHGs resulting from use of fire in site preparation in year <i>t</i>
GHGfmf, <i>t</i>	t CO2-	Emission of non-CO2 GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land or other forest management, in year <i>t</i>
GHGff, <i>t</i>	t CO2-	Emission of non-CO2 GHGs resulting from fire in year <i>t</i>

As this is the first planting cycle, fire is not used to clear the land of harvest residue prior to replanting and forest is not existent in this stratum only the emission of non-CO2 GHGs

resulting from use of fire in site preparation (GHG_{spf}) is relevant since fire is used in site preparation.

However, the tool states that where *“slash-and-burn is a common practice in the baseline and fire has been used in the area at least once during the period of ten years preceding the start of the A/R CDM project activity: GHG_{spf,t} = 0”*

Fire due to anthropogenic and natural causes is common in the area (38) (39) (7) (9). Each year farmers use slash and burn techniques to clear their land and each year dozens of fires have to be prevented from entering the plantations. The outcome of the above analysis is that GHG_{E,t} due to site preparation can be neglected and accounted as zero. Therefore:

$$\text{GHG}_E = 0$$

Leakage

In CDM methodology AR-ARM0001, leakage is only taken into account if it is caused by displacement of pre-project agricultural activities. Since the major activity is subsistence farming, market leakage due to project activities does not occur in the proposed project. Leakage from an increase of machinery use is considered as *de minimis* according to AFOLU requirement v 3.0 section 4.3.3.

CDM tool: *“Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity”* is used to determine project leakage.

Applicability:

1) This tool is applicable to emissions which cannot be considered insignificant according to the most recent: Guidelines on conditions under which increase in GHG emissions attributable to displacement of pre-project crop cultivation activities in A/R CDM project activity is insignificant”

Following the guidelines, the areas that have been subjected to displacement is larger than 5% of the project area and existing cropland is not managed in an extensive way so leakage is not insignificant.

2) The displacement of agricultural activities is not expected to cause any drainage of wetlands or peatlands, since apart from small and isolated swampy areas in the rainy season, wetlands and peatland are not a vegetation type in Ghana.

Step 1: estimate the area subject to pre-project activities that is expected to be reforested and therefore the activities have to be displaced.

Looking at the satellite photos in the baseline emission (Figure 3), all areas have been completely cleared for farming, except some patches of riverine forest. Most of the cleared areas consist of fallow land. Social surveys showed that an average farmer actively farms about 2,5 ha. In total, 54% of the degraded area was farmed actively and 33% was fallow land. The area is quantified making use of data presented in chapter 3.1. The fraction of area D_t subject to leakage is determined to be 0.87.

Equation 1 from the tool is therefore not used to determine the fraction, since we got this figure from the SEIA (7).

Step 2

The annual change in carbon stock in all selected carbon pools ΔC_t is displayed in table 15 of this PDD.

Step 3 Calculation of the amount of carbon stored in the area subject to pre-project activity displacement.

Parameter	Unit	Description
	t CO ₂	The sum of annual change in carbon stock in all selected carbon pools since the start of the A/R CDM project activity attributable to the area subject to displacement.
	ha	Fraction of the total area subjected to displacement of pre-project agricultural activities
	t CO ₂	Area subject to pre-project agricultural activities that are displaced during year <i>t</i>

*Step 4 Estimate factor *f**

A value for the forest cover in the Offinso forest district was not available. Most of Ghana's forest is in the South west, the northern part is mostly savannah, and Offinso forest district lies on the fringe area. Therefore, a national average value of 0.22 is used for forest cover (37).

Step 5 Calculation of leakage

Crediting period is 40 years.

Parameter	Unit	Description
	t CO ₂	Amount of leakage per year
F	-	Fraction of forest cover in Ghana (0,22)
Tcred	-	Crediting period (40 years)
—	-	Ratio of molecular weight of CO ₂ to C
	t C	Sum of annual change of carbon stock in all selected carbon pools since the start of the project activity till verification event.

Total leakage is shown in table 15 of this PDD.

VCUs teak (Carr *vcs,teak*)

VCU per year can now be calculated for one hectare of teak (eq 28). VCUs are only generated until the long term average is reached.

Parameter	Unit	Description
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the project scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ by PP
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the baseline scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Leakage attributable to pre-project agricultural activity displacement

3.2.2.2 Reforestation type II : Indigenous plantations (*Cvcs arr,ind*)

ΔC_{actual} for indigenous plantations is determined analogously with ΔC_{actual} for teak strata, and therefore only relevant differences will be discussed below.

Indigenous trees are planted in areas not suitable for teak, to conserve protected species such as the Kokrodua (*Pericopsis elata*) to increase biodiversity on the plantation. Planting has started in 2008 on small areas (less than 20 hectares). Since mortality rate was high all the areas were replanted in 2009 and 2010 and merged to one stratum. Coppice teak is growing on some of these areas. These teak trees are left standing to speed up canopy closure process. Once the canopy is closed, all the remaining teak in these areas will be thinned out gradually.

The estimated emissions and removals in the indigenous plantation are calculated similar to the teak plantation. Carbon removals through clearing from the baseline ($C_{baseline}$), soil organic carbon (ΔC_{soc}), GHG emissions (GHG_e) and leakage (LK) are the same as for the teak plantation. Therefore, only carbon removals by indigenous tree biomass (C_{tree_proj}) will be discussed below.

Carbon stock in indigenous tree biomass (*Ctree,ind*)

Yield tables of the planted indigenous tree species are rare, of poor quality or non-existent so we therefore base the *ex ante* calculation on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (33). Although the area is defined as tropical moist deciduous forest according to these guidelines, we assume that the climate is between this definition and the definition stated by Hall and Swaine (1976) for dry semi-deciduous forest (38); so between tropical dry and tropical moist forest (IPCC 2006 table 4.9, Hall and Swaine 1976, Fig4 & 5). This ensures a more conservative estimation of biomass growth in the project area.

Mean annual biomass increments are expressed as tons dry weight matter (DW) (table 13 below). PP *ex ante* calculations are based on these figures and local literature. IPCC assumes faster growth the first 20 years and after that reduction, however local data of

species planted by PP indicates a higher growth of $\pm 8 \text{ m}^3/\text{year}$ for 40 years (41). The *ex ante* growth curve is therefore assumed to be conservative (table 13 and figure 9).

Carbon fraction and root to shoot ratio (R_{mix}) were also derived from IPCC (ref IPCC). R_{mix} is conservatively chosen for moist deciduous forest as these values are lower than for tropical dry forest. For biomass increment an average value was chosen for forest $>125 \text{ ton DW/ha}$ aboveground and $<125 \text{ ton DW/ha}$ aboveground, since this forest will change gradually from lower than 125 ton/ha to more than that. The form factor is derived from Dawkins in Cannel 1984 (34). This form factor converts DBH/height to total aboveground biomass.

Table 13: Mean annual increment adapted from IPCC Guidelines, 2006

MAI class	MAI (Ton DW Aboveground)
<30 year	4 per year
>30 year	1 per year
max DW	160

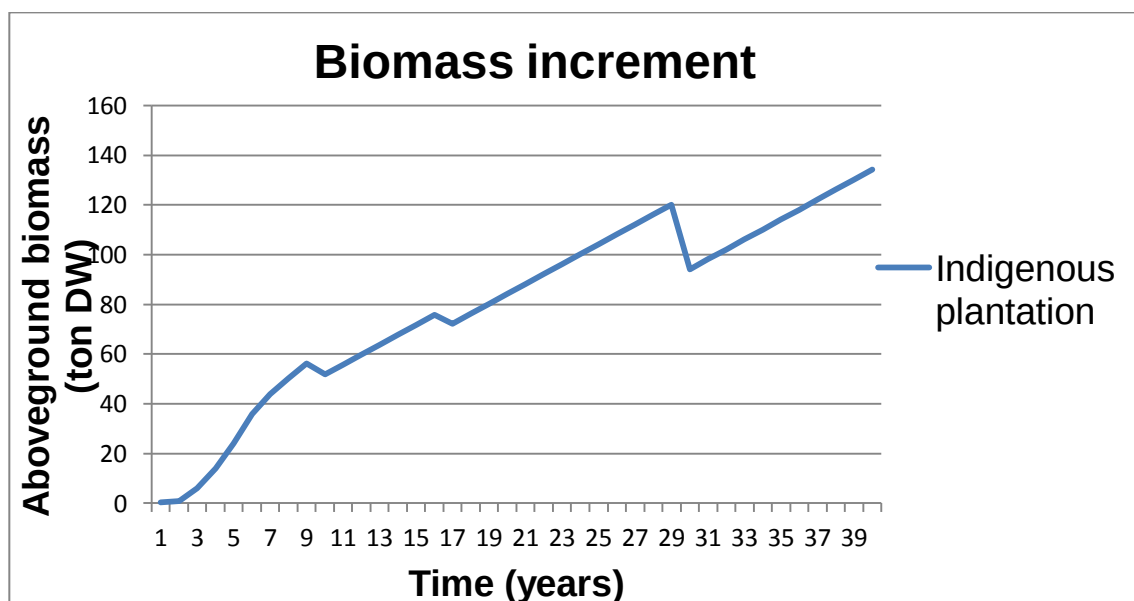


Figure 9 Biomass growth curve of the indigenous plantation based on logistic regression analysis and figures from IPCC, 2006

Thinning, felling and long term average

As elaborated above, indigenous trees are planted in mixed stands, but depending on site specifications and availability of species some areas may be planted with a single species also. These stands are gradually developed to managed areas under selective harvesting. Commercial thinning and selective harvesting are the assumed management for these mixed stands, but clear felling is also a management option. For these mixed forest types good quality management and growth data are lacking, which makes it difficult to predict future management and harvesting volumes to base our LTA calculation on. Therefore we have chosen the most conservative scenario for a conservative LTA estimate. This scenario is clear felling with a rotation period of 40 year, where the 40 years is based on sustainability

guidelines of the Ghanaian forest service (42). Three thinnings are anticipated and thinning intensity is based on professional judgement considering expected increments and stem densities. In practice the timing and extraction levels depend on the growth performance of a stand and on total basal area per hectare. The expected biomass growth is displayed in figure 9 above.

The LTA for indigenous plantation stands is 206 t CO₂/ha.

Table 14 Indigenous species planted.

Scientific name	Local name
Triplochiton scleroxylon	Wawa
Terminalia superba	Ofram
Terminalia ivorensis	Emeri
Mansonia altissima	Mansonia
Khaya anthoteca	Mahogany
Nauclea diderrichii	Kusia
Cola gigantean	Watapuo
Ceiba pentrandra	Onyina
Albizia ferruginea	Awiemfosamin
Hildegardia barteri	A.Kyewewa
Pericopsis elata	Kokrodua
Pteleopsis hylodendron	Kwae-Kane
Antiaris toxicaria	Kyenkyen
Rhodognaphalon brevisuspe	Bombax
Erythroleum ivorense	Potrodom
Blighia sapida	Akyi

VCUs indigenous plantation (Cvcs_arr.ind)

VCU per year can now be calculated for one hectare of indigenous plantation (eq 8). VCUs are only generated until the long term average is reached.

Parameter	Unit	Description
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the project scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ by PP
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the baseline scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Leakage attributable to pre-project agricultural activity displacement

3.2.2.3 Reforestation type III: Planted buffer zones (*Cvcs_arr.plbuff*)

Looking at the zoomed figure 10 below, the orange line represents the area the PP commits to manage as buffer zones. Detailed elaboration on the management can be found in chapter 1.8 of this PDD. The green line is the demarcation of the degraded forest left in the project area. The area between the orange and the green line will be reforested and is the planted buffer.

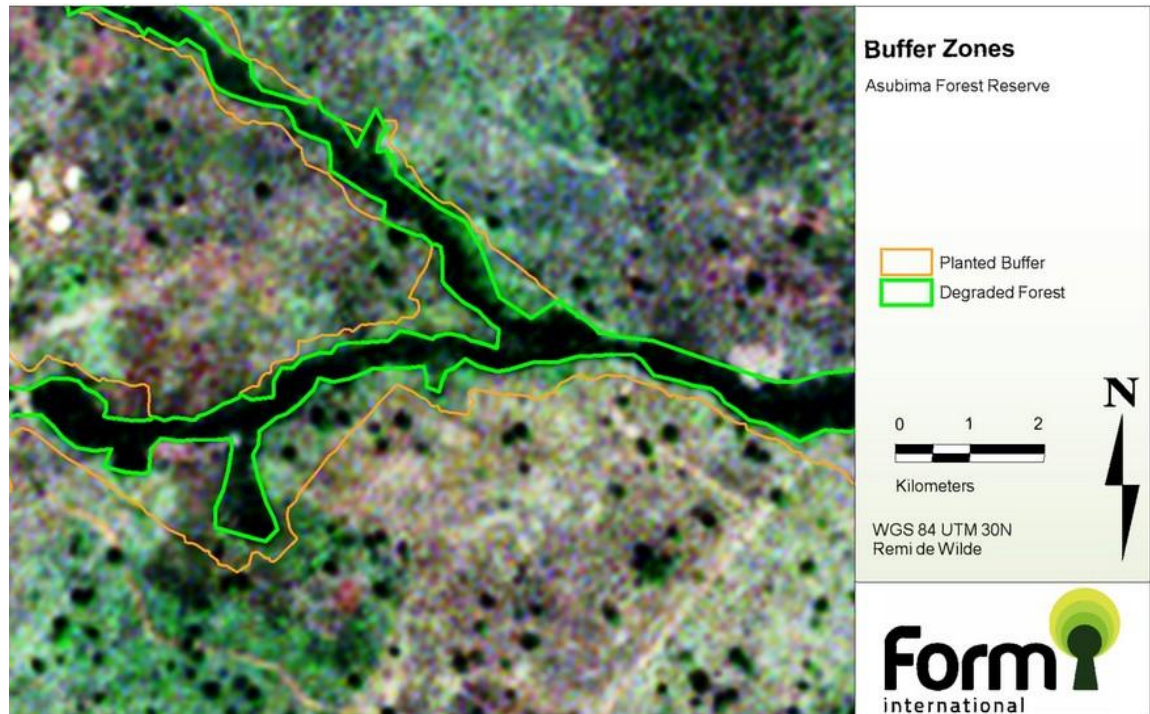


Figure 10: Buffer zones. The orange line shows the total outline committed as buffer zones. The green line shows patches of degraded forest. Between the orange and the green line will be planted with indigenous tree species and managed with ANR.

ΔC_{actual} for planted buffers is determined analogously with ΔC_{actual} for indigenous plantation strata. Specific details on the determination of C_{tree_plbuff} are outlined in this section.

Carbon stock in indigenous tree biomass (C_{tree_plbuff})

The tree carbon stocks of indigenous trees in the planted buffer (C_{tree_plbuff}) are based on the same biomass increment values as indigenous plantation (table 13). One difference is that no pruning and commercial thinning are carried out. Non-commercial thinning might be done to promote growth and diversity of standing tree species, but this will not negatively influence biomass increment and is therefore not displayed in the growth curve. Therefore no long term average is calculated for this stratum. Although average values are derived from IPCC logarithmic growth is expected instead of linear. Logistic regression analysis was performed on the available data to estimate biomass growth per year.

The maximum dry weight (DW) value of 160 ton aboveground biomass / ha is conservative, since total above and belowground tree carbon stock of natural dry semi-deciduous forest in

Ghana was determined to be 178.3 t C / ha (43), which corresponds to 356.6 t DW / ha. The result is shown in figure 11 below.

Leakage

In the degraded forest no agricultural activities exist and leakage is therefore zero. In the planted buffers leakage is the same as for the other reforestation types illustrated in table 12.

VCUs planted buffer (Cvcs_arr,plbuff)

VCU per year can now be calculated for one hectare of planted buffer (eq 8).

Parameter	Unit	Description
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the project scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ by PP
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the baseline scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Leakage attributable to pre-project agricultural activity displacement

3.2.2.4 Degraded forest buffer zones (Cvcs_arr,degbuff)

ΔC_{actual} for degraded buffers is determined analogously with ΔC_{actual} for planted buffer strata, but in this reforestation type, ΔC_{tree} is calculated differently and leakage does not apply.

Estimating change in carbon stock in tree biomass (ΔC_{tree})

What is notably different is that baseline stratum 2 applies (see section 3.1.2) with the following equation:

Methods for determining (total carbon in baseline stratum 2) and (York clearing) are given in section 3.1.2.

Forest growth in the degraded forest buffer is assumed to resemble the growth curve of the planted buffer, since the management scheme is the same and the vegetation type is highly similar. Because the initial carbon stock is higher in this case, the actual growth to estimate C_{deg_buff} is lower than the one to determine C_{ind} and C_{pl_buff} . Assuming a logistic growth curve based on the data in table 13, figure 11 shows the expected biomass increase in the planted buffer. The degraded buffer is expected to follow the same curve, starting from the baseline stratum2 level explained in chapter 3.1. The maximum biomass stock will be reached earlier in degraded forests than in the planted buffer zones. The result is shown below in figure 11.

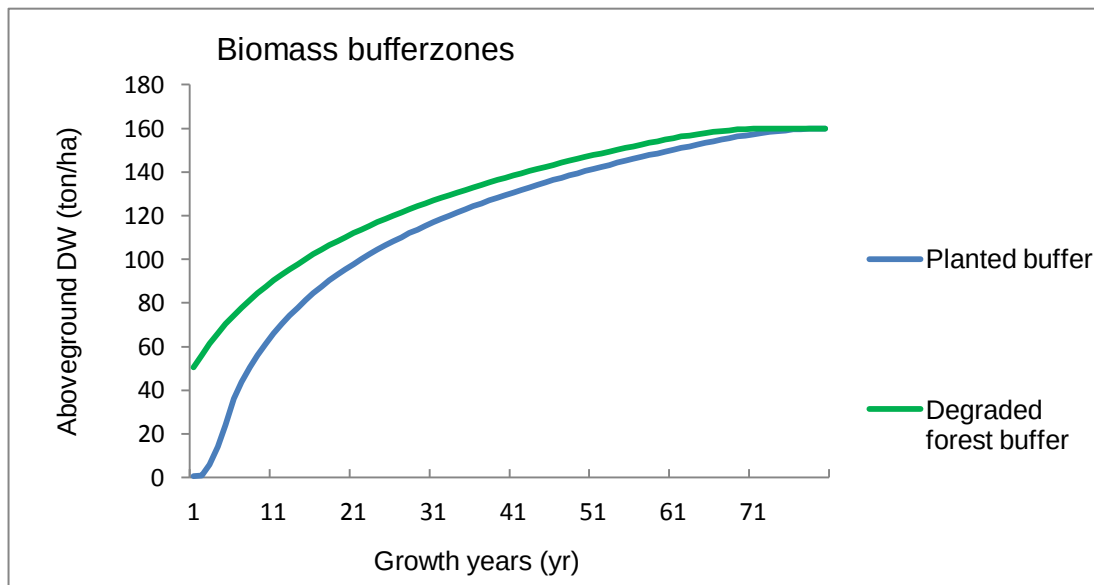


Figure 11: Biomass growth curve of the indigenous vegetation in the buffer zones. Note that the indigenous plantation will follow the same growth curve as the planted buffer (blue line). The initial biomass in the degraded buffer was determined and assumed to follow the same line as the planted buffer.

GHGe

There is no fire used in site preparation in the degraded buffer zones. Only invasive york is felled and this is further quantified in C_{tree_proj} calculations.

Leakage

In the degraded forest no agricultural activities exist and leakage is therefore zero. In the planted buffers leakage is the same as for the other reforestation types illustrated in table 12.

VCUs degraded buffer ($C_{vcs_arr,degbuff}$)

VCU per year can now be calculated for one hectare of degraded buffer (eq 8).

Parameter	Unit	Description
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the project scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ by PP
	t CO ₂ yr ⁻¹ ha ⁻¹	Net removal of CO ₂ in the baseline scenario
	t CO ₂ yr ⁻¹ ha ⁻¹	Leakage attributable to pre-project agricultural activity displacement

3.3 Leakage

According to the VCS AFOLU requirements, leakage should be included in the long term average calculation. The leakage determination methodology is therefore already elaborated in the teak plantation stratum section (3.2.2.1). As displayed in table 12, leakage is the same for the teak plantation, the indigenous plantation and the planted buffer zone. A summary of total project leakage is shown in the GHG emission reductions and removal summary table 15.

3.4 Summary of GHG Emission Reductions and Removals

Table 15: Summary table of GHG Emissions

Years	Estimated baseline emissions or removals (t CO ₂ e)	Estimated project emissions or removals (t CO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (t CO ₂ e)
0	0	0	0.0	0
1	0	0	0.0	0
2	0	1,162	-7.3	1,155
3	0	7,400	-40.1	7,360
4	0	24,596	-118.6	24,477
5	0	45,478	-210.3	45,267
6	0	51,077	-237.9	50,839
7	0	33,829	-156.1	33,673
8	0	47,329	-221.2	47,108
9	0	49,497	-232.1	49,265
10	0	27,612	-127.7	27,484
11	0	4,429	-31.2	4,398
12	0	38,238	-254.5	37,984
13	0	8,151	-152.2	7,999
14	0	2,013	-8.6	2,005
15	0	1,892	23.9	1,916
16	0	2,099	-260.9	1,838
17	0	2,001	-230.8	1,770
18	0	1,891	-180.4	1,710
19	0	1,130	-185.2	945
20	0	1,558	-196.3	1,362
21	0	970	92.8	1,063
22	0	78	946.0	1,024
23	0	-514	1309.0	795
24	0	765	-3.4	762
25	0	735	-3.3	732
26	0	707	-3.3	703
27	0	681	-3.2	678
28	0	657	-3.1	653
29	0	634	-3.1	631
30	0	613	-3.0	610
31	0	594	-3.0	591
32	0	562	10.6	572
33	0	558	-2.9	555
34	0	542	-2.9	539
35	0	526	-2.9	523
36	0	512	-2.8	509
37	0	498	-2.8	495
38	0	485	-2.8	482
39	0	473	-2.7	470
40	0	461	-2.7	458
Total	0	361,461	-517	360,943

4 MONITORING

4.1 Data and Parameters Available at Validation

Data Unit / Parameter:	Mean annual increment teak (ΔV_{teak})
Data unit:	m ³ /yr/ha
Description:	The expected average growth for teak of the stem volume.
Source of data:	Pilot plantation and literature
Value applied:	14.2
Justification of choice of data or description of measurement methods and procedures applied:	Yield tables for teak in Ivory coast were established for different growth classes. Based on these tables site class was determined for the 64 hectare pilot plantation. The pilot plantation serves as a model for the rest of the plantation.
Any comment:	

Data Unit / Parameter:	Teak wood density (D_{teak})
Data unit:	kg/m ³
Description:	The density for teak to determine dry weight
Source of data:	Wiselius, S.I., Hout vademecum, Stichting centrum hout, 1992
Value applied:	660
Justification of choice of data or description of measurement methods and procedures applied:	Peer reviewed publication
Any comment:	

Data Unit / Parameter:	Carbon fraction Teak (CF_{teak})
Data unit:	-
Description:	Fraction of carbon in dried teak
Source of data:	Kraenzel et al 1993., Carbon storage of harvest-age teak
Value applied:	0.5

Justification of choice of data or description of measurement methods and procedures applied:	Peer reviewed publication
Any comment:	

Data Unit / Parameter:	Form factor teak (ffteak)
Data unit:	-
Description:	Factor to convert cylinder measured from DBH and height to trunk volume
Source of data:	Calculated from pilot plantation
Value applied:	0.36 for trees <8 years old 0.40 for trees >8 years old
Justification of choice of data or description of measurement methods and procedures applied:	From yield tables
Any comment:	

Data Unit / Parameter:	Biomass expansion factor teak (BEFteak)
Data unit:	-
Description:	This is BEF and R in one. Converts trunk biomass to total above and belowground tree biomass.
Source of data:	Kraenzel et al., Carbon storage of harvest-age teak (<i>Tectona grandis</i>) plantations, Panama
Value applied:	1.54
Justification of choice of data or description of measurement methods and procedures applied:	Peer reviewed publication
Any comment:	

Data Unit / Parameter:	Mean annual aboveground biomass increment Indigenous plantation (ΔB_{ind})
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Data unit:	ton dw/year/ha
Description:	Expected annual growth of aboveground biomass of indigenous plantation
Source of data:	IPCC guidelines for national greenhouse gas inventories 2006 (33) Lawson, G. J. Indigenous trees in West African forest plantations: the need for domestication by clonal techniques (41) (44)
Value applied:	<30 years= 4 ton dw/yr/ha >30 years= 1 ton dw/yr/ha
Justification of choice of data or description of measurement methods and procedures applied:	Value is based on IPCC Guidelines 2006, 4.9 moist/dry semi-deciduous forest and published literature on selected tree species PP plants. IPCC assumes faster growth the first 20 years and after that reduction of growth. PP chose a modified growth scenario because local data of species planted by PP indicates a growth of +/- 5 m ³ /year of more than 50 years (41) (44). To be conservative, PP chose a faster growth over thirty years (instead of 50) and after 30 years a reduction in growth per year.
Any comment:	

Data Unit / Parameter:	Total biomass indigenous forest (Bind)
Data unit:	ton dw/ha
Description:	This is the maximum expected value for indigenous forest plantation.
Source of data:	IPCC guidelines for national greenhouse gas inventories 2006 (33) (43)
Value applied:	160
Justification of choice of data or description of measurement methods and procedures applied:	Value between default value of moist/dry tropical forest. Is considered conservative since literature showed values up till 356.6 t DW / ha in representative forests in Ghana.
Any comment:	

Data Unit / Parameter:	Average wood density for Indigenous
------------------------	--

	forest (Dind)
Data unit:	kg/m3
Description:	This is a calculated parameter of the average wood density.
Source of data:	(36) (30) (31) (33) (32)
Value applied:	458
Justification of choice of data or description of measurement methods and procedures applied:	Sample plots in the buffer zones have been laid out and the tree species identified. With various literature an average weighed wood density was calculated and is applied to calculated DW in the degraded forests.
Any comment:	

Data Unit / Parameter:	Carbon fraction indigenous trees (CFind)
Data unit:	-
Description:	Amount of carbon in dry matter
Source of data:	IPCC guidelines for national greenhouse gas inventories 2006, 4.3
Value applied:	0.49
Justification of choice of data or description of measurement methods and procedures applied:	Default value from IPCC
Any comment:	

Data Unit / Parameter:	Root to Shoot ration (Rj)
Data unit:	-
Description:	The weight of the roots divided by the weight of the shoot
Source of data:	IPCC guidelines for national greenhouse gas inventories 2006 table 4.4
Value applied:	0.21
Justification of choice of data or description of measurement methods and procedures applied:	Conservatively chosen for moist deciduous forest as these values are lower than for dry forest. Average chosen of R values for forest >125 ton dw/ha aboveground and <125 ton

	dw/ha aboveground, since forest will change gradually from lower than 125 ton/ha to more than that in the project period.
Any comment:	

Data Unit / Parameter:	Form factor indigenous trees (ffind)
Data unit:	-
Description:	This converts dbh/height cylinder into total aboveground tree volume.
Source of data:	Dawkins in Cannel 1984, Woody biomass in forest stands.
Value applied:	0.6
Justification of choice of data or description of measurement methods and procedures applied:	Peer reviewed data specifically for tropical broadleaved trees
Any comment:	

Data Unit / Parameter:	SOCref
Data unit:	ton C*ha-1
Description:	Reference soil organic carbon stock
Source of data:	CDM "tool for estimation of change of soil organic carbons stocks" (version 1)
Value applied:	41
Justification of choice of data or description of measurement methods and procedures applied:	Average between dry and moist tropical forest as PP project lies on the border of the moist forest zone. Soil research showed that soils are mostly low activity and therefore all conservatively assumed low activity clay soils (LAC)
Any comment:	

Data Unit / Parameter:	flu
Data unit:	-
Description:	SOC stock change factor for land use

Source of data:	CDM “tool for estimation of change of soil organic carbons stocks” (version 1)
Value applied:	0.82
Justification of choice of data or description of measurement methods and procedures applied:	Flu is chosen as an average between short term and long term cultivation because the pre-project land use ranges from long term cultivation (>20 years) to short term cultivation (between 0 and 20 years).
Any comment:	

Data Unit / Parameter:	fmg
Data unit:	-
Description:	SOC stock change factor for management regime
Source of data:	CDM “tool for estimation of change of soil organic carbons stocks” (version 1)
Value applied:	0.7
Justification of choice of data or description of measurement methods and procedures applied:	F_{MG} is chosen as severely degraded. The area previously consisted of forest.
Any comment:	

Data Unit / Parameter:	fin
Data unit:	-
Description:	SOC stock change factor for input of organic matter
Source of data:	CDM “tool for estimation of change of soil organic carbons stocks” (version 1)
Value applied:	0.935
Justification of choice of data or description of measurement methods and procedures applied:	F_{IN} s considered to be low since residues are removed via collection and the land is burned afterwards.
Any comment:	

Data Unit / Parameter:	Dt
Data unit:	
Description:	fraction of area prone to leakage
Source of data:	SEIA, Abeney et al., 2008 (7)
Value applied:	0.87
Justification of choice of data or description of measurement methods and procedures applied:	Independent social and environmental impact assessment showed that this percentage of area is being farmed.
Any comment:	

Data Unit / Parameter:	f
Data unit:	-
Description:	fraction of forest cover in Ghana
Source of data:	FAO, state of the world's forests 11
Value applied:	0.22
Justification of choice of data or description of measurement methods and procedures applied:	Peer reviewed literature. The value for Ghana has been chosen since no reliable data could be found for the forest cover in the Offinso district.
Any comment:	

Data Unit / Parameter:	York wood density (Dyork)
Data unit:	kg/m ³
Description:	the wood density of <i>Broussonetia papyrifera</i>
Source of data:	Orwa et al. 2009
Value applied:	506
Justification of choice of data or description of measurement methods and procedures applied:	Literature (32).
Any comment:	

4.2 Data and Parameters Monitored

Data Unit / Parameter:	Ai
Data unit:	ha
Description:	Area of tree biomass stratum i
Source of data:	Mapping
Description of measurement methods and procedures to be applied:	Demarcation with GPS (Garmin) making use of Forestry Commission coordinates and forest reserve boundary pillars. Calculation of the area size is done with GIS (Mapinfo)
Frequency of monitoring/recording:	Once at project start and updated when needed.
Value applied:	Between 1 and 1000 ha
Monitoring equipment:	GPS (garmin), compass
QA/QC procedures to be applied:	Geo referencing of coordinates in the field.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	Ap,i
Data unit:	ha
Description:	Total area of sample plots
Source of data:	PP field monitoring
Description of measurement methods and procedures to be applied:	See chapter 4.3 of this PDD
Frequency of monitoring/recording:	Annually
Value applied:	Aim is to sample 1% of the stratum area
Monitoring equipment:	GPS, measuring tape.
QA/QC procedures to be applied:	Internal auditing on determining plot size by field monitoring teams
Calculation method:	Plot size times number of plots
Any comment:	-

Data Unit / Parameter:	H
Data unit:	m
Description:	Total height of the trees
Source of data:	Measured by project proponent
Description of measurement methods and procedures to be applied:	Is measured in permanent sample plots, see chapter 4.3 of this PDD for elaboration.
Frequency of monitoring/recording:	Yearly
Value applied:	Depending on age between 0,5 and 30 meters
Monitoring equipment:	Suunto Inclinator PM5: accuracy +/- 1m for trees more than 10 meters high. +/- 1 m Measuring pole for trees under 10 meters high. Accuracy +/- 25cm Measuring tape for tree under 2 meters high. Accuracy +/- 5 cm
QA/QC procedures to be applied:	Remeasurement of 5% of the trees is done as quality control during internal audit and check of correct implementation of procedures by monitoring team.

Data Unit / Parameter:	DBH
Data unit:	cm
Description:	Diameter of the tree at 1,3m height
Source of data:	Measured by project proponent
Description of measurement methods and procedures to be applied:	Is measured in permanent sample plots, see chapter 4.3 of this PDD for elaboration.
Frequency of monitoring/recording:	Yearly
Value applied:	Depending on age, between 0 and 45 cm
Monitoring equipment:	Calliper is used for accurate measurements. Accuracy +/- 1mm
QA/QC procedures to be applied:	Remeasurement of 5% of the trees is done as quality control during internal audit and check of correct implementation of procedures by monitoring team.

4.3 Description of the Monitoring Plan

Forest health is monitored yearly in all forest types: teak plantations, indigenous plantations and buffer zones. These measurements are taken in permanent sample plots (PSP), which are established throughout the concession area, in different forest stands. Every year after planting, additional plots are created in the newly planted areas. The number of plots will therefore increase yearly.

Updating of strata

For each verification event an assessment is made of the need to update or change the existing strata. Reasons for changing strata are if unexpected disturbances or management activities have occurred that have altered otherwise homogeneous strata. The need or possibility to merge strata is also assessed.

Teak plantation PSPs

Teak plantations are stratified according to plant year and PSPs are laid out randomly per teak stratum, based on an allocation procedure carried out in GIS (MapInfo). The cumulative PSP area is at least 1% of the Teak plantations: per stratum and overall. After monitoring the maximum allowable relative margin of error of the mean for estimation of tree biomass is 10% at 90% confidence level. PSPs have a fixed area of 800 m². At the 1% sampling density there is 1 PSP for every 8 ha of plantation. GPS coordinates are obtained from the GIS procedure and are provided to the field monitoring team, along with a plantation map including all PSPs.

Indigenous plantation PSPs

Procedures for indigenous plantation PSP monitoring are the same as for Teak plantations. Only, sampling density is 2%, meaning that PSP area is 2% of the indigenous plantation area, per stratum and overall. The higher percentage is needed because these are mixed species plantations, which are characterized by higher variability.

Buffer zones

As elaborated before in this PDD, the buffer zones are divided in degraded forest buffer and planted buffers. Procedures are the same as for indigenous plantation. Since the same level of heterogeneity is expected PP aims at 2 % sampling density.

Environmental monitoring

As a FSC certified plantation PP commits strongly to environmental values. Therefore, flora and fauna, water quality and erosion monitoring is also undertaken.

4.3.1 Organizational structure, responsibilities and competencies

A number of staff are involved in the monitoring of the plantations and buffer zones. They are listed in the table below, including their specific tasks and responsibilities.

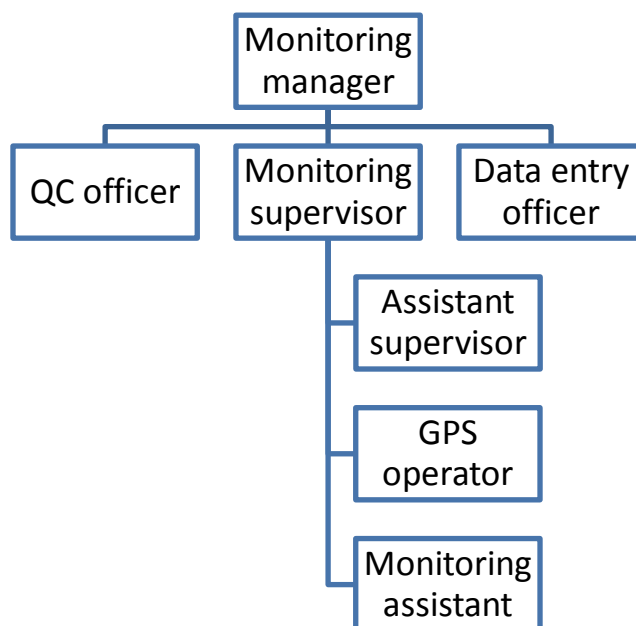


Figure 12 Overview monitoring staff

Table 16 Task and responsibilities of monitoring staff

Staff	Task	Responsibility
Monitoring manager	- Planning and management of the monitoring process - Training of dedicated personnel	- Quality assurance of PSP monitoring - Data analysis and reporting to FORM Ghana management
Monitoring supervisor	- Supervise implementation of PSP measurements - Recording on field sheets - Supervise correct data entry - Archiving of field data (on paper and digital) - Report/send progress and data updates to monitoring manager	- Correct implementation of PSP measurements - Clear and correct recording on field sheets Maintenance and completeness of equipment - Correct and timely data entry - Report progress
Assistant supervisor	- Assist supervision of field teams - Recording on field sheets - Deliver field data to monitoring supervisor - Report progress and	- Clear and correct recording on field sheets - Correct implementation of PSP measurements - Maintenance and completeness of equipment

	updates to monitoring supervisor	
GPS operator	- Localizing PSPs and navigating the field team - Erection of poles and numbered tags of new PSPs at the correct GPS position. - Assisting in plot measurements	- Correct operation of the GPS - Safe keeping of the GPS - Taking correct measurements
Monitoring assistant	- Assisting in plot measurements - Clearing of PSP where necessary	- Taking correct measurements - Provide easy access in and between PSPs
Data entry officer	- Entering data from field sheets into the correct Excel data formats - Sending data updates to Monitoring supervisor	- Correct data entries - Timely provision of data updates to the monitoring supervisor
Quality control officer	Carry out quality control on field measurements and data entry	Quality control

4.3.2 Methods for recording storing and aggregating data on parameter

Field measurements procedure

Annually, PSPs are assessed using the following procedure:

- The basic shape of a PSP is a circular plot with a pole in the centre.
- GPS coordinates as received from the GIS system determine the site location.
- At the plot centre a pole of durable wood is placed
- An aluminium tag with the plot number punched into it is nailed to the pole.
- Poles and tags are replaced in case they have decayed too far.
- The PSP size is 800m².
- Lay out the plot by measuring the plot radius with a measuring tape to eight directions and positioning temporary and visible pegs at the plot boundaries. The plot radius to attain 800m² is 15.96m.
- The plot size is the same for all plantation ages and stem densities.
- When a plot is on a slope additional guidance shall be followed stated in PP's protocol 13, Annex 3.

The measurements to be taken in the PSPs are:

General data

- Plot number
- GPS coordinates
- Date of measurement
- Crew members taking the measurements

Terrain and soil

- Slope (inclination): with a clinometer the slope of the plot area is measured and recorded. This recording is only done in the first monitoring year.
- Soil depth: With a soil auger (Edelman type) and / or a spade the effective soil depth is determined to a maximum soil depth of 120 cm. Effective soil depth is the depth to which roots can grow unhindered. Gravel or other impenetrable soil layers limit effective rooting depth and the start of such layer is recorded as soil depth. This recording is only done in the first monitoring year.
- Soil erosion: any visual sign of erosion will be noted descriptively, especially washed away soil.

Undergrowth/weeds

- Plant species or type, coverage (%) and height range (m) is noted plant types covering at least 15% of the PSP area.
- For qualifying quantities of Acheampong, York and agricultural crops the species is recorded.
- For qualifying quantities of grass or herbs record only 'grass' or 'herbs'
- Coverage of each plant species or type is estimated as percentage of PSP cover.
- The height or height range is measured per plant species or type.

Teak trees

- Qualifying trees are teak trees that have been planted, teak wildlings and teak coppice.
- Tree DBH (diameter at breast height, measured at 1.3m above ground level): The DBH of each teak tree is measured with a calliper.
- Height: The height of all trees is measured as accurately as possible with a clinometer or a (telescopic) measurement pole.
- Tree health, pests and diseases: record as observation in case a tree is affected by a pest or disease.
- When a tree is standing near the boundary, the distance from the center to the tree shall be measured to make sure the tree falls in or outside the plot

Other trees

- Other trees are only measured if they are qualified
- Qualifying trees are trees that were present before plantation establishment. These are remnant, indigenous trees, typically with a DBH >10 cm.
- Tree DBH: From qualifying trees the tree DBH is measured with a calliper.

Detailed guidance on these measurements are recorded in PP's protocol 13 Annex 3.

Indigenous plantation PSPs and buffer zone PSPs

Procedures for indigenous plantation PSP monitoring are the same as for Teak plantations, with a few exceptions:

- Tree height and DBH of all planted trees are recorded the same as for Teak.
- Unplanted trees are only measured if they qualify.
- An unplanted tree is qualified if it not York and is ≥ 5 cm DBH (unplanted Teak is included).
- Tree DBH: From qualifying trees the tree DBH is measured with a calliper.
- When a tree is standing near the boundary, the distance from the center to the tree shall be measured to make sure the tree falls in or outside the plot

Detailed guidance on these measurements are recorded in PP's protocol 13

4.3.3 Quality assurance and quality control procedures

To increase the accuracy of the monitoring data quality assurance and quality control Qa/Qc procedure are established following IPPC good practice guidance for LULUCF, 2003 (45).

Hard copies of data sheets are kept on file by plant year and plot number and stored at least five years.

Data is entered by the data entry officer in a data entry template in excel. The monitoring supervisor checks for typing mistakes that may occur from entering data from field sheets into the computer by comparing all hard copy data sheets with the digitalized records before sending to the monitoring manager. The excel sheets are then send to the monitoring manager for analysis. Digital data is backed up and stored until at least two years after the crediting period is expired.

The monitoring manager performs further quality control on the data by checking a number of possible errors, being:

- Missing diameter records for trees >1.3 m high.
- Extreme values for H and DBH that are outside the biological potential of the trees. This is checked through a 'max-min' check by filtering the records in the spreadsheet.
- Very unlikely height-diameter (H/D) ratios. An H/D ratio check is carried out by filtering the records in the spreadsheet. For plantation trees in regeneration and pole phases the ratio should be between 0.5 and 2.5. Deviations from this ratio will be checked.

When (possible) errors are found the source of the error will be searched. The mistake can be made during data entry or during field measurements. The monitoring supervisor will review problematic records on request and verify whether the records are correct or whether mistakes were made during data entry or in the field. In case a field check or remeasurement is required this will be done.

Training of the monitoring team is essential and is given on-site by an experienced monitoring professional. This is done yearly and the tasks are assigned to different members of the monitoring team. Activities are cross checked to assess if the monitoring is carried out according to protocol

Internal auditing is done yearly. During this audit 5 % of the permanent sample plots are re-measured plots and 5% of the data that is entered in a spreadsheet is re-entered. The leader of the quality control measurements is not involved in the original measurements. The data from the re-measurements will be compared with the monitoring data. Any errors discovered will be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error. If the difference is larger than 10%, the cause(s) will be identified and included in the next training session. This is to ensure accuracy and continuous improvement of the system

The task of monitoring manager and monitoring supervisor can at all times be carried out by two qualified and trained staff, to prevent that absence of one person per position might lead to insufficient supervision, management or quality control.

5 ENVIRONMENTAL IMPACT

A social and environmental impact assessment (SEIA) was conducted in 2007 before the start of the project and included an environmental survey. This showed that the area was severely degraded and water quality was below standard. In this study it was also predicted that the reforestation activities would have a positive influence on soil quality, water quality and biodiversity (7).

Further, the SEIA did not foresee any environmental and social negative impacts by implementation of project activity following AFOLU requirement 3.1.4. The project is FSC certified demonstrating environmental and social benefits beyond GHG emissions removals.

Conservation and restoration of buffer zones, elimination of logging, forest conversion and the abandonment of fire and poaching has resulted in an increase of wildlife presence, water quality, and soil quality. Flora and fauna is monitored annually (46). Rare and threatened tree species such as the Kokrodua, are raised in the nursery and planted in the buffer zones. The water quality survey in 2011 showed that all values are now within WHO limits. This is a significant improvement compared to water analyses from 2007 showing that water quality was poor (7).

6 STAKEHOLDER COMMENTS

A stakeholders committee consisting of traditional landowners, farmers, environmental NGOs, a forestry commission and FORM Ghana has been set up in 2009. The committee holds meetings three times a year to discuss wishes, demands and complaints of the stakeholders. Minutes of the meetings are kept on file. Before the project start a social survey was conducted as part of the social and environmental impacts assessment (7).

In 2010 and 2011 more than 100 intercropping agreements were signed between farmers and PP. During the last social monitoring survey, it became clear that many people living in the project area found either temporal or permanent employment with the PP, while they could still work as a farmer because of the possibility of intercropping and therefore PP presence has positively changed their income situation. Most people perceived the forest restoration as a positive activity and already see positive changes in the presence of wildlife (46).

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