



**Verified Carbon
Standard**

MONITORING REPORT “REFORESTATION OF DEGRADED FOREST RESERVES IN GHANA”



Document Prepared by Form International

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The project aims at reforestation of 20,000 ha in degraded forest reserves in Ghana. Currently, 1,476 hectares in the Asubima Forest Reserve are realized, which is the first project instance of this grouped project with the start date being 1 March 2008. In addition to this also 1,738 hectares are realized in Afrensu Brohuma Forest Reserve, which is the second project instance of this grouped project with a start date of 1 March 2011. A further 8,878 hectares have been planted in the Tain II forest reserve, which is the third instance of this grouped project with a start date of 1 March 2013. The project foresees an average expansion of 1000 hectare per year, adding new project areas and instances.

The plantation of Form Ghana is managed on several rotations. Form Ghana has a lease (50 years) that spans several rotations and is renewable. The business model of Form Ghana has timber as a main focus though carbon is essential in the investments phase. Through annual planting of Teak and Gmelina the estate has become a mosaic of forest stands of different age classes which will eventually cover the whole rotation. Each commercial stand is planned to be harvested through clear felling at 20 years of age, after which it is replanted. The plantation is polycyclic. The areas that area restored to natural vegetation will not be subjected to a clear-felling but only to thinning and pruning when needed.

The Asubima, Afrensu Brohuma and Tain II Tributaries Forest Reserves used to be productive reserves covered with high, semi-deciduous forest. However, the reserves have been severely degraded by over-exploitation, bush fires and conversion to agricultural land, particularly between 1980 and 2000, and have 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 landowners 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. Their plantations in Asubima and Afrensu Brohuma Forest Reserves are certified according to the principles and criteria of the Forest Stewardship Council (FSC) since January 2010. Tain II Tributaries Forest Reserve is managed along the same lines but currently not certified. 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 is 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-ACM0003: *Afforestation and reforestation of lands except wetlands --- Version 02.0* for a project period of 40 years.

The current monitoring period covers the period from 01-07-2019 to 31-07-2021 and in this period a total of 414,333.9 GHG emission removals have been generated.

The main change in the current monitoring period is the inclusion of new planted areas in 2019 - 2021 in the Tain II Forest Reserve. No new areas have been established within other parts of the project area. Only regular management operations, such as pruning, thinning and forest protection have been carried out. Risks are monitored systematically through the monitoring system as elaborated in the Project Description Document.

Planting

GHG emission removals are achieved by establishing tree plantations of exotic and indigenous tree species. Below are details of plantings that were carried out during the monitoring period.

Table 1: Planted areas (hectares) within the monitoring period (July 2019 to July 2021) in Tain II FR

Year	Teak (ha)	Gmelina (ha)	Indigenous (ha)
2019	863.17	25	363.060
2020	272.739	28.674	377.43
2021	138.091	0	9.548

Beating up (Blanking)

A few months (August / September) after planting the mortality rate was assessed. This assessment was done using row counts, where for at least four lines per block the survival was counted. Once the survival was less than 80%, beating up was carried out.

Singling

Teak (and some Gmelina) stumps grow multiple stems. About one year after planting, the extra stems are removed. This is done with secateurs, not with cutlasses, along with weeding. Singling is done in later stages as well, whenever forked or multiple stems are formed. Then it is done with chainsaws, prior to pruning. Because of safety reasons singling should not be done above breast height. Singling was done after planting during the monitoring period. This is not applicable to the indigenous areas.

Weeding

Weeding is done at least two times a year before canopy closure. Weeding is done manually with cutlasses. Two types of manual weeding are used: full weeding and circle weeding. Circle weeding removes the vegetation in a one meter radius around the planted tree and from the base of the tree. In addition to manual weeding, Glyphosate-based herbicides are applied to further control weeds. Glyphosate is not considered to be a highly hazardous chemical by FSC. Depending on the weed pressure, the Glyphosate-based herbicide is used after manual weeding for optimal effect. Both manual and total weeding were done during the monitoring period in both Asubima and Afrensu Brohuma FRs and Tain II FR.

Pruning

Pruning is done to remove side branches on the tree stem to obtain more and higher quality timber. Branches are removed up to 1/3 of the height of the tree. For practical reasons, this is determined per block based on the observed average tree height at the time of pruning. The first pruning is done at year three after planting, then at years five and seven. Pruning is done in the dry season so that the pruning wounds can dry in the sun, preventing infestation from fungi. Pruning is done with a sharp and clean pruning saw or with secateurs, not with a cutlass. Pruning was done during this monitoring period in Asubima and Afrensu Brohuma FRs and Tain II FR. This is not applicable to the indigenous areas.

Thinning

Thinning is done to optimize diameter growth and minimize excess biomass. Thinning was

carried out in all plantations during the monitoring period. Commercial thinning is only carried out in the teak and Gmelina areas.

Plantation Protection (illegal activities and fire)

Form Ghana security guards monitor all activities that take place in and around the plantation. Rapid response fire teams are stationed at strategic areas within the plantation and one backup rapid response team patrols the plantation and guards look out over the terrain from the permanently manned watchtowers. In addition to the manned towers, a camera system has been installed to monitor and send signals to the operations room on site for further action. They enforce a no-fire rule in plantations, identify high-risk areas and notify management in case of fire outbreaks. All observed fires are recorded and analyzed as described in Protocol 13. Part of fire management is fuel reduction. Activities such as weeding, fire belt clearing around the external boundaries, and internal road construction were carried out to reduce fuel built up in the plantations. This is necessary to reduce fire risk. Form Ghana did not lose any of its plantations to fire throughout the monitoring period. Form Ghana has boom gates at different locations within plantations which serve as access control. Security guards monitor and report all illegal activities to management.

Conservation measures

The environmental impact assessment conducted prior to the establishment of plantations by Form Ghana showed that little of the original semi-dry deciduous forest remained. The vegetation has been degraded so drastically that it is now a mosaic of savannah, agricultural land, unmanaged teak plantation, and degraded forest. The forest occurs in patches throughout the reserve, mainly bordering the streams and rivers in the area. Some of the original forest fauna still remains, such as bush pigs and antelopes, but most of the animals encountered during the survey are birds, snakes and small mammals characteristic of savannah vegetation. The conservation strategy is therefore to reforest part of the degraded forest reserves and restore some ecological values. Through the restoration of tree cover a forest climate will be created, carbon is stored above and below-ground, nutrient cycling, as well as water quality, improves and corridors of natural, riparian forest are established in the form of buffer zones alongside rivers and water bodies. Indigenous areas were planted to ensure forest restoration around the Tain river in the Tain II forest reserve. Areas with good and intact forests were left while in some areas enrichment planting was done and protected against illegal activities and fires.

As part of Form Ghana's monitoring system (see Protocol 13), biodiversity (flora and fauna) studies were carried out in the TAIN II plantations. Monitoring in the Akumadan plantation is due in 2023.

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 (scope 14) 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

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.

Organization name	FORM Ghana Ltd.
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Contact person	Mr. Willem Fourie
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1.4 Other Entities Involved in the Project

Organization name	Form international B.V.
Role in the project	Project development - Form international is contracted by FORM Ghana to deliver 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 analysis of data and training of FORM Ghana personnel.
Contact person	Ms. Ronja Knippers, Mr. Tieme Wanders
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Organization name	Sustainable Forestry Investments B.V. (SFI)
Role in the project	Owner and shareholder of FORM Ghana, but no active role in VCS implementation.
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1.5 Project Start Date

The project start date was 01-March-2008. This date was chosen because the time of first issuance was 2013 and project activities up to five years old are able to be included. Earlier planting activities (2001-2007) fell outside of the crediting period. The start date of March 1st was chosen to lie just before the 2008 planting activities, so that they could be included in the project in their entirety.

1.6 Project Crediting Period

Start date: 01 - March - 2008

End date: 01 - March - 2048

Total number of years: 40

1.7 Project Location

The Asubima and Afrensu Brohuma Forest Reserves are situated in the dry, semi-deciduous forest zone at about 100 km north of Kumasi in the Ashanti region in Ghana (Figure 1). It falls under the authority of the Offinso Forest District.



Figure 1 Location of the Form Ghana plantations in Asubima and Afrensu Brohuma and Tain II Forest Reserves

Asubima Forest Reserve and Afrensu Brohuma Forest Reserve are 2 adjacent Forest Reserves. Tain lies some 100 km to the east located in Berekum District, Bono Region. The Form Ghana land leases (Figure 2) cover only a portion of these 3 Forest Reserves. The land leases are located in the south-eastern part of Asubima Forest Reserve, the north-eastern part of Afrensu Brohuma Forest Reserve and the northeastern part of Tain II reserve.



Figure 2 Outline of Form Ghana land leases (red) in Asubima, Afrenso Brohuma and Tain II Forest Reserves

1.8 Title and Reference of Methodology

The CDM consolidated methodology AR-ACM0003: Afforestation and reforestation of lands except wetlands --- Version 02.0 is applied.

In addition, the following tools are applied by the project:

- Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities (Version 01)
- Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities (Version 01)
- Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity (Version 02.0)
- Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities (Version 04.2)
- Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities (Version 01.1.0)
- VCS AFOLU Non-Permanence Risk Tool (Version 3.3)

1.9 Participation under other GHG Programs

The project *Reforestation of degraded Forest Reserves in Ghana* is not registered under any other GHG program, nor are the areas under this project used in other GHG programs under the same or a different name.

1.10 Other Forms of Credit

Reforestation of degraded Forest Reserves in Ghana does not collect any other credits apart from VCS.

1.11 Sustainable Development

Ministry of Lands and Natural Resources

The Ministry has the oversight responsibility for the land and natural resources sector and its functions include: Policy formulation, Co-ordination, Monitoring and Evaluation, Validation of Policies, Programmes and Projects, Supervision of Sector Departments and Agencies; and Negotiations with Development Partners.

The Ministry's aims and objectives are:

- Develop and manage sustainable lands, forest, wildlife and mineral resources;
- To facilitate equitable access, benefit sharing from and security to land, forest and mineral resources;
- Promote public awareness and local communities' participation in sustainable forest, wildlife and land use management and utilization;
- To review, update, harmonise and consolidate existing legislation and policies affecting land, forest and mineral resources;
- To promote and facilitate effective private sector participation in land service delivery, forest, wildlife and mineral resource management and utilization;
- Develop and maintain effective institutional capacity and capability at the national, regional, district and community levels for land, forest, wildlife and mineral service delivery; and
- Develop and research into problems of forest, wildlife, mineral resources and land use.

MLNR is the sector Ministry to which the Forestry Commission reports. It is also responsible for Ghana's Forest Investment Program (FIP).

The project contributes to the achievement of several of the listed aims and objectives, because PP:

- implements sustainable forest management according to the principles and criteria of the Forest Stewardship Council (Forest Stewardship Council, 2015);
- has a benefit sharing agreement (Forestry Commission, 2009; Forestry Commission, 2012; Forestry Commission, 2013);
- raises public awareness within the surrounding communities through community engagement; and
- is part of the private sector that manages parts of some national Forest Reserves.

Forestry Commission

The Forestry Commission of Ghana is responsible for the regulation of utilization of forest and wildlife resources, the conservation and management of those resources and the coordination of policies related to them. The Climate Change Unit, established in 2007 as a unit of the Commission has a mandate to manage forestry-sector initiatives related to climate change mitigation. It is the aim of the Commission to be a corporate body of excellence in the sustainable development management and utilization of Ghana's forest and wildlife resources meeting both national and global standards for forest and wildlife resource conservation and development.

The project contributes to the aim of the Climate Change unit by sustainable forest management and carbon sequestration.

Environmental Protection Agency (EPA)

As the law stipulates, the EPA is statutorily mandated to ensure that the implementation of all undertakings does not harm the environment. The Agency has eleven (11) regional

offices, which are accessible and staffed and equipped to perform their functions. It is expected that sub-projects that will require the preparation of EIA will abide by statutory requirements and the implementing institutions will liaise sufficiently with the Agency to ensure compliance. The EPA is the National Focal Point for Climate Change and is responsible for all national communications to the UNFCCC.

PP's project is covered by Environmental Impact Assessments (Abeney, et al., 2008; Tollenaar, 2012; Tollenaar & Wanders, 2015) and adheres to the principles and criteria of FSC (Forest Stewardship Council, 2015). Further, with the implementation of the project it contributes to further mitigation of climate change.

2 SAFEGUARDS

2.1 No Net Harm

Form Ghana's Akumadan plantations are certified according to FSC's Principles and Criteria. The Tain II plantation is managed according to the same principles and criteria. Based on this Form Ghana has developed a management system of separate protocols that describe the process of environmental and social management. Together with the Management Plan, these documents form the Environmental and Social Management Plan, which is aimed to mitigate any negative environmental and socio-economic impacts. The systematics between the various documents is described in Figure 3.

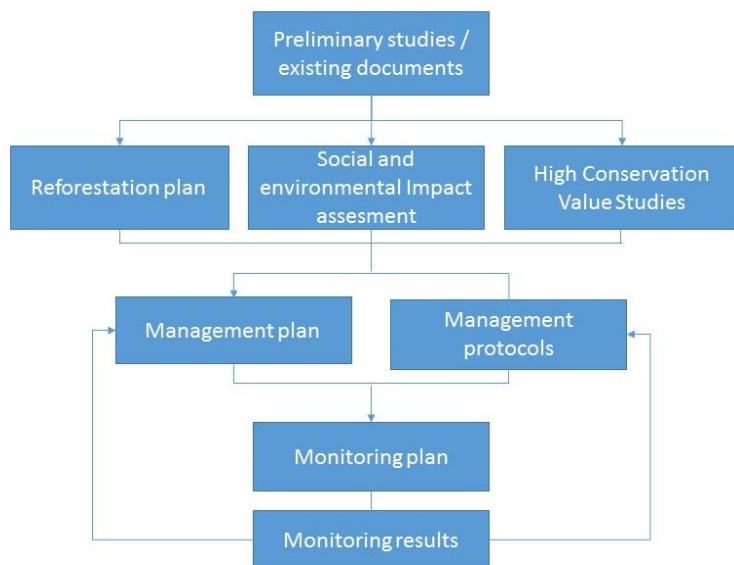


Figure 3 Relation between the various documents

The environmental and social management of Form Ghana addresses the recommendations and mitigation measures proposed in the impact assessments of Tain II Forest Reserves (Tollenaar & Wanders, 2015).

Form Ghana has found farmers on the plantation sites that were engaged in farming inside the Forest Reserves. This is an illegal activity. FG has however not engaged in any forceful

removal of illegal occupants. People were invited to continue activities as intercroppers. As such they could plant crops amidst the young teak. Most of the intercroppers have moved with the planting, so occupying new terrain as the company developed it. Form Ghana now also implements a landscape activity which is partly oriented toward farmers providing them training and crop inputs.

The scope of the environmental and social management plan (ESMP) is the same as the scope for the Social and Environmental Impact Assessment. The goal is to give guidelines to all parties involved during establishment, maintenance and harvesting of the plantation in fulfilment of environmental and social requirements.

The environmental and social management plan has a long-term objective to ensure that:

- (i) Environmental management activities and requirements are implemented during the establishment, maintenance and harvesting of the plantation;
- (ii) The interests of the stakeholders are considered throughout the project;
- (iii) Damage to the environment, the biological diversity and sensitive habitats (where present) are avoided.

The ESMP addresses the recommendations and mitigation measures proposed by prescribing appropriate technologies and systems in protocols to be used during the execution of the work and by monitoring the effects of the measures. The environmental and social management plan is composed of plans and protocols that describe the techniques and methods to be used and the way work is monitored.

The effectiveness of management is checked annually through monitoring activities. Monitoring is done based on a matrix that identifies the fields of monitoring. This matrix is presented in the annual monitoring plan. Subjects covered during monitoring are:

- Mapping and map analysis;
- Fauna diversity;
- Buffer zone Permanent Sample Plots;
- Timber plantation Permanent Sample Plots;
- Water quality;
- Soil texture;
- Fire monitoring;
- Forest production;
- Section analysis of trees;
- Timber and carbon sales;
- Economic aspects;
- Social impact;
- Training and capacity building;
- Health and safety;
- Nursery development.

Findings from monitoring activities are fed back into the management system through the adaptation of protocols or management plans. A public monitoring report is produced for the general public. Reports on the specific monitoring activities are produced for Form Ghana management.

The responsibility for implementing the ESMP lies with Form Ghana who delegates part of the responsibilities to Form international, regarding monitoring, training and document maintenance.

2.2 Local Stakeholder Consultation

Form Ghana has held regular stakeholder meetings within the framework of preparation for FSC certification for the reforestation project since 2008. While preparing the Social and Environmental Impact Assessments specific stakeholder meetings have been held. With the obtention of FSC in 2010, these meetings have continued. Meetings are held separately for the Akumadan plantations and the Tain II plantations. Meetings take place at least annually. (see stakeholder engagement plan). Outcome from the stakeholder engagement has been that the communities are well aware of the project, its activities, the benefit share they are entitled to and how they have to conduct themselves in the plantations (rights and obligations). Specific stakeholder engagement is done in preparation of the fire season and farmers can get help from PP in the preparation of their farm to protect it from fire.

During stakeholder engagements several specific subjects have been discussed such as:

- The results of project implementation, including the results of monitoring.
- Any changes, where relevant, to risks, costs and benefits the project may bring to local stakeholders.
- Any changes, where relevant, to relevant laws and regulations covering workers' right in the host country.
- The process of VCS Program verification and the validation/verification body's site visit.

Since 2013 more than 500 intercropping agreements were signed between farmers and PP (Wanders, 2019). During social monitoring surveys 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 (Ogoe, 2011).

The following documentation governs the local stakeholder consultation process

- *P06 Stakeholder engagement plan*
This plan identifies the stakeholders of Form Ghana and describes how stakeholders are engaged.
- *P 07 Grievance and Redress*
This document describes how grievances are dealt with and how grievances are redressed.
- *Resettlement Action Plan*
This document describes the resettlement activities that Form Ghana undertakes for people that need as a consequence of Form Ghana activities.
- *P28 Community Development Plan*
This plan describes the community development activities that Form Ghana undertakes.

During the 2019-2021 monitoring period, stakeholders were consulting through stakeholder meetings. These took place on June 28th 2019 in Berekum, December 13th in Berekum, July and December of 2019 in Akumadan, September 8th 2020 in Akumadan, September 11th 2020 in Bekerum, August 10th 2021 at Akumadan and August 13th 2021 in Berekum. They were held in neutral venues such as meeting halls and churches. Stakeholders meetings were announced using invitation letters. Stakeholders to receive a meeting invitation were selected using Protocol 6. Attendance lists and minutes for all meetings were documented and kept by Form Ghana and include photos of the meetings. The minutes include all concerns or comments raised by stakeholders and their immediate response from Form Ghana representatives. They also show the response of Form Ghana to concerns raised during earlier meetings and how they have decided to respond to them. Moreover, these meeting were used to convey the current status of the project as well as any new plans for

the near future, including monitoring results, costs and benefits to communities and changes to laws and legislation. Meetings lasted for an average of two hours.

Any complaints or conflict situation from or with stakeholders are addressed using the Grievance Redress Mechanism described in Protocol 7.

Major concerns raised during the 2019-2021 monitoring period include the wish that more people from fringe communities should be included during worker and firefighter recruitment. This was thereafter implemented by Form Ghana during further recruitment instances.

2.3 AFOLU-Specific Safeguards

By customary rules local people have access to non-timber forest products in natural forests and communities could also access timber for development work by obtaining permits from the Forestry Service Division (FSD). FSD cannot grant such permits inside a plantation under lease by another party. People interviewed for the impact assessments, derive very little or no economic value from forest products and none of the respondents reported depending on the collection of NTFPs as their primary occupation. This can be easily explained with the degraded state of the forest reserves

A Socio-Economic Impact Assessment has been carried out for all project locations to:

- Integrate environmental and socio-economical components in management decisions at the earliest stages of program investments.
- Develop plans to mitigate negative effects and enhance positive effects on existing conditions.
- Promote participation by local communities, project proponents, private and government agencies in the assessment and review of proposed actions.

No major negative impacts of the proposed project were identified in the SEIA.

Form Ghana will organise at least two stakeholder meetings per year. If the need arises it is possible to organize additional meetings. When a stakeholder meeting is organised all known stakeholders are invited. Invitation is based on the stakeholder database. The database is kept up to date and checked prior to the organisation of a stakeholder meeting.

From the Form Ghana side the meeting is prepared by the listing of new information that has become available since the last meeting (new reports, new developments, events in the field). A summary is made of this information and prepared as a handout for the meeting.

The Grievance Redress mechanism describes the way Form Ghana manages internal and external complaint and conflict situations. The policy is aimed at preventing conflicts by investing in community sensitization and an open dialogue with all stakeholders.

Updates in the GRM will be communicated through stakeholder meetings and included in the employees' training program.

For the farmers that were present in the Akumadan plantations a Resettlement Action Plan was formally implemented between 2016 and 2020. Farmers that were still living inside the Akumadan plantations in 2016 were given the possibility to move to the Tain II area to start a new live there with the assistance of PP.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The main change in the monitoring period is the inclusion of the areas planted in 2019 until 2021 in the Tain II Forest Reserve. This area is managed as a separate unit together with the areas planted in Asubima and Afrenso Brohuma Forest Reserve. Part of the project area (Asubima and Afrenso Brohuma) is included in the scope of the FSC certification. No new areas have been established within that part of the project area. Only regular management operations, such as pruning, thinning and forest protection have been carried out. Risks are monitored systematically through the monitoring system as elaborated in the PDD.

3.2 Deviations

3.2.1 Methodology Deviations

No deviations from the methodologies and tools used during this project were undertaken.

3.2.2 Project Description Deviations

Volume calculations for indigenous trees and stands

The method of calculating the AGB of indigenous trees and stands in the baseline calculations as well as the monitoring data was changed from the pantropical model previously used to a model specific for tropical forest trees and stands in Ghana, as described by Aabeyir et al. (2020). Given that the parameters in this model were estimated based on trees from stands with a similar species composition and similar climatic circumstances, they can be assumed to be more accurate to our data than the pantropical model used previously. Moreover, the model was based on destructive sampling and thereby on very accurate AGB numbers for the included trees.

This change does not impact any other part of the methodology, nor the additionality. The baseline scenario likewise stays the same, with the exception that the baseline values for indigenous trees are affected by the changed AGB formula for indigenous trees.

The precise methodology changes between these methods are explored in the Project Description Document. Regarding the carbon calculations, values for the new methods are higher than those computed with the old form factor. This is illustrated in Table 2:

Table 2: Changes in C_TREE for the crediting period up to present between the two AGB approximations.

Plantations	Plant year	C_TREE old method (over whole project duration up to 2021)	C_TREE new method (over whole project duration up to 2021)	Absolute difference	% change (2019 as baseline)
Akumadan	2010	4348	5305	957	22.1
Akumadan	2011	18862	23006	4143	22.0
Akumadan	2012	1107	1352	245	22.2

Tain II	2013	1595	1948	353	22.2
Tain II	2014	7661	9356	1695	22.1
Tain II	2015	3480	4244	764	22.0
Tain II	2017	3006	3675	669	22.3
Tain II	2018	11929	14553	2624	22.0

As can be seen in Table 2, an increase of ~22% in total C_TREE over the whole project period is the result of the implementation of the new volume calculations. This increase is justified by the fact that the model used in Aabeyir et al. (2020) is significantly better suited to our own data than the pantropical model concerning monitoring area, species composition and climatic circumstances, as noted earlier.

The baseline calculations for the indigenous plantation areas were also heightened by the new AGB calculations; they increased from 8.9 to 10.8 t CO₂e ha⁻¹.

This change does not affect previous credit issuances. The calculated credits for the vintages can be seen as extra conservative through the use of the pantropical AGB model.

Yield prognosis for indigenous stands

Based on analysis of the project's own data it becomes clear that the growth approximation for indigenous was optimistic in the previous reports. We have calculated a new approximation based on a hill function which reduced the predicted growth significantly but is closer to what the data shows us. Since this only concerns the ex-ante carbon storage predictions, this change does not influence carbon storage calculations for credit issuance. A detailed description of the new growth approximation for indigenous trees can be found in the Project Description Document. A detailed description of the new volume calculations and yield prognosis for indigenous trees and stands is found in the project description under paragraph 3.2.2.2.

3.3 Grouped Projects

The eligibility criteria for new instances that join in the Form Ghana grouped project have been described in the Form Ghana VCS Project Description document. All potential new project instances must adhere to these criteria. The current project locations are in the south-eastern part of Asubima Forest Reserve, the north-eastern part of Afrensu Brohuma Forest Reserve and the northeastern part of Tain II reserve and are considered a grouped project. No new instances were added to the project in the monitoring period between 2019 and 2021. The newly planted areas are part of the existing TAIN II instance.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	Allometric constant for AGB and volume formula for indigenous trees ($a_{i,IND}$)
Data unit	-
Description	This converts DBH and height into total aboveground tree biomass or volume.

Source of data	(Aabeyir et al., 2020)
Value applied	0.058
Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed data specifically for tropical broadleaved tropical trees in Ghana.
Purpose of the data	• Calculation of baseline emissions • Calculation of project emissions
Comments	

Data / Parameter	Allometric exponent for AGB and volume formula for indigenous trees ($b_{i,IND}$)
Data unit	-
Description	This converts DBH and height into total aboveground tree biomass or volume.
Source of data	(Aabeyir et al., 2020)
Value applied	0.999
Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed data specifically for tropical broadleaved trees in Ghana.
Purpose of the data	• Calculation of baseline emissions • Calculation of project emissions
Comments	

Data / Parameter	Average wood density for Indigenous forest (D_{IND})
Data unit	kg m ⁻³
Description	This is a calculated parameter of the average wood density.
Source of data	The average wood density is determined based on relevant literature (The Wood Explorer, n.d.; Orwa, et al., 2009; IPCC, 2006)
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 calculate DW in the indigenous vegetation.
Purpose of the data	• Calculation of project emissions • Calculation of baseline emissions
Comments	

Data / Parameter	Root to shoot ratio for mixed tropical broadleaf species (R_{mix})
Data unit	-
Description	Converts the above-ground biomass to the above- and below-ground biomass
Source of data	(IPCC, 2006)
Value applied	1.22
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 ⁻¹ aboveground and <125 ton DW ha ⁻¹ aboveground, since forest will change gradually from lower than 125 ton ha ⁻¹ to more than that in the project period.
Purpose of the data	• Calculation of project emissions • Calculation of baseline emissions
Comments	

Data / Parameter	Carbon fraction indigenous trees (CF_{IND})
Data unit	-
Description	Amount of carbon in dry matter
Source of data	(IPCC, 2006)
Value applied	0.49
Justification of choice of data or description of measurement methods and procedures applied	Default value from IPCC
Purpose of the data	• Calculation of project emissions • Calculation of baseline emissions
Comments	

Data / Parameter	Form factor remnant teak
Data unit	-
Description	Factor to convert cylinder measured from DBH and height to trunk volume
Source of data	(Dupuy, 1990)
Value applied	0.36
Justification of choice of data or description of	Peer reviewed publication

measurement methods and procedures applied	
Purpose of Data	Calculation of project emissions
Comments	

Data / Parameter	Biomass expansion factor teak (BEF_{TEAK})
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., 2003)
Value applied	1.53
Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed publication.
Purpose of the data	- Calculation of project emissions - Calculation of baseline emissions
Comments	

Data / Parameter	Teak wood density (D_{TEAK})
Data unit	ton m ⁻³
Description	The density for teak to determine dry weight
Source of data	(IPCC, 2003)
Value applied	0.55
Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed publication.
Purpose of the data	- Calculation of project emissions - Calculation of baseline emissions
Comments	

Data / Parameter	Carbon fraction Teak (CF_{TEAK})
Data unit	-
Description	Fraction of carbon in dried teak
Source of data	(Kraenzel, et al., 2003)
Value applied	0.495

Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed publication.
Purpose of the data	- Calculation of project emissions - Calculation of baseline emissions
Comments	

Data / Parameter	York wood density (D_{YORK})
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
Purpose of the data	Calculation of baseline emissions
Comments	

Data / Parameter	Cassia wood density (D_{CASSIA})
Data unit	kg m ⁻³
Description	The wood density of <i>Cassia siamea</i>
Source of data	(Mainoo & Ulzen-Appiah, 1996)
Value applied	640
Justification of choice of data or description of measurement methods and procedures applied	Literature
Purpose of Data	Calculation of baseline emissions
Comments	

Data / Parameter	<i>Gmelina</i> wood density ($D_{GMELINA}$)
Data unit	ton m ⁻³
Description	The density for teak to determine dry weight

Source of data	(IPCC, 2003)
Value applied	0.45
Justification of choice of data or description of measurement methods and procedures applied	Peer reviewed publication
Purpose of Data	Calculation of project emissions
Comments	

Data / Parameter	Biomass expansion factor Gmelina ($BEF_{GMELINA}$)
Data unit	-
Description	Converts trunk biomass to total aboveground tree biomass.
Source of data	Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities (Version 04.2)
Value applied	1.15
Justification of choice of data or description of measurement methods and procedures applied	Methodology default value
Purpose of Data	Calculation of project emissions
Comments	

Data / Parameter	$SOC_{REF,i}$
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) – Table 3
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)
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	$f_{LU,i}$
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) – Table 4
Value applied	0.70
Justification of choice of data or description of measurement methods and procedures applied	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). Following determination of $SOC_{REF,i}$ also an average is applied between dry and moist tropical forest
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	$f_{MG,i}$
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) – Table 4
Value applied	1.12
Justification of choice of data or description of measurement methods and procedures applied	Pre-project land use management is ‘reduced tillage’, since farming is characterized by low intensity and reduced soil disturbance. Following determination of $SOC_{REF,i}$ also an average is applied between dry and moist tropical forest
Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	$f_{IN,i}$
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) – Table 4
Value applied	0.935
Justification of choice of data or description of measurement methods and procedures applied	Inputs are considered to be low since residues are removed via collection and the land is burned afterwards.

Purpose of the data	Calculation of project emissions
Comments	

Data / Parameter	Constant to convert biomass to age for mixed tropical trees ($a_{50_{age,IND}}$)
Data unit	years
Description	Converts biomass to stand age (or vice versa) as one of two used parameters and is an indicator of the age at which halve of the biomass in a stand has been acquired.
Source of data	(Chazdon et al., 2016)
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	Estimated from peer reviewed literature regarding biomass accumulation in regenerating forests in Africa (Lewis et al., 2013).
Purpose of the data	Calculation of biomass accumulation prognosis for indigenous stands
Comments	

4.2 Data and Parameters Monitored

Data / Parameter	Constant to convert biomass to age for mixed tropical trees ($a_{age,IND}$)
Data unit	t CO ₂ e h ⁻¹
Description	Converts biomass to stand age (or vice versa) as one of two used parameters and is an indicator of the AGB in an old growth forest.
Source of data	(Chazdon et al., 2016)
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Every year, based on the yearly monitoring data.
Value applied	26.11401
Monitoring equipment	-

QA/QC procedures to be applied	-
Justification of choice of data or description of measurement methods and procedures applied	Estimated by fitting the model from Chazdon et al. (2016) to the PSP monitoring data from 2021.
Purpose of the data	Calculation of biomass accumulation prognosis for indigenous stands
Calculation method	Estimated based on the monitoring data by setting the parameter at random, calculating the summed squared residuals of the monitoring data vs. the model data and then minimizing the residuals using the Excel solver (see Annex I).
Comments	

Data / Parameter	Form factor teak (f_{TEAK})
Data unit	-
Description	Factor to convert cylinder measured from DBH and height to trunk volume
Source of data	Calculated from section measurements in PP plantations. Equation obtained from literature (Burkhart & Tomé, 2012)
Description of measurement methods and procedures to be applied	For a selection of trees felled in thinning operations among others the DBH is measured at 1m intervals. Section measurements are carried out according PP's protocol 13.
Frequency of monitoring/recording	Section analysis is done during every thinning operation in the plant year where thinning takes place.
Value applied	Value depends on tree dimensions
Monitoring equipment	Calliper and measurement tape
QA/QC procedures to be applied	PP's protocol 13 for monitoring is implemented, including training of the monitoring team
Purpose of data	Calculation of project emissions
Calculation method	The following formula is used to calculate tree volume, based on which the form factor can be calculated: $\ln(V) = b_1 + b_2 \ln(d) + b_3 \ln(h)$ $b_1 = -9,605$

	$b_2 = 1,955$ $b_3 = 0,799$
Comments	

Data / Parameter	$A_{PLOT,i}$
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 the 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
Purpose of data	Calculation of project emissions
Calculation method	Plot size x number of plots
Comments	

Data / 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 the PDD for elaboration.
Frequency of monitoring/recording	Annually
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.
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	

Data / 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 the PDD for elaboration.
Frequency of monitoring/recording	Annually
Value applied	Depending on age, between 0 and 45 cm
Monitoring equipment	Diameter tape 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.
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	

4.3 Monitoring Plan

Description of the Monitoring Plan

Forest health is monitored in all forest types: commercial plantations with Teak and Gmelina, indigenous plantations and buffer zones. The measurements are taken in permanent sample plots (PSP), which are established throughout the project 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 / Gmelina plantation PSPs

Teak and Gmelina plantations are stratified according to plant year and PSPs are laid out per stratum, based on an allocation procedure carried out in GIS. The cumulative PSP area is at least 1% of the 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. PSP layout and size differs per plantation, and this is recorded per plot in the PSP database. At the 1% sampling density there is approximately 1 PSP for every 7 - 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.

Every plant year is monitored every 2 years, starting in the 3rd year after planting, because at this age normally a DBH can be established.

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. Every plant year is monitored every 2 years, starting in the 3rd year after planting as at this age normally a DBH can be established.

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. The buffer zones are monitored every 5 years.

Environmental monitoring

PP commits strongly to environmental values. Therefore, monitoring of flora and fauna, water quality and erosion are also undertaken.

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.

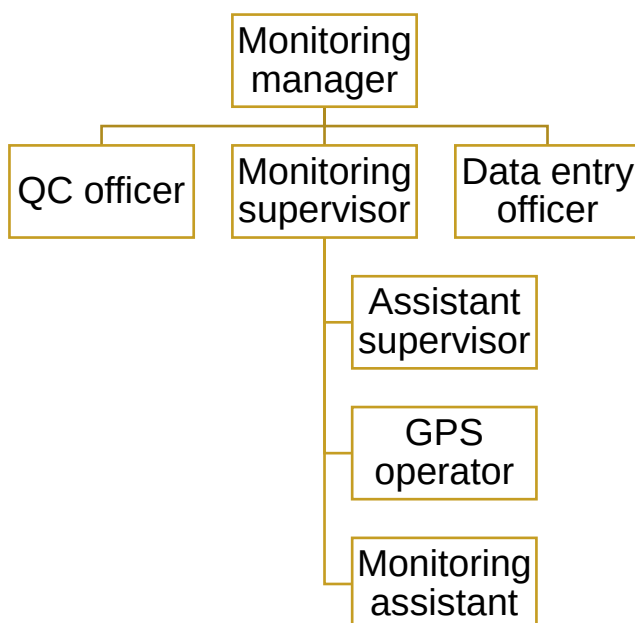


Figure 4 Overview monitoring staff

Table 3 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 the 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 updates to monitoring supervisor	- Clear and correct recording on field sheets - Correct implementation of PSP measurements - Maintenance and completeness of equipment
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

Methods for recording, storing and aggregating data on parameter

Field measurements procedure Akumadan

Annually, PSPs are assessed using the following procedure:

- The basic shape of a PSP is a circular plot with a pole in the center.
- GPS coordinates as received from the GIS system determine the site location.
- At the plot center a metal pole is placed
- The PSP size is normally 800m², and the plot radius to attain 800m² is 15.96m.
- Lay out the plot by measuring the plot radius with a measuring tape to eight directions and marking the trees in the plot with paint.
- 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.

Field measurements procedure Tain II

Annually, PSPs are assessed using the following procedure:

- The basic shape of a PSP is a square plot with a pole at the four corners of the plot. Poles and tags are replaced in case they have decayed.
- The plots cover 9x9 planting positions, and planting density is 3x3m. This implies a PSP size of 729m² assuming equal spacing, where each side of the square has a length of 27 m.

- 5 poles are placed to mark the plot (in the picture these are the green dots with a ring around them). Four poles on the corners and a 5th pole to indicate the direction in which the first line of trees must be monitored (Figure 5) The four corner posts must be placed on a specific point in the middle of a cross made between 4 trees.

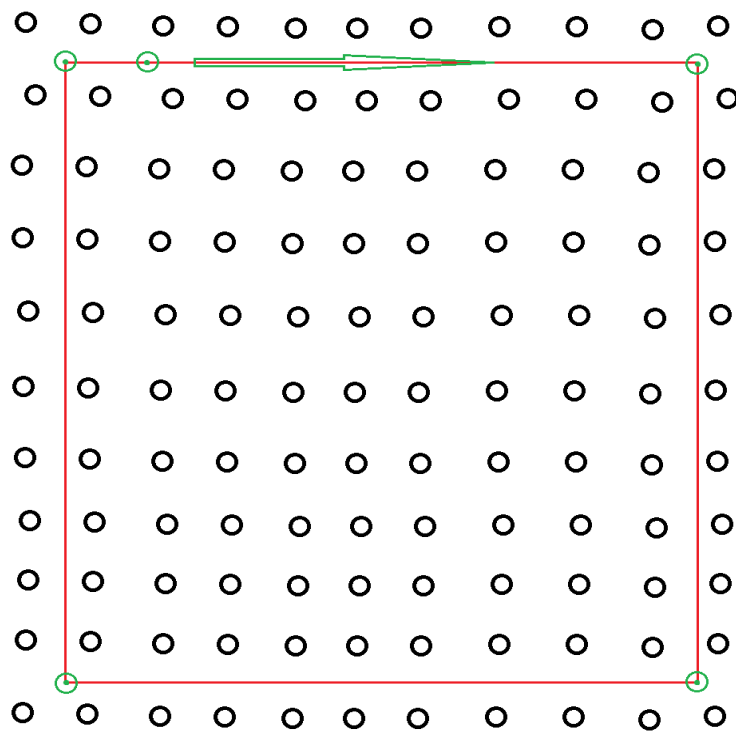


Figure 5 Design Permanent Sample Plots Tain II plantations

- On the corner post the GPS point must be taken for GIS positioning of the plots and to be able to calculate the plot surface. After the corner posts have been placed the distances between the poles are measured. This will later help the GIS to test if the coordinates were correct. The trees on the edge of the plot have to be marked with paint, so it is clear what is inside and outside of the plot.

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 / Gmelina trees

- Qualifying trees are commercial trees that have been planted, as well as wildlings and coppice of this species.
- Tree DBH (diameter at breast height, measured at 1.3m above ground level).
- 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.
- All trees standing in the plot are marked with paint to make sure that it is clear which 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 caliper.

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

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 diameter tape.
- All trees standing in the plot are marked with paint to make sure that it is clear which tree falls in or outside the plot

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

Quality assurance and quality control procedures

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

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 re-measurement 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 approximately 5% of the permanent sample plots are re-measured plots. 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.

Protocol guidelines

The activities that lead to the minimization of manual transportation errors are described in more detail in Protocol 13:

"Quality assurance and quality control (Qa/Qc) procedures are established following IPCC good practice guidance for LULUCF, 2003 (45). Hard copies of data sheets are filed by plant year and plot number and stored at least five years. A backup is made of the digital data.

Data is entered by the data entry officer in an Excel template provided by Form international. He/she sends the data to the monitoring manager for analysis. The monitoring manager checks the data for:

1. Missing DBH records for trees >1.3m high.
2. Extreme values for H and DBH.

3. Deviating height-diameter (H/D) ratios. Common H/D ratio for teak trees is 0.5-2.5.

Potential errors are sent to the monitoring supervisor. He/she checks whether the records are correct or whether mistakes were made during data entry in the field. In case a field check or re-measurement is required this will be done.

5 % of the PSPs is re-measured and 5% of the entered data is re-entered every year, to ensure accuracy and continually improve the system. These quality control measurements are done by someone that was not involved in the original measurements. The plots are chosen at random. Plots with 'strange' data can also be re-measured but should not be included in the quality control analyses.

For the re-entered data, the average DBH and Height per plot are compared to the average of the original monitoring data from the same plots. If the difference is larger than 10%, the cause(s) will be identified and included in the next training session.

Re-measurement is done under supervision of a Form international consultant. The consultant brings the original data into the field to check for inconsistency in the field. After re-measurement, the stem density of the original data of planted teak, so excluding coppice, wildlings and indigenous trees, is compared to the stem density of the planted trees in the re-measured data. If the stem density of the planted teak differs >10% between original and re-measured data, a new plot is chosen for re-measurement. Stem density is therefore analysed during the visit of the Form international consultant. This should result in a total of 5% re-measured plots with an average stem density of planted teak that deviates <10% of the original data. These plots are used for analyses of DBH and Height. The difference in DBH and Height of planted teak trees should not exceed the limit of 10% between measured and re-measured data.

The data used for analyses are always the original data. Re-measured data will never be used in PSP report analyses, to prevent growth differences between the plots to interfere in data analyses."

Results from 2021 monitoring

For monitoring in 2021, the results of the quality control were as follows: in Akumadan 21 teak plots and 6 indigenous plots were measured for Quality Control. In Tain 43 teak plots and 3 indigenous plots were measured for Quality control. In Akumadan 48 teak plots and 4 indigenous plots were measured for Quality Control. In Tain 90 teak plots and 17 indigenous plots were measured for Quality Control. The Quality control measurements and analysis are focused on 3 parameters: (1) number of trees per plot, (2) tree diameter (DBH), and (3) total tree height.

No differences were found regarding the number of trees per plot for Teak in either Akumadan or Tain. No further investigation into the quality of the measurements of the number of trees per plot was conducted. No differences were found for the indigenous plots in the Akumadan area. Only one plot in Tain showed a difference of 1 for number of observed trees.

Differences in tree diameter and height are shown in Figure 6.

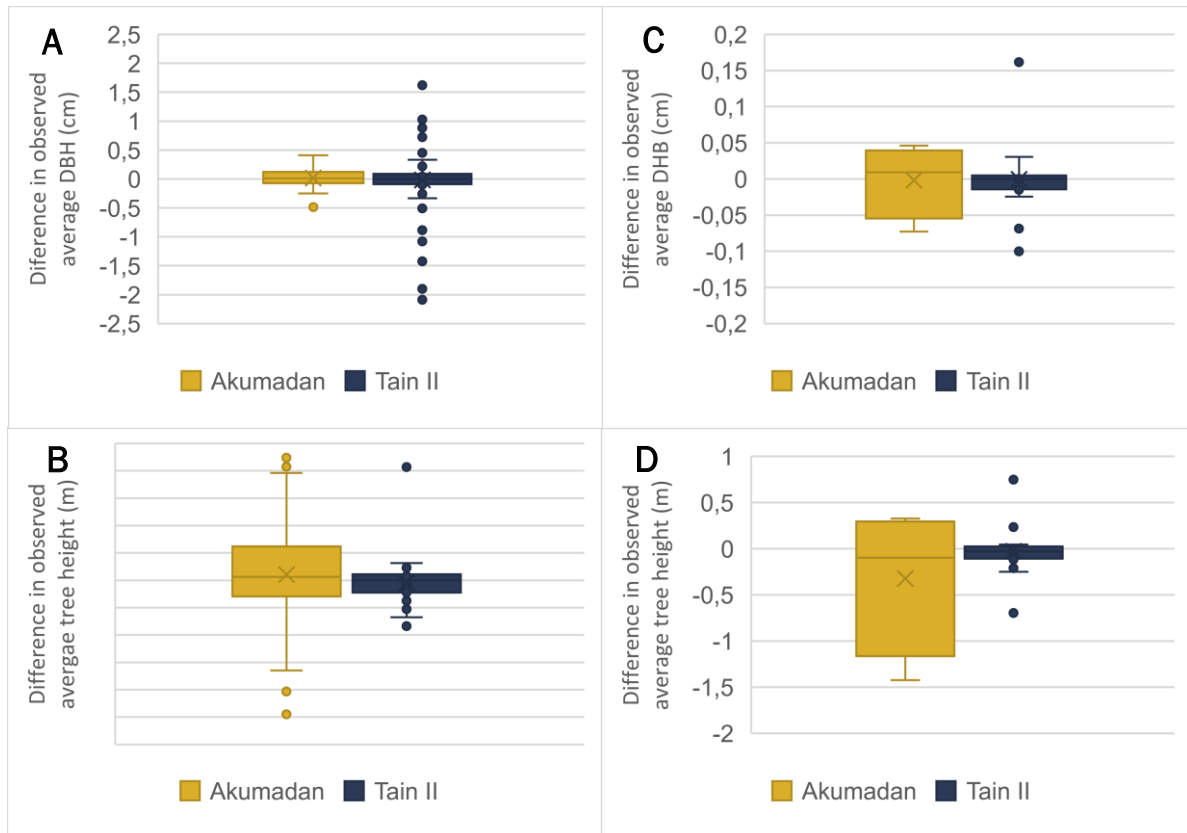


Figure 6: Differences between original measurements and quality control measurements for A) DBH in Teak, B) height in Teak, C) DBH in indigenous trees, D) height in indigenous trees.

For the 2021 monitoring data, the following conclusions and points of improvement were written up relating to the control of data entry errors, which will be implemented during the next monitoring period:

- For monitoring dates separate columns in the excel files should be used for year, month and day. This is to avoid messing up of data due to incorrect or different date formats.
- Data entry officers should check the data entry of their colleagues for a sample of PSPs. Plot numbers checked and any findings should be documented. Documented findings should be submitted together with submission of PSP data for analysis.
- With data entry attention must be paid to replicate data, as e.g. plot numbers or monitoring dates are copied down to other plots. There were a number of occasions that the data of some plots was entered twice in the database, resulting in duplicate data.
- For a number of plots data was missing. It is uncertain if the plots were not measured, if data was not captured, or if something else happened. A control mechanism is needed to ensure all existing plots in the measured area are actually measured and included in the analysis

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

Following the methodology carbon stock changes in dead wood and litter can be excluded for accounting of carbon stock changes. Shrub biomass is neglected as they are hardly present in the area. The baseline net GHG removals are therefore determined as:

$$\Delta C_{BSL,t} = \Delta C_{TREE_BSL,t} \quad (\text{Eq. 1 AR-ACM-003})$$

The C_{TREE_BSL} at start of the project activities was determined for two different baseline carbon stock levels, because two clearly distinct strata have been identified with the use of satellite imagery and vegetation sampling. These baseline carbon stock strata are:

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

As can be observed in Table 4 and 5, stratum 1 has much lower woody biomass levels than stratum 2, with more remaining native vegetation. The tables show the carbon pools of these two baseline carbon stock strata for the Tain II and Akumadan plantations.

Table 4 Baseline carbon stocks determined for the Tain II plantations

Baseline carbon stock stratum	Relevant biomass pool	Value (ton CO ₂ e ha ⁻¹)
$C_{TREE_BSL_1}$	Remnant Indigenous Trees (RIT)	20.46
	Remnant Teak (RT) & Invasive Trees (IT)	0.52
	Total	20.98
$C_{TREE_BSL_2}$	Mixed Degraded Forest (MDF)	49.81
	Total	70.80

Table 5 Baseline carbon stocks determined for the Akumadan plantations

Baseline carbon stock stratum	Relevant biomass pool	Value (ton CO ₂ e ha ⁻¹)
$C_{TREE_BSL_1}$	Remnant Indigenous Trees (RIT)	10.8
	Remnant Teak (RT) & Invasive Trees (IT)	6.8
	Total	17.6

$C_{TREE_{BSL_2}}$	<i>Mixed Degraded Forest (MDF)</i>	120.1
	<i>Invasive Trees (IT)</i>	3.2
	Total	123.3

Remnant Indigenous Trees (RIT), Remnant Teak (RT) and Invasive Trees (IT) ($C_{TREE_{BSL_1}}$)

As elaborated in the PDD, the change in carbon stock in Remnant Indigenous Trees is accounted as zero since the trees are protected and excluded from further estimation of project net GHG removals by sink.

The Remnant Teak (RT) and Invasive Trees (IT) are cleared with land preparation, although regularly Remnant Teak plantings are conserved and managed by PP and consequently these areas are excluded from the project.

To provide a solid estimation of the carbon stock in this pool, the number of trees felled for land preparation in the 2013 area were counted and summarized in Appendix I. (Knippers & Wanders, 2021) but the conservativeness of this figure is further verified by land clearing information in the subsequent planting years. This resulted in a weighed estimate of 0.41 ton CO_{2e} ha⁻¹, which clearly demonstrates that the applied figure of 0.52 ton CO_{2e} ha⁻¹ is sufficiently conservative to be applied in the Tain II Forest Reserve for this stratum.

The same methodology was used for the Akumadan plantations, where information on carbon stocks from RT and IT were based on felling data covering 1008 hectares from the 2008 area, as can be seen in Annex I.

Therefore, $\Delta C_{TREE_{BSL_t}} = 0$ and because of the exclusion of carbon stock changes in dead wood, litter and soil organic carbon, and shrubs hardly present in the area, $\Delta C_{BSL_t} = 0$.

Mixed Degraded Forest ($C_{TREE_{BSL_2}}$)

To determine the carbon stocks of the mixed degraded forest at the start of the project activity in baseline carbon stock stratum 2, 13 sample plots of 2500 m² were laid out in this stratum during the environmental study (Oduro & Danquah, 2012) as part of the Social and Environmental Impact Assessment (Tollenaar & Wanders, 2015). Tree height (H), tree diameter at breast height (DBH) and tree species were recorded, among other parameters. Using this data, a total above ground tree volume of all trees in the sample plots was calculated using the methods described in the Project Description Document (Knippers & Wanders, 2021). The total aboveground volume per hectare is derived from this number. The calculations and associated uncertainty are further elaborated in Appendix I.

A figure of 41.6 ton CO_{2e} ha⁻¹ was calculated for Tain II, but with the calculated uncertainty of 26% a discount of 75% was applied. This resulted in a final figure of 49.81 ton CO_{2e} ha⁻¹ for Mixed Degraded Forest in the Tain II plantations. For Akumadan, the final figure was 120.1 CO_{2e} ha⁻¹ for Mixed Degraded Forest after a deduction rate of 37% following CDM tool 14 (version 3.0.0).

As in the Tain II and Akumadan plantations no further clearing of invasive trees is done in the Mixed Degraded Forest, further change in carbon stock is determined in regular forest monitoring. This is however not part of the current verification period, and therefore not further elaborated in this monitoring report.

5.2 Project Emissions

Stratification

As the project expands gradually for all the different reforestation types, the project is further stratified by planting year as shown in Table 6. The project consists of three different reforestation types: teak (monoculture, 20-year rotation), Gmelina (monoculture, 12-year rotation) and mixed indigenous trees (restoration, no rotation). The long-term average shall be calculated following the AFOLU requirements 4.5.5 for areas where harvesting is applied (teak and Gmelina). Clear felling is only done in the teak and Gmelina plantation, not in the indigenous reforestation areas. In the indigenous areas silvicultural measures such as thinning and may take place. The Gmelina is not yet part of the VCU calculations. The Gmelina is, for now, only presented in the strata for completeness. In this monitoring report, the VCU's are only calculated for the teak and indigenous strata.

Table 6: Stratification

Forest Reserve	Abbreviation	Year	Teak (ha)	Indigenous (ha)	Buffer restoration (ha)	Gmelina (ha)
Asubima	ASU	2008	225			
Asubima	ASU	2009	511.7		0.5	
Asubima	ASU	2010	538.3	47.7	9.8	
Afrensu Brohuma	AFR	2011	845.6	181.5	3.9	
Afrensu Brohuma	AFR	2012	666.2	80.4		
Tain II	TAIN	2013	573.8	26.7	44.3	
Tain II	TAIN	2014	1,849.9	194.2	53.4	
Tain II	TAIN	2015	1,098.1	93.3	130.3	3.6
Tain II	TAIN	2016	87.6		33.1	
Tain II	TAIN	2017	567	82.6	44.7	
Tain II	TAIN	2018	1,597.5	306.5	25.2	5
Tain II	TAIN	2019	863.2	363.1	42	25
Tain II	TAIN	2020	272.7	377.4	2.2	28.7
Tain II	TAIN	2021	138.6	9.6	0.6	
Total			9,835.2	1763	390	62.3

The Teak and Gmelina Plantation (I and IV) and Indigenous Tree Plantation (II) strata for all planting years are submitted for verification and described in this monitoring report.

Actual net GHG removals by sinks

The project consists of three different reforestation types: teak (monoculture, 20-year rotation), Gmelina (monoculture, 12-year rotation) and mixed indigenous trees (restoration, no rotation). The long-term average shall be calculated following the AFOLU requirements 4.5.5 for areas where harvesting is applied (teak and Gmelina). Clear felling is only done in the teak and Gmelina plantation, not in the indigenous reforestation areas. 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 AR-ACM0003 version 02.0 is followed.

The estimated net GHG emission removals (t CO₂-e) per year are calculated as:

$$\Delta C_{AR-VCS,t} = \Delta C_{AR-VCS,t_TEAK} + \Delta C_{AR-VCS,t_IND} + \Delta C_{AR-VCS,t_BUFFER} + \Delta C_{AR-VCS,t_GMELINA}$$

In the following sections, the actual net carbon emissions and removals per hectare are elaborated per carbon pool and per reforestation type.

Reforestation type I: Teak Plantation

As elaborated in the PDD $GHG_{E,t} = 0$, which means that $\Delta C_{ACTUAL,t} = \Delta C_{P,t}$. Since shrubs, litter and dead wood are conservatively excluded, $\Delta C_{P,t} = \Delta C_{TREE_PROJ,t} + \Delta SOC_{AL,t}$.

Estimating change in carbon stock in tree biomass ($\Delta C_{TREE_PROJ,t}$)

The change in tree biomass is calculated by estimating the biomass in each plant 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. *The change in tree biomass is estimated using the following equation:*

$$\Delta C_{TREE_PROJ} = C_{TREE,t_2} - C_{TREE,t_1} \quad (Eq. 1 AR-TOOL14)$$

The tree biomass in the first year is the same as the baseline biomass in trees (remnant indigenous trees, remnant teak and invasive trees) at the start of the project activity ($C_{TREE_BSL_1}$). The tree biomass cleared (remnant Teak, York and Cassia) during land preparation ($C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}$), is deducted from the baseline carbon stock and the increment of the planted teak trees (C_{TREE_TEAK}) added.

$$C_{TREE} = C_{TREE_BSL_1} - C_{TREE_BSL_1,2} - C_{TREE_BSL_1,3} + C_{TREE_TEAK}$$

Methods for determining $C_{TREE_BSL_1}$ have been discussed in the PDD. The remnant indigenous trees are a constant figure where change in carbon stock is conservatively estimated to be zero. As discussed in the baseline, the amount of carbon in this pool is expected to decrease due to anthropogenic factors. The remnant 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.

For the already verified teak strata during the previous verification in 2018, C_{TREE} is used as established in the previous monitoring report for these strata.

For the new teak strata in Tain II no verification has been done before, and therefore the tree biomass which is cleared during land preparation is deducted from the baseline carbon stock. As for the Remnant Indigenous Trees (RIT) change in carbon stock is conservatively assumed to be zero, the baseline carbon stock ($C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}$) that is removed during land clearing is accounted as C_{TREE,t_1} . Therefore, for the new teak strata in Tain II the following applies:

$$\Delta C_{TREE_PROJ} = C_{TREE,t_2} - (C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}) \quad (Eq. 1 AR-TOOL14)$$

This calculation assumes that no GHG emission reductions have been realized through teak trees from the planting date till the start of this verification period. This is justified as the carbon stock in teak was far below the carbon stock that has been removed with land clearing, and it can only be determined that the baseline carbon stock is exceeded after 3 years. Before the 3 years there is usually no volume that can be measured because of the size of the trees. Therefore, monitoring usually only starts 3 years after planting as elaborated in PP's protocol 13 'Monitoring' when the trees have a size where a DBH can be measured. Therefore, the planting years 2019 – 2021 have not been measured yet.

For the 2013 and 2014 area the first measurement was further delayed as these trees faced a stronger backlog in growth. In 2016 these areas faced a significant fire (*Amoako & Wanders, 2016*). Based on field observations it was expected that this caused a backlog in growth of 1 to 2 years, and a significant area had to be replanted. Consequently, regular and sufficiently homogeneous PSP measurements could only be expected at an age of 4 – 5 years. This observation was further strengthened as growth was delayed in these areas due to inadequate plantation maintenance due to the financial challenges at that time. The first PSP measurements that were carried out recently indeed show a backlog in growth in terms of diameters (*Polinder, 2018*), although height growth has caught up with the rest of the plantations. As before the 3 years there is no volume that can be measured because of the size of the trees, it is considered to be appropriate to apply the following for the teak strata in the Tain II plantations.

$$C_{TREE,t_1} = C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}$$

Table contains the total value of C_{TREE,t_1} for the different teak strata.

The total tree biomass in teak at C_{TREE,t_2} is estimated based on field measurements in Permanent Sample Plots as elaborated in the monitoring plan.

The tree volume is calculated as:

$$V_{TREE,teak} = \pi \times \frac{DBH^2}{2} \times H \times f_{TEAK}$$

According to the methodological tool the amount of tree biomass is estimation using the following equations:

$$B_{TREE,l,teak,p,i} = V_{TREE,teak} \times D_{TEAK} \times BEF_{TEAK} \quad (Eq. 5 AR-TOOL14 – Appendix 1)$$

The total tree biomass in a sample plot is calculated by summing the biomass of all individual trees measured in each sample plot. The teak biomass equals the total tree biomass in the sample plot, since other tree species are not taken into consideration. The area of a sample plot is close to 800 m² in Akumadan, as the plot radius is 15.96m. In the Tain II plantations the plot size is 729 m². Tree biomass per hectare in the sample plots is calculated by dividing the total tree biomass in the sample plot by the size of the plot.

Based on the mean biomass of the plots per stratum, as well as the associated variance, the mean carbon stock in teak (C_{TREE}) within the teak biomass estimation strata and the associated uncertainty (u_c) are estimated following the methodology as described in the PDD. The results are shown in Table 7, where the uncertainty in t_1 is obtained from the previous monitoring report (Polinder et al., 2019).

Table 7 Mean tree biomass and associated uncertainty in teak strata

Parameter	Unit	t ₁	t ₂	Δt
C_{tree}	t CO ₂ e	337,320.0	692,986.5	356,166.5
u_c	-	2.3%	1.7%	3.9%

Since the uncertainty in C_{TREE} less than 10%, there is no need to make C_{TREE} conservative by applying an uncertainty discount. The summary of change in tree biomass in the teak strata is shown in Table 8.

Table 8 Change in tree biomass in teak strata

Plantations	Abbreviation	Plant year	$C_{TREE,t1}$	$C_{TREE,t2}$	ΔC_{TREE}
Akumadan	ASU	2008	13,162.1	24,651.7	11,789.6
Akumadan	ASU	2009	46,738.2	55,739.8	9,001.6
Akumadan	ASU	2010	56,224.6	57,830.2	1,605.6
Akumadan	AFR	2011	70,708.5	95,704.4	24,995.8
Akumadan	AFR	2012	39,858.1	60,512.9	20,654.9
Tain II	TAIN	2013	27,698.8	74,441.9	46,743.1
Tain II	TAIN	2014	62,898.7	196,856.5	133,957.8
Tain II	TAIN	2015	19,246.0	79,008.5	59,762.5
Tain II	TAIN	2016	785.6	4,661.0	3,875.4
Tain II	TAIN	2017	297.1	19,161.5	18,864.5

Tain II	TAIN	2018	837.0	24,118.1	23,281.1
Total			338,454.5	692,986.5	354,532.0

Change in Soil Organic Carbon (ΔSOC)

The change in Soil Organic Carbon is estimated using the “Tool for estimation of change in soil organic carbon stock due to the implementation of A/R CDM project activities” (version 01.1.0).

The implementation of this tool is elaborated in the PDD. The result of this tool is a fixed estimate of the change in soil organic carbon stock per year per hectare over a period of twenty years.

The results are summarized in Table 7. $\Delta SOC_{AL,t}$ represents the fixed amount of annual carbon storage. The calculation can be found in the guiding excel document. Multiplying the number of years and hectares with the $\Delta SOC_{AL,t}$ results in the amount soil organic carbon change within the teak strata.

Table 9 Change in Soil Organic Carbon in teak plantations

Forest Reserve	Abbreviation	Year	Δ Years	A (ha)	ΔSOC
Asubima	ASU	2008	2	225.0	1,143.0
Asubima	ASU	2009	2	511.7	2,599.2
Asubima	ASU	2010	2	538.3	2,734.7
Afrensu Brohuma	AFR	2011	2	845.6	4,295.4
Afrensu Brohuma	AFR	2012	2	666.2	3,384.2
Tain II	TAIN	2013	2	573.8	2,914.7
Tain II	TAIN	2014	2	1,849.9	9,397.3
Tain II	TAIN	2015	2	1,098.1	5,578.4
Tain II	TAIN	2016	2	87.6	445.1
Tain II	TAIN	2017	2	567.0	2,880.2
Tain II	TAIN	2018	2	1,597.5	8,115.1
Tain II	TAIN	2019	2	863.2	4,384.8
Total				9,423.9	47,872.2

Sum of changes in selected carbon pools ($\Delta C_{p,t}$)

The total change in selected carbon pools in the teak strata is the change in tree biomass and soil organic carbon. Total $\Delta C_{p,t}$ is therefore:

$$354,532 (\Delta C_{TREE}) + 47,872 (\Delta SOC) = 402,404 \text{ ton CO}_2\text{e} (\Delta C_{p,t})$$

Since $GHG_{E,t} = 0$, $\Delta C_{ACTUAL,t} = \Delta C_{P,t}$.

Reforestation type II: Indigenous Plantation

As elaborated in the PDD $GHG_{E,t} = 0$, which means that $\Delta C_{ACTUAL,t} = \Delta C_{P,t}$. Since shrubs, litter and dead wood are conservatively excluded, $\Delta C_{P,t} = \Delta C_{TREE_PROJ,t} + \Delta SOC_{AL,t}$.

Estimating change in carbon stock in tree biomass ($\Delta C_{TREE_PROJ,t}$)

The change in tree biomass is calculated by estimating the biomass in each plant 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. The change in tree biomass is estimated using the following equation:

$$\Delta C_{TREE_PROJ} = C_{TREE,t_2} - C_{TREE,t_1} \quad (\text{Eq. 1 AR-TOOL14})$$

The tree biomass in the first year is the same as the baseline biomass in trees (remnant indigenous trees, remnant teak and invasive trees) at the start of the project activity ($C_{TREE_BSL_1}$). The tree biomass cleared (remnant teak and invasive trees) during land preparation ($C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}$), is deducted from the baseline carbon stock and the increment of the planted indigenous trees (C_{TREE_IND}) added.

$$C_{TREE} = C_{TREE_BSL_1} - C_{TREE_BSL_1,2} - C_{TREE_BSL_1,3} + C_{TREE_IND}$$

Methods for determining $C_{TREE_BSL_1}$ have been discussed in the PDD. The remnant indigenous trees are a constant figure. 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. There is no intention for harvesting after the crediting period. Silvicultural interventions such as thinning and pruning may take place.

$$C_{TREE,t_1} = C_{TREE_BSL_1,2} + C_{TREE_BSL_1,3}$$

Table 9 contains shows the total value of C_{TREE,t_1} for the different indigenous strata.

The total tree biomass in indigenous trees at C_{TREE,t_2} is estimated based on field measurements in Permanent Sample Plots as elaborated in the monitoring plan.

The tree volume is calculated according to Aabeyir et al. (2020) as:

$$V_{TREE,ind} = (a_{i,IND} * ((DBH)^2 H)^{bi,IND}) / 1000$$

According to the methodological tool the amount of tree biomass is estimation using the following equations:

$$B_{TREE_IND} = f_{IND} \times R_{mix} \quad (\text{Eq. 4 AR-TOOL14 – Appendix 1})$$

The total tree biomass in a sample plot is calculated by summing the biomass of all individual trees measured in each sample plot. Tree biomass per hectare in the sample plots is calculated by dividing the total tree biomass in the sample plot by the size of the plot.

Based on the mean biomass of the plots per stratum, as well as the associated variance, the mean carbon stock in indigenous plantations (C_{TREE}) within the indigenous biomass estimation strata and the associated uncertainty (u_C) are estimated following the methodology as described in the PDD.

The summary of change in tree biomass in the indigenous strata is shown in Table 10.

Table 10 Change in tree biomass in indigenous strata

Plantations	Plant year	$C_{TREE,t1}$	$C_{TREE,t2}$	ΔC_{TREE}
Akumadan	2010	1,708.9	5,304.9	3,595.9
Akumadan	2011	2,086.6	23,005.6	20,919.0
Akumadan	2012	400.6	1,352.4	951.8
Tain II	2013	431.2	1,948.3	1,517.1
Tain II	2014	1,819.4	9,356.5	7,537.1
Tain II	2015	166.1	4,244.1	4,078.0
Tain II	2017	43.3	3,675.3	3,632.1
Tain II	2018	160.6	14,553.0	14,392.4
Total		6,816.7	63,440.1	56,623.4

Since the uncertainty in C_{TREE} is 17.8%, C_{TREE} is made conservative according to the methodological tool by applying an uncertainty discount of 50%. After application of the discount ΔC_{TREE} becomes 50,978 ton CO_{2e}.

Change in Soil Organic Carbon (ΔSOC)

The change in Soil Organic Carbon is estimated using the “Tool for estimation of change in soil organic carbon stock due to the implementation of A/R CDM project activities” (version 01.1.0).

The implementation of this tool is elaborated in the PDD. The result of this tool is a fixed estimate of the change in soil organic carbon stock per year per hectare over a period of twenty years.

The results are summarized in Table 11. $\Delta SOC_{AL,t}$ represents the fixed amount of annual carbon storage. The calculation can be found in the guiding excel document. Multiplying the number of years and hectares with the $\Delta SOC_{AL,t}$ results in the amount soil organic carbon change within the teak strata.

Table 11 Change in Soil Organic Carbon in indigenous plantations

Forest Reserve	Plant year	$\Delta Years$	A (ha)	ΔSOC
Asubima	2010	2	47.7	242.2
Afrensu Brohuma	2011	2	181.5	921.9
Afrensu Brohuma	2012	2	80.4	408.5

Tain II	2013	2	27.7	135.8
Tain II	2014	2	194.2	986.5
Tain II	2015	2	93.3	473.7
Tain II	2017	2	82.6	419.4
Tain II	2018	2	306.5	1,557.0
Tain II	2019	2	363.1	1,844.3
Total			1,375.9	6,989.3

Sum of changes in selected carbon pools ($\Delta C_{P,t}$)

The total change in selected carbon pools in the indigenous strata is the change in tree biomass and soil organic carbon. Total $\Delta C_{P,t}$ is therefore:

$$50,978 (\Delta C_{TREE}) + 6,989 (\Delta SOC) = 57,967 \text{ ton CO}_2\text{e} (\Delta C_{P,t}).$$

$$\text{Since } GHG_{E,t} = 0, \Delta C_{ACTUAL,t} = \Delta C_{P,t}.$$

5.3 Leakage

Under the applicability of AR-ACM0003 the only relevant type of leakage is due to displacement of agricultural activities.

$$LK_t = LK_{AGRIC,t} \quad (\text{Eq. 4 AR-ACM0003})$$

As demonstrated in the PDD leakage is deemed de minimis, and therefore set to zero.

5.4 Net GHG Emission Reductions and Removals

GHG credits can now be calculated using the following equation:

$$\Delta C_{AR-VCS,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t \quad (\text{Eq. 5 AR-ACM0003})$$

Since $\Delta C_{BSL,t} = 0$ (paragraph 4.1) and $LK_t = 0$ (paragraph 4.3), $\Delta C_{AR-VCS,t} = \Delta C_{ACTUAL,t}$. $\Delta C_{ACTUAL,t}$ has been established in paragraph 4.2.2. Since $\Delta C_{AR-VCS,t} = \Delta C_{AR-VCS,t,TEAK} + \Delta C_{AR-VCS,t,IND} + \Delta C_{AR-VCS,t,BUFFER} + \Delta C_{AR-VCS,t,GMELINA}$, and because GHG emission removals in the buffer vegetation is not included in this monitoring report, $\Delta C_{AR-VCS,t} = \Delta C_{AR-VCS,t,TEAK} + \Delta C_{AR-VCS,t,IND}$.

Therefore, $\Delta C_{AR-VCS,t} = 402,404 + 57,967 = 460,371 \text{ t CO}_2\text{e}$ which is the number of generated GHG credits.

As established in the non-permanence risk report (Knippers & Wanders, 2021), the risk rating is 10%. This means that 46,037.1 GHG credits need to be deposited into the AFOLU pooled buffer account. Therefore, a total number of 414,333.9 GHG credits are eligible to be issued as VCUs for the current monitoring period.

Long-term average

The analysis of the monitoring data results in a calculation of the available VCU eligible for issuance. The same data are also used to calculate the long term average which is a ceiling

for VCU that can be issued. The LTA is calculated based a.o. on plantation growth and rotation length. Details are provided in Appendix 1 in sheet EP overview. In the table below, the LTA per planting year and the amount of VCU already issued relative to the LTA are presented. The 2008 area is approaching 100% and will not provide credits in the years to come. The total long-term average is currently 1,308,765.5 VCU's.

Table 12 Summary of Long-term averages and progress of issuance of VCU's

Plant year	Δ C AR_CDM total (VCU)	LTA ha-1 (VCU)	LTA total (VCU)	% of LTA
2008	27,997.7	125.3	28,194.8	99%
2009	64,420.3	130.6	66,819.1	96%
2010	64,578.4	139.7	75,205.6	86%
2011	105,242.9	144.3	121,991.7	86%
2012	67,810.2	156.6	104,316.1	65%
2013	75,688.4	152.0	87,203.6	87%
2014	202,009.6	165.6	306,260.6	66%
2015	81,696.4	156.7	172,103.1	47%
2016	4,424.8	178.1	15,610.5	28%
2017	18,931.5	170.4	96,595.0	20%
2018	24,378.6	146.8	234,465.4	10%
	737,178.8	151.5	1,308,765.5	56%

Table 13 presents a summary of the results of this monitoring report, which are divided between the three years (partly) covered by the monitoring period: 2019, 2020 and 2021. Monitoring is a process that takes several months per year and is not in sync with the precise start and end dates of monitoring periods. Consequently, carbon emissions/removals are calculated for the total monitoring period. The project emissions and removals per year have been calculated by dividing the total carbon benefits between the three years according to the number of months that they represented in the monitoring period. The monitoring period includes six months (July-December) in 2019, twelve months in 2020 and seven months in 2021 (January-July), totaling 25 months in the 2019-2021 monitoring period. As such, 6/25 of the total credits was awarded to 2019, 12/25 to 2020 and 7/25 to 2021.

Table 13 Summary of key results from the 2019-2021 monitoring period.

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)	Buffer pool allocation	VCUs eligible for issuance
2019 (July 1 st – December 31 st)	0	110,609.0	0	110,609.0	11,060.9	99,548.1
2020 (January 1 st – December 31 st)	0	221,218.1	0	221,218.1	22,121.8	199,096.3
2021 (January 1 st – July 31 st)	0	128,543.9	0	128,543.9	12,904.4	115,639.5
Total	0	460,371.0	0	460,371.0	46,037.1	414,333.9

APPENDIX I: CALCULATIONS

The calculations are attached to this report in a separate excel file.

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