



**Forest Carbon Partnership Facility (FCPF)
Carbon Fund**

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Ghana Cocoa Forest REDD+ Programme (GCFRP), Ghana
Reporting Period covered in this report:	01-01-2020 to 31-12-2021
Number of FCPF ERs:	3,517,888
Quantity of ERs allocated to the Uncertainty Buffer:	551,392
Quantity of ERs allocated to the Reversal Buffer:	323,484
Quantity of ERs allocated to the Reversal Pooled Reversal buffer:	202,177
Date of Submission:	16-12-2022
Version	2.4

WORLD BANK DISCLAIMER

The boundaries, colors, denominations, and other information shown on any map in ER-MR does not imply on the part of the World Bank any legal judgment on the legal status of the territory or the endorsement or acceptance of such boundaries.

The Facility Management Team and the REDD Country Participant shall make this document publicly available, in accordance with the World Bank Access to Information Policy and the FCPF Disclosure Guidance.

Table of Contents

1	IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD	1
1.1	Implementation status of the ER Program and changes compared to the ER-PD	1
1.2	Update on major drivers and lessons learned	11
2	SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD	13
2.1	Forest Monitoring System.....	13
2.2	Measurement, monitoring and reporting approach	20
3.	DATA AND PARAMETERS	35
3.1	Fixed Data and Parameters.....	35
3.2	Monitored Data and Parameters	44
4	QUANTIFICATION OF EMISSION REDUCTIONS	52
4.1	ER Program Reference level for the Monitoring / Reporting Period covered in this report	52
4.2	Estimation of emissions by sources and removals by sinks included in the ER Program's scope	52
4.3	Calculation of emission reductions	53
5	UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS.....	53
5.1	Identification, assessment and addressing sources of uncertainty	53
5.2	Uncertainty of the estimate of Emission Reductions	64
5.3	Sensitivity analysis and identification of areas of improvement of MRV system.....	76
6	TRANSFER OF TITLE TO ERs	78
6.1	Ability to transfer title.....	78
6.2	Implementation and operation of Program and Projects Data Management System.....	78
6.3	Implementation and operation of ER transaction registry	78
6.4	ERs transferred to other entities or other schemes	78
7	REVERSALS	79
7.1	Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)	79
7.2	Quantification of Reversals during the Reporting Period	79
7.3	Reversal risk assessment.....	79
8	EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND	85
	ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS.....	87
	ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN.....	87
	ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS	87

LIST OF TABLES

TABLE 1: SUMMARY OF UPDATE OF WORK IN THE SIX HIAs AS OF 2022.....	3
TABLE 2: UPDATES ON DISPLACEMENT RISKS ASSOCIATED WITH DIFFERENT DRIVERS OF DEFORESTATION.	7
TABLE 3: INSTITUTIONS INVOLVED IN GHANA’S FOREST MONITORING SYSTEM	15
TABLE 4: THE FOLLOWING GHG RELATED DATA AND INFORMATION IS SELECTED.....	16
TABLE 5: STOCK CHANGE FACTORS FOR CHANGE IN ORGANIC CARBON IN MINERAL SOILS	30
TABLE 6: SAMPLE PLOT SIZE AND DISTRIBUTION IN GCFRP	45
TABLE 7: SOURCES OF UNCERTAINTY TO BE CONSIDERED UNDER THE FCPF METHODOLOGICAL FRAMEWORK	55
TABLE 8: PARAMETERS IN MONTE CARLO.....	64
TABLE 9: QUANTIFICATION OF UNCERTAINTY OF THE ESTIMATE OF ERS.....	76
TABLE 10: REVERSAL RISK ASSESSMENT	79

LIST OF FIGURES

FIGURE 1: MAP OF THE GCFRP WITH TARGET HIA	2
FIGURE 2: OVERALL INSTITUTIONAL FRAMEWORK FOR FMS	15
FIGURE 3: ORGANIZATIONAL STRUCTURE FOR REFERENCE LEVEL DEVELOPMENT	18
FIGURE 4: ORGANIZATIONAL STRUCTURE FOR ACTIVITY DATA FOR ANNUAL REFERENCE LEVEL (2020/2021)	19
FIGURE 5: OVERVIEW OF DIFFERENT STEPS.....	20
FIGURE 6: AD DATA COLLECTION & ANALYSIS	22
FIGURE 7: GCFRP EMISSIONS FACTORS FOR DEFORESTATION AND FOREST DEGRADATION.....	23
FIGURE 8: GHANA GCFRP REFERENCE LEVEL.....	24
FIGURE 9: GHANA GCFRP EMISSIONS REDUCTIONS.....	25

LIST OF ACRONYMS

ACRONYM	MEANING
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Uses
AGC	Above Ground Carbon
ASM	Artisanal Small-scale Mining
BGC	Below Ground Carbon
BUR	Biennial Update Report
CEA	Community Extension Agents
CFI	Cocoa and Forest Initiative
CIFOR	Centre for International Forestry Research
COCOBOD	Ghana Cocoa Board
CREMA	Community Resource Management Support Area
CSC	Climate Smart Cocoa
DBH	Diameter at Breast Height
DW	Dead Wood
EF	Emission Factor
EPA	Environmental Protection Agency
ER	Emission Reduction
ER-PD	Emission Reduction Program Document
ESMF	Environmental and Social Management Framework
EU	European Union
FAO	Food and Agricultural Organisation of the United Nations
FC	Forestry Commission
FCPF	Forest Carbon Partnership Facility
FPP	Forest Preservation Programme
FREL	Forest Reference Emissions Level
FSD	Forest Services Division
GCFRP	Ghana Cocoa Forest REDD+ Program
GFOI	Global Forest Observation Initiative
GHG	Greenhouse gas
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HIA	Hotspot Intervention Area
HMB	HIA Management Board
ICT	Information Communication Technology
IPCC	Intergovernmental Panel on Climate Change
L	Litter
LIDAR	Light Detection and Ranging
LMB	Landscape Management Board
MC	Monte Carlo
MMR	Measuring, Monitoring and Reporting
MRV	Measurement, Reporting and Verification
MTS	Modified Taungya System

NCRC	Nature Conservation Research Centre
NDC	Nationally Determined Contributions
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NFPDP	National Forest Plantation Development Programme
NRS	National REDD+ Secretariat
NW	North West
PMU	Project Management Unit
QA/QC	Quality Assurance/Quality Control
RDA	REDD+ Dedicated Account
REDD+	Reducing Emissions from Deforestation and Forest Degradation plus the role of conservation, sustainable management and enhancement of forest carbon stocks
RMSC	Resource Management Support Centre
RPF	Resettlement and Policy Framework
SE	South East
SESA	Strategic Environmental and Social Assessment
SLMS	Satellite and Land Monitoring System
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
tCO ₂ -e/yr	Tons of Carbon Dioxide equivalent per year
UNDP	United Nations Development Programme
USD	United States Dollar
WD	Wildlife Division

1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

The Ghana Cocoa Forest REDD+ Programme (GCFRP) is the first program to be developed under REDD+ in Ghana. It is jointly coordinated by the Climate Change Directorate of the Forestry Commission which houses the National REDD+ Secretariat (NRS) of the Forestry Commission (FC), and Ghana Cocoa Board (Cocobod). The FC is responsible for the regulation of the utilization of forest and wildlife resources, the conservation and management of those resources, and the coordination of policies related to them, while the Cocobod's mission is to regulate the production, processing, and marketing of good quality cocoa.

The GCFRP is centered on the development of a sustainable commodity supply chain that hinges upon the non-carbon benefits that will be channeled to farmers as a result of significant private sector investments into the landscape and the supply chain.

The projected ER benefits from a potential carbon payments of \$50 million (against performance over time), coupled with the cocoa industry's annual \$2 billion dollar investment into the sector, can together drive this transition to a more sustainable cocoa production landscape, while providing added incentives to farmers, traditional leaders, and communities that support landscape governance and management activities that reduce deforestation and support the adoption of climate-smart practices.

The program area covers 5.92 million ha and is located in the southern third of the country (Fig. 1). Given the size of the programme, the GCFRP has been designed to adapt the well-established Community Resource Management Area (CREMA) model for the purpose of landscape governance of cocoa farming areas. The adapted model is called a Hotspot Intervention Area (HIA) and envisages a multi-tiered, governance structure for the people in the landscape, including the cocoa farmers, communities, landowners and traditional leaders that live within and preside over the HIA landscape. Further, the HIA institution represented by the HIA Management Board is expected to work in collaboration with a Consortium body of private sector, government and civil society stakeholders who work together to support the implementation of activities towards a common landscape vision, including climate-smart cocoa and reducing deforestation. Carbon accounting will happen at the program scale, but GCFRP implementation will target at least six Hotspot Intervention Areas (HIAs) (Fig. 1) spread across the entire landscape. The establishment of the HIA areas is further supported by land scape scale initiatives such as the Cocoa and Forests Initiative¹ which has adopted the HIAs as the implementation areas. In 2020, as part of the Emission Reductions payment Agreement, Ghana received an Upfront Advance Payment of USD1.3 million dollars.

¹¹ [chrome-extension://efaidnbmnnnibpcjpcglclefindmkaj/https://cfighana.mlnr.gov.gh/wp-content/uploads/2021/05/CFI-2020-ANNUAL-PROGRESS-REPORT.pdf](https://efaidnbmnnnibpcjpcglclefindmkaj/https://cfighana.mlnr.gov.gh/wp-content/uploads/2021/05/CFI-2020-ANNUAL-PROGRESS-REPORT.pdf); [chrome-extension://efaidnbmnnnibpcjpcglclefindmkaj/https://www.idhsustainabletrade.com/uploaded/2022/07/Cocoa-Forests-Initiative-Ghana-2021-Annual-Report.pdf?x56932](https://efaidnbmnnnibpcjpcglclefindmkaj/https://www.idhsustainabletrade.com/uploaded/2022/07/Cocoa-Forests-Initiative-Ghana-2021-Annual-Report.pdf?x56932)

Detailed progress updates on the UAP and other related activities within the various HIA can be found in the link below:

<https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf>

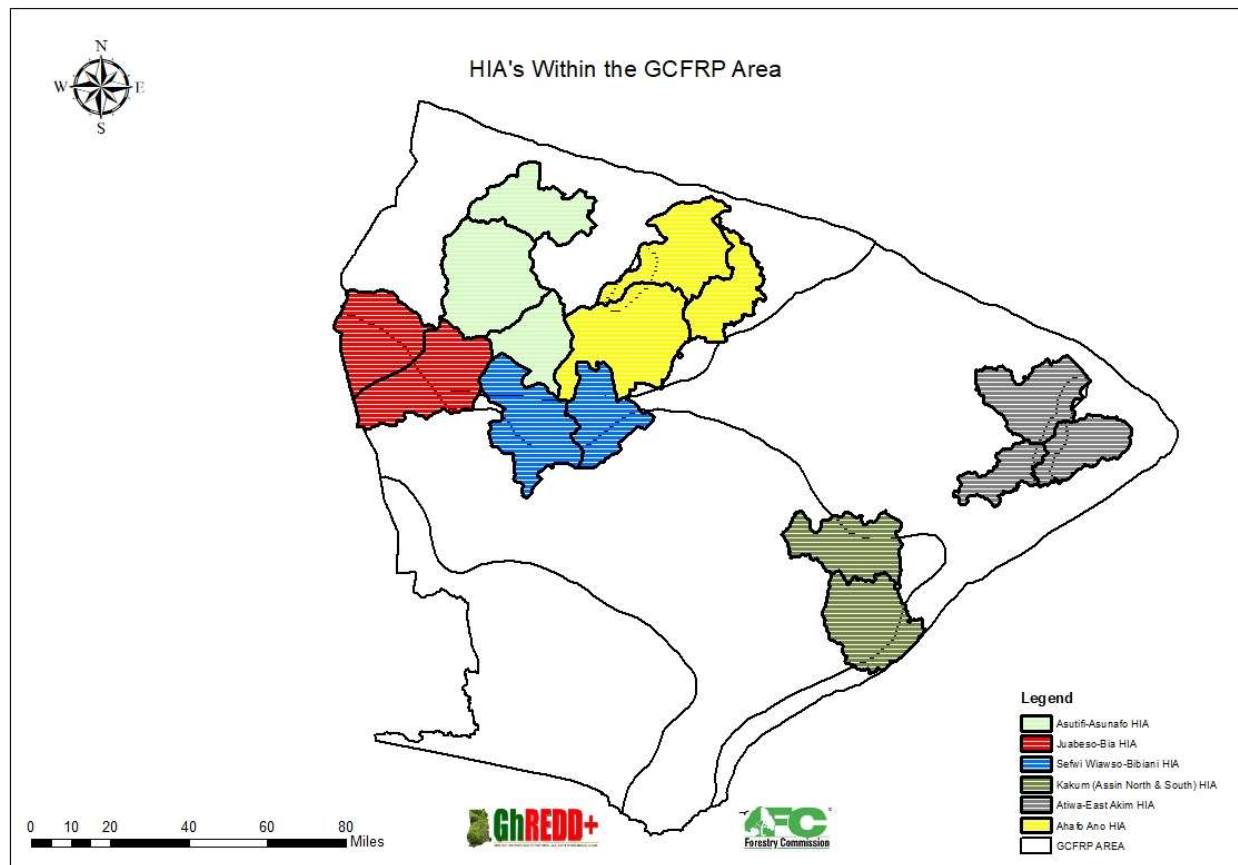


Figure 1: Map of the GCFRP with target HIA

The update of works in the six HIAs are however summarized in Table 1 below.

Table 1: Summary of update of work in the six HIAs as of 2022

Name	Area (ha)	Partners	Status	Main Activities
Juabeso/Bia	243,560	<p>SNV Ghana, Touton, Agro-Eco Louis Bolk Institute, Touton SA, Tropenbos Ghana, Nature Conservati on Research Center (NCRC), Solidaridad West Africa</p>	<p>The governanc e Structures in this HIA are fully developed. A framework Agreement amongst Forestry Commissio n, Ghana Cocobod and the Hotspot Managemen t Board has been signed. Some Partners have signed an addendum to support the signed Framework Agreement .</p> <p>The HIA account has been opened for the receipt of future Carbon Payments</p>	<p>Under the Upfront Advance Payment, 67,771 tree seedlings were used to establish 61 ha of forest plantation using the Modified Taungya System (MTS) approach. 63 farmers established the plantation with 20 of them being females. Also, 80,000 seedlings were supplied to farmers under the Trees on farms component. The average survival rate for the seedlings supplied is 65.5% The tree species supplied were indigenous species which included Ofram, Mahogany, Emire. The purpose is to serve as shade trees within the cocoa farms. This is a CSC intervention to incorporate shade trees in cocoa farms to ensure sustainability and carbon stock enhancement within the cocoa forest landscape.</p> <p>Additional livelihood options have been provided for 30 beneficiaries in the HIA.</p> <p>(kindly refer to the pgs 3-6 of the report below for details on communities and gender disaggregation, same applies to the other HIAs)</p> <p>Link to report: https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf</p>

Name	Area (ha)	Partners	Status	Main Activities
Kakum	212,863	NCRC, Hershey,	<p>The Hotspot Management Board has been set up</p> <p>The HIA account has been set up</p>	<p>Under the Upfront Advance Payment, 51,000 tree seedlings were used to establish 40 ha of forest plantation using the Modified Taungya System (MTS) approach. 63 farmers established the plantation, with 10 of them being females.</p> <p>Also, 70,000 seedlings were supplied to farmers under the Trees of farms component. The average survival of trees planted is estimated to be 70.5%</p> <p>Additional livelihood options have been provided for 22 beneficiaries in the HIA.</p> <p>(kindly refer to the pgs 3-6 of the report below for details on communities and gender disaggregation, same applies to the other HIAs)</p> <p>Link to report: https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf</p>
Ahafo-Ano	365,673	Olam Ghana	<p>HMB set-up completed.</p> <p>HIA account for the receipt of Carbon Payments set up</p>	<p>Under the Upfront Advance Payment, 20,000 tree seedlings were used to enrich 2 compartments in the Tinte Bepo Forest Reserve.</p> <p>Also, 25,000 seedlings were supplied to farmers under the Trees on farm component.</p> <p>The average survival is estimated to be 72%</p>
Asutifi/Asunafo	328,512	Mondelez Cocoa life (Ghana), UNDP, Proforest Ghana	<p>HMB has been set up.</p> <p>A framework Agreement has been</p>	<p>Under the Upfront Advance Payment, 30,000 tree seedlings were used to enrich 2 compartments in the Goa Shelter Forest Reserve.</p> <p>Also, 120,000 seedlings were supplied to farmers under the Trees of farms component28 beneficiaries have</p>

Name	Area (ha)	Partners	Status	Main Activities
			signed with the HMB. HIA account has been set up.	benefited from provision of additional livelihoods schemes . The average survival rate of the seedlings is estimated as 78%. Training of stakeholders on REDD+ safeguards instruments (ESMF, SESA). Mondelez Cocoa Life restored 100 ha of degraded forest plantation using the MTS approach
Sefwi Wiawso/Bibi ani	209,495	Olam Ghana, Rain Forest Alliance, Landscape Management Board (LMB)	HMB has been set up. Framework Agreement signed with HMB. HIA account for the receipt of Carbon Payments set up	Under the Upfront Advance Payment, 23,000 tree seedlings were used to enrich 2 compartments in the Sui River Forest Reserve. Also, 20,000 seedlings were supplied to farmers under the Trees. The average survival of the seedlings is estimated as 70.5% Training of stakeholders on REDD+ safeguards instruments (ESMF, SESA). Provision of additional livelihood schemes for 23 beneficiaries (kindly refer to the pgs 3-6 of the report below for details on communities and gender disaggregation, same applies to the other HIAs) Link to report: https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf
Atewa	216,964	Proposed Partners are Arocha Ghana, CIFOR (as part of their on-going research on	Continuous engagements with key stakeholders to collectively develop the governance	Additional Livelihoods options is being provided for farmers to serve as entry points for the eventual set up of governance structures.

Name	Area (ha)	Partners	Status	Main Activities
		governance structures for small-holders in Cocoa and Oil palm).	existing structures for the HIA	(kindly refer to the pgs 3-6 of the report below for details on communities and gender disaggregation, same applies to the other HIAs) Link to report: https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf

Additional details for activities within the HIAs can be found here: <https://www.reddsis.fcghana.org/admin/controller/publications/MAY%20-%202023%20-%20PROGRESS%20UPDATE%20ON%20GCFRP%20IMPLEMENTATION.pdf>.

Furthermore, the links below give further details on restoration activities by the Government of Ghana within the regions where the HIAs is found here; (<https://fcghana.org/?p=3362>, <https://fcghana.org/?p=3501>)

On June 11, 2019, Ghana signed Emission Reductions Payment Agreements (ERPAs) (Tranches A and B) with the World Bank as a Trustee for the Carbon Fund. On April 14 2020, the World Bank declared all conditions of effectiveness to the ERPAs to have been fulfilled. Subsequently, an amount of 1.3 million USD as Upfront Advance Payment as negotiated under the ERPAs was released on September 3, 2020 to support Program implementation. The Benefit Sharing Plan, which gives guidance on the sharing of Carbon Benefits that would be generated under the GCFRP has been finalized and disclosed. The REDD+ Dedicated Account (RDA) has been opened to receive all the Carbon Payments. The RDA Steering Committee to provide transparency backstopping to the disbursement of Carbon Payments has been set up, in line with the Benefit Sharing Plan. The GCFRP has also developed the right Safeguard architecture to tackle and report on all social and environmental safeguards issues (details in annex 1).

In addition, under the auspices of the Cocoa & Forests initiative, the government of Ghana through the World Cocoa Foundation signed an agreement with 27 global cocoa companies and chocolate producers in 2017. They jointly agreed to transform the Cocoa sector from a major driver of deforestation to one that is enhancing the protection and reforestation of the High Forest Zone as well as the sustainable production of cocoa at the landscape level. Subsequently, in developing the implementation plan for the CFI, the HIAs have been adopted by companies as the implementation areas. This has therefore enhanced the level of engagements and companies see the GCFRP as the main program and vehicle to achieve their commitments.

Table 2: Updates on displacement risks associated with different drivers of deforestation.

Cocoa Farming	
Risk of displacement	Low
Progress of the strategy in Place	<p>In the first place, Cocoa production in Ghana is central to the GCFRP landscape. Limited or no cocoa production happens outside this landscape with some minimal cocoa production within the transition zone.</p> <p>. Again, the threat from a changing climate and its impacts on cocoa production outside the recommended growing areas further reduces the likelihood of displacement.</p> <p>However, with recent threats of displacement due to small scale mining in cocoa growing areas, though, the Transition area falls outside the GCFRP area, capacity building, training and extension services by both FC and Cocobod extend to the Transition areas to ensure that farmers implement CSC practices.</p> <p>For instance, FC through the NRS is implementing a project in collaboration with FAO dubbed Forest and Farm Facility Phase II within the Forest, Transition and Savannah Zones, which aims to help forest farm producer organizations become stronger, amplify their potential and connect with each other whilst helping to promote sustainable development through management of farm land and forests that produce food, livelihoods, medicine. In 2022 training workshops on Climate Change Mitigation and Adaptation, and Access to Finance were organized for 46 farmers in the transition zone.</p> <p>Generally, the strategy employed by Ghana to mitigate the potential for displacement of deforestation associated with Cocoa farming is anchored in the initiatives focused in the HIA areas. With an ageing population of Cocoa farms leading to a decrease in farm yield, communities are most likely to shift their activities to forested areas within the GCFRP. Several initiatives underway within the HIA areas are mitigating this potential displacement. In this regard, the Ghana Cocoa Board is currently rehabilitating all diseased and old cocoa farms to reverse the trend of decreases cocoa yield. As of 2020, 4199 hectares had been rehabilitated. In addition to this, other efforts in the form of projects are also complementing the efforts.</p> <p>For instance, in the Juaboso Bia HIA, a consortium of stakeholders from both the private and public sectors are involved in the Partnership for Productivity, Protection and Resilience in Cocoa Landscapes (3PRCL). These partners are the Touton, SNV Netherlands, NCRC, Forestry Commission (FC), Ghana Cocoa Board (Cocobod) and have signed addendum to the Juaboso Bia Framework Agreement. The project has established landscape governance and forest protection mechanisms and enhanced Cocoa productivity at the farm level</p>

	<p>while also providing incentives and income diversification options for farmers as conditions for forest protection and sustainable land management.</p> <p>In the Asutifi/Asunafo HIA, the Environmental Sustainability project (Public and Private Partnership; Mondelez, United Nations Development Program (UNDP), FC, Cocobod) has established community-level governance structures while also providing incentives and income diversification options for farmers as conditions for forest protection and sustainable land management In addition, through the partnership established under this project, Mondelez has reforested a total area of 167.5 ha using the Modified Taungya System approach. The first of its kind by any Chocolate Brand in Ghana.</p> <p>COCOBOD in collaboration with Forestry Commission and other private sector participants have developed Climate Smart Cocoa (CSC) Standard, which is undergoing series of stakeholder engagements, and expected to be finalized by the third quarter of 2023. The document is a working document to be used in all cocoa-growing regions to ensure sustainability in the face of climate change. The CSC standard document would guide Community Extension Agents (CEAs) in the provision of extension services to farmers to promote on-farm best agricultural practices.</p> <p>These initiatives and more have and will continue to reduce the potential for displacement in the program area.</p>
Subsistence farming	
Risk of displacement	Low
Progress of the strategy in Place	<p>While clearing forests for Cocoa production is considered one of the main drivers of deforestation in the program area, subsistence farming has also been shown to contribute to displacement. As outlined in the ERPD, shifting subsistence agriculture is constrained by the same ecological limits placed on Cocoa, and therefore farmers are unlikely to shift their cultivation outside their farms. Cocoa farmers typically establish their subsistence agricultural fields adjacent to their Cocoa trees and typically engage in diversified farming practices. These practices have been enhanced and incentivized through the initiatives (as indicated above) which seek to reward good forest governance within the area. These incentives include the provision of additional livelihood for the farmers, using the MTS approach to reforest degraded forest reserves, where farmers have access to additional lands to cultivate their food crops provision of free extension services for cocoa farmers, the supply of tree seedlings for planting on farm, provision of farm inputs and farm services as well as protective clothing etc. Farmers are now less likely to engage in the clearing of forested environments as there are specific mechanisms established to identify and sanction those engaging in clearing activities.</p>

	<p>In addition to the above, community governance structures have been developed for five out of the six HIAs. The Framework Agreements, which indicate the roles and responsibilities of farmers have also been signed with the HIA Management Boards (HMBs). The roles of farmers/communities include the protection of the forests and undertaking sustainable agriculture practices. Through series of engagements and capacity building programs, and the announcement of the receipt of the first ER payment by Ghana, farmers are more encouraged to undertake their roles in the Framework Agreements. (https://www.graphic.com.gh/news/general-news/emission-reduction-programme-dividends-cocoa-farmers-tell-success-stories.html)</p> <p>Going forward, the Ghana Cocoa Board has begun the process to establish the Cocoa Management System in anticipation of implementing several new, farmer-focused initiatives including pension schemes. This system would help provide tailor-made extension services to farmers. (further details on the system would be given in subsequent ERs)</p>
Illegal logging	
Risk of displacement	Medium
Progress of the strategy in Place	<p>Illegal logging within the GCFRP was identified as a risk in the ERPD, however this risk is being mitigated as described below:</p> <p>Improved landscape governance and planning (HIA governance structures development) along with enhanced skills mainly through sensitization on monitoring allow both communities and government entities to collaboratively respond to identified acts of illegal logging.</p> <p>Enhanced monitoring capabilities partnered with improved agricultural production have and will continue to reduce the likelihood of displacement related to illegal logging activities. Further, the establishment of the Trees in Agroforestry program (a major component of ERPD) will in the future provide a sustainable source of timber to meet local needs.</p> <p>Again, Ghana has ratified a Voluntary Partnership Agreement with the EU, and has developed the Ghana Wood Tracking System systems to control, verify and license legal timber. In line with this, a new legislative Instrument (LI 2254) has been developed to guide the value chain of timber from the forest gate to processing. All Timber Permits need to be ratified by Parliament. So far, the first batch of 19 have been laid before Parliament for ratification.</p> <p>The Forestry Commission has been undertaking forest protection including forest reserve patrol to detect and apprehend illegal offences including illegal</p>

	<p>logging, farming, mining sand/gravel wining, charcoal production, hunting, cattle grazing, carving of canoe, setting of forest fire and infrastructure development. This exercise is undertaken by staff of FC at National, Regional and District levels with the support of the Rapid Response Unit.</p> <p>Arrested culprits are arraigned before court of Law and punitive measures are meted against them to serve as deterrent for others. The table below provides details of forest related number of prosecutions for 2020 and 2021.</p> <table border="1"> <thead> <tr> <th>Year</th><th>Prosecutions</th></tr> </thead> <tbody> <tr> <td>2020</td><td>55</td></tr> <tr> <td>2021</td><td>20</td></tr> <tr> <td>Total</td><td>75</td></tr> </tbody> </table>	Year	Prosecutions	2020	55	2021	20	Total	75
Year	Prosecutions								
2020	55								
2021	20								
Total	75								
Illegal small-scale mining									
Risk of displacement	Medium								
Progress of the strategy in Place	<p>The displacement of illegal small-scale Gold mining in the GCFRP project area was recognized as a medium risk in the original ERPD</p> <p>Since then Ghana has made significant progress with regards to mitigating this risk.</p> <p>With a new government in place, in 2017, the government launched a new program (artisanal mining) to enforce the law by putting up measures to stop the menace, this helped to reduce the menace</p> <p>Some reports do indicate that the practice has returned however, in the project landscape.</p> <p>In response, Government has introduced some policies to help mitigate illegal mining. These include the following:</p> <ul style="list-style-type: none"> All eighty-three (83) Small Scale Mining Committees in the various mining districts, in accordance with section 92 of the Minerals and Mining Act, 2006 (Act 703), to assist the District Offices of the 								

	<p>Minerals Commission to effectively monitor, promote and develop mining operations in their jurisdictions. This is the first time, since the passage of Act 703, that Small Scale Mining Committees have been established in all mining districts in the country. Under the Ghana Landscape Restoration and Small-Scale Mining Project, members of these Committees to build their capacity efficiently perform their functions.</p> <ul style="list-style-type: none"> • Establishment of Community Mining Schemes, which allows mining to be undertaken in a sustainable manner • Implementation of the National Alternative Livelihood Program (NALEP) carry out its mandate. This program which has an objective of creating jobs as alternative to illegal mining was launched on 25 October 2021. <p>In addition to the above, through the Forest Investment Programme and GCFRP, additional livelihood schemes are being provided to farmers to increase their income levels. Again, the logic of intensification of good farm practices and other climate smart interventions is to help increase the cocoa yields. Through this, farmers are motivated not to give up their cocoa farms to illegal mining persuasions.</p> <p>Furthermore, Cocobod, in October 2022 announced the start of a Cocoa Farmers Pension Scheme² to assure farmers of earning income in their old ages. The scheme has just been rolled after piloting in the Ashanti Region. Subsequent MRs would give details.</p>
--	--

1.2 Update on major drivers and lessons learned

In 2017 Ghana submitted its ERPD to the FCPF in which it identified the following four drivers of deforestation:

1. Uncontrolled agricultural expansion at the expense of forests;
2. Overharvesting and illegal harvesting of wood;
3. Population and development pressure;
4. Mining and mineral exploitation

² <https://cocobod.gh/news/full-rollout-of-cocoa-farmer-pension-scheme-begins-in-october>

The drivers of deforestation and forest degradation are believed to remain the same comparing the reference period to the monitoring period. The underlying causes of this deforestation were identified at the time the ERPD was drafted as forest industry over-capacity, policy and market failures, population growth, increasing demand for agriculture and wood products, low-tech farming systems which relied on slash and burn farming methods as well as a growing mining sector (including illegal mining). Clearing for new Cocoa farms was seen as the most significant driver of deforestation. Initial quantitative estimates of the impacts, these drivers were having in the GCFRP area were captured as part of Ghana's initial ERPD submission. Again, for the lessons learnt, there are no changes from the first monitoring report.

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

The management of GHG related data and information is performed by Ghana's Forestry Commission, with data collected through the National Forest Monitoring System (NFMS). The data necessary to estimate emissions and removals from enhancements, deforestation and degradation are collected at the national level and are continuously improved on a step-wise basis. These data serve as the basis of Ghana's National Forest Monitoring System (NFMS), which is consistent with IPCC guidelines for forest monitoring, and were used to estimate the reference level for the ER Programme.

In line with the NFMS, and specifically, for Ghana's Measuring, Monitoring and Reporting (MMR) system, the following institutions are directly involved:

- The Forestry Commission's Climate Change Unit (CCU) / NRS
- Ghana Cocoa Board
- The Forestry Commission's Resource Management Support Center (RMSC)
- The Forestry Commission's Forest Services Division (FSD)
- ICT Department of the Forestry Commission
- The Environmental Protection Agency (EPA)
- Private Sector, NGOs and Research Institutions
- HIA Consortium/ Governance Body
- Academia

Many of these institutions have clear mandates that effectively allow them to undertake their specified roles during MMR of programme performance. For instance, RMSC, FSD, ICT and the NRS play significant roles in the collection, analysis, and storage of data during the MMR phase. The detailed roles of all the institutions are described in Ghana's first monitoring report. To ensure proper coordination of the institutional activities, the MRV sub-working group has been formed, to include the institutions listed above. The MRV sub-working group primarily undertake assessment of outputs received from the various institutions whilst supporting efforts towards information sharing with relevant agencies.

Ghana produced Standard Operating Procedures (SOPs) in 2014 to guide the production of Emission Factors, Activity Data, Quality Control and Quality Assurance. However to reflect the amendment in the Reference Level as proposed, updated SOPs were also developed in 2019/2020, (details of the first and updated SOPs are found here:

<http://www.ghanaredddatahub.org/doclibrary/sops/>

(<https://drive.google.com/drive/u/4/my-drive>) .

The details of the 2014 SOPs cover the following areas:

No	NAME
001	Estimating Annual Forest Emissions and Removals
002	Key Category Analysis
003	Acquisition of Remote Sensing Data and Generation of Activity Data
004	Stratification of Lands
005	Field Inventory Protocol
006	Estimation of Above- and Belowground Biomass and Deadwood
007	Estimating Emissions from Soil Organic Carbon
008	Estimation of Emissions and Removals from Timber Harvests
009	Estimation of Emissions from Extraction of Wood for Fuel
010	Emissions From Fire
011	Estimating National and Sub-National Forest Reference Emission Level
012	Combining Uncertainty

The NFMS has several data collection components as indicated here below:

- Satellite land monitoring system (SLMS) (providing AD on deforestation and forest degradation)
- Field inventory data from the Forest Preservation Programme (providing EF for deforestation and forest degradation through a field inventory exercise with data collected in 2012)
- National Forest Plantation Development Programme (NFPDP) (providing statistics on planted areas, including details on species and whether planting was in- or outside reserve areas. Removals factors for enhancement through the conversion of non-forest land into forest land through plantation establishment are obtained from IPCC)

The responsibility of reporting the GHG data and information are divided between Forestry Commission Environmental Protection Agency (EPA) and the Forestry Commission as follows:

- Forest reference level – Ghana’s Forestry Commission
- GHG inventory (national communication / BUR) – Environmental Protection Agency
- Technical annex to the BUR in case REDD+ results are reported –Environmental Protection Agency / Ghana’s Forestry Commission

INSTITUTIONAL FRAMEWORK FOR GHANA'S FMS

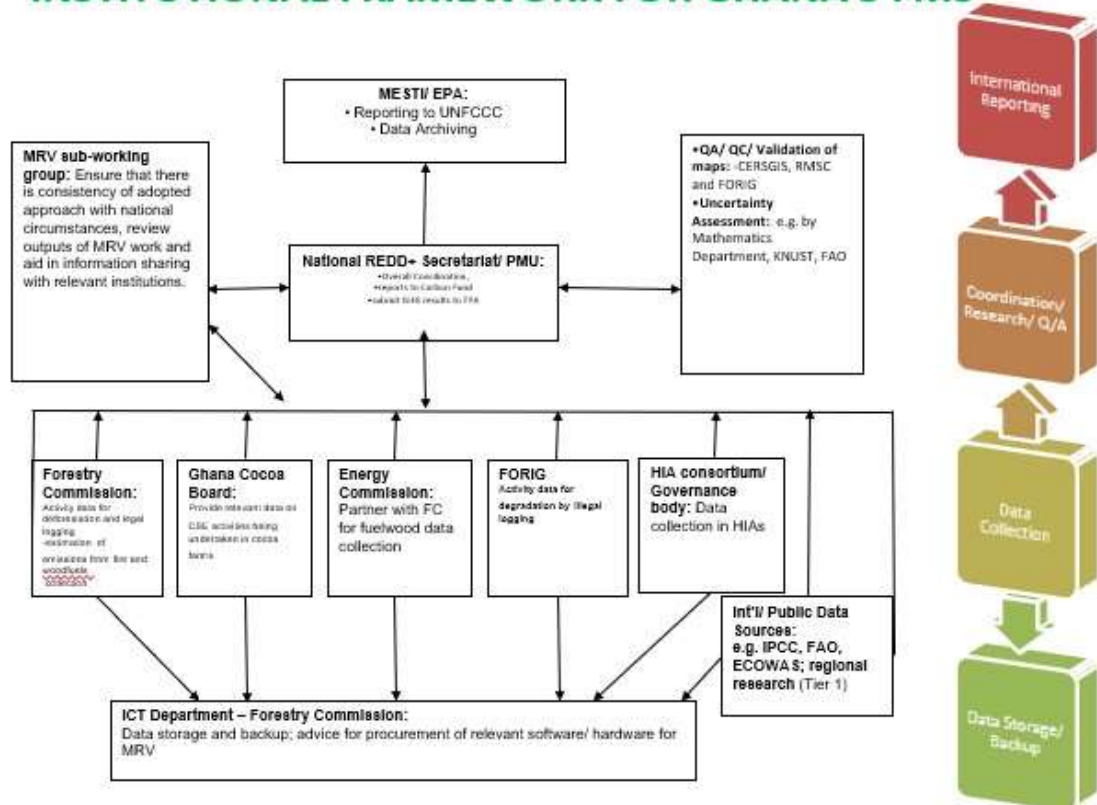


Figure 2: Overall institutional framework for FMS

Table 3: Institutions Involved in Ghana's Forest Monitoring System

MMR Institutions	Main Roles and Responsibilities
Ministry of Lands and Natural Resources (MLNR)	The sector ministry to which the Forestry Commission reports. Responsible for Ghana's Forest Investment Programme(FIP) and will serve as the programme'sCoordination and Management Committee to ensure integration with FIP projects and related activities.The MLNR will also provide financial support for operationalizing the MRV
Forestry Commission (FC)	Allocate funding to support monitoring activities
Districts and Regions of the Forest Services Division FSD, of the FC)	Provide data on on-reserve CSE activities and legal timber harvest to RMSC; Support RMSC to collect field data for classification and accuracy assessment.
National REDD+ Secretariat	Overall coordination of the MMR processes - Reports to the Carbon Fund - Reports to the EPA

Resource Management Support Centre (RMSC, of the FC)	Technical lead for collection of field data and analysis of spatial data to generate emissions estimates
Forestry Research Institute of Ghana (FORIG)	Support with collection of data on illegally harvested timber; Develop/ refine allometric equations for carbon stocks estimation in various strata/ forest types.
Soil Research Institute (SRI)	Estimation of forest carbon
Center for Remote Sensing & Geographic Information Services (CERSGIS), University of Ghana	QA/ QC of maps
Environmental Protection Agency (EPA, under MESTI)	The National Focal Point for Climate Change and is responsible for the National Communications to the UNFCCC
Ghana Energy Commission (under MOE)	Collection of woodfuel data
Ghana Cocoa Board (COCOBOD)	Provide relevant data on CSE activities being undertaken in cocoa farms
HIA Consortium/ Governance Board	The HIA Consortium and Governance Board will constitute the

Table 4: The following GHG related data and information is selected

GHG flux	Gases included	Parameter	Elements included	Source	Responsible Institutions
Net emissions from deforestation	CO ₂	Emission factor deforestation	Carbon pool measurements at plot level: <ul style="list-style-type: none"> Above Ground Carbon Below Ground Carbon Litter Deadwood Soil Organic Carbon 	NFMS: FPP	NRS,FSD, RMSC, National REDD+ Working Group, FAO
			Post-deforestation carbon (measurements at plot level)	NFMS: FPP	RMSC, NRS, FAO
		Activity data deforestation	Deforestation assessments at plot level	NFMS: SLMS	FSD, RMSC, NRS, CERSGIS, MRV Sub Working Group

Net emissions from forest degradation	CO ₂	Emission factor degradation	Carbon pool measurements at plot level: <ul style="list-style-type: none"> • Above Ground Carbon • Below Ground Carbon • Deadwood 	NFMS: FPP	NRS, FAO, RMSC, MRV Sub Working Group
		Activity data degradation	Canopy cover reduction assessments at plot level	NFMS: SLMS	NRS, FAO, RMSC, MRV Sub Working Group
Net removals from enhancement (afforestation/reforestation)	CO ₂	AD enhancement	Planted area assessment	NFMS: NFPDP	NRS, FSD
			Survival rate assessment		FSD
		Removal factor enhancement	Teak	Adu-Bredu et al. (2008)	Publication
			Other broadleaf species	IPCC 2006 (Vol 4, Chapter 4, Table 4.8)	

Forest Monitoring for the ER Program

The above institutional arrangement is adapted with respect to the implementation and updating of the MRV and RL for the ER program and the operation of the data management system., This responsibility falls under the NRS, which houses the Program Management Unit (PMU) with technical support led by RMSC. The PMU is responsible for the activities at both national and programme(s) levels. In this regard, the PMU is responsible for coordinating the accounting and monitoring procedures to clearly demonstrate the performance of the GCFRP against its FRL, annual monitoring and oversight of impacts and changing trends, and maintaining data management systems for housing key information related to REDD+ and Climate Smart Cocoa operations in the programme landscape. The PMU also monitors and records the implementation status of activities in each Hotspot Intervention Area (HIA), by verifying with communities what institutions in HIAs have reported and guarantees that the annual planning of activities is being followed and implemented. The PMU is therefore developing a system to comprehensively monitor activities at full scale. Details of the output would be reported in the next MR

In addition, communities within the implementation area are involved during field data collection through participatory dialogues to verify information provided by other stakeholders within their landscapes who are implementing emission reductions activities. Members within communities also support as field assistants during field data collection. Their knowledge of the landscapes contributes to the appreciation/description of the landuse dynamics of the landscapes. In the development of this report, however, Food and Agriculture Organisation (FAO), provided quality assurance for all the data collected, and the corresponding analysis of data.

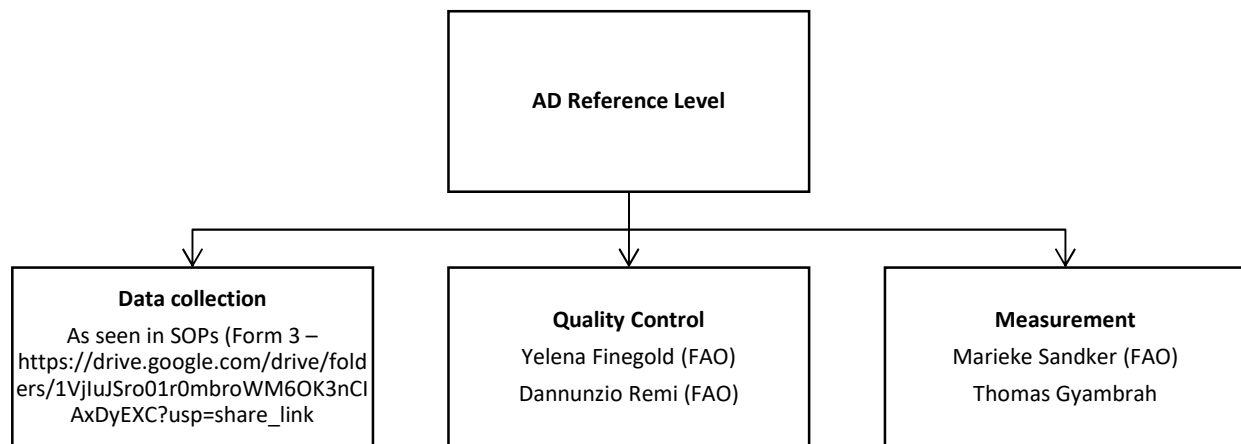


Figure 3: Organizational structure for Reference level development

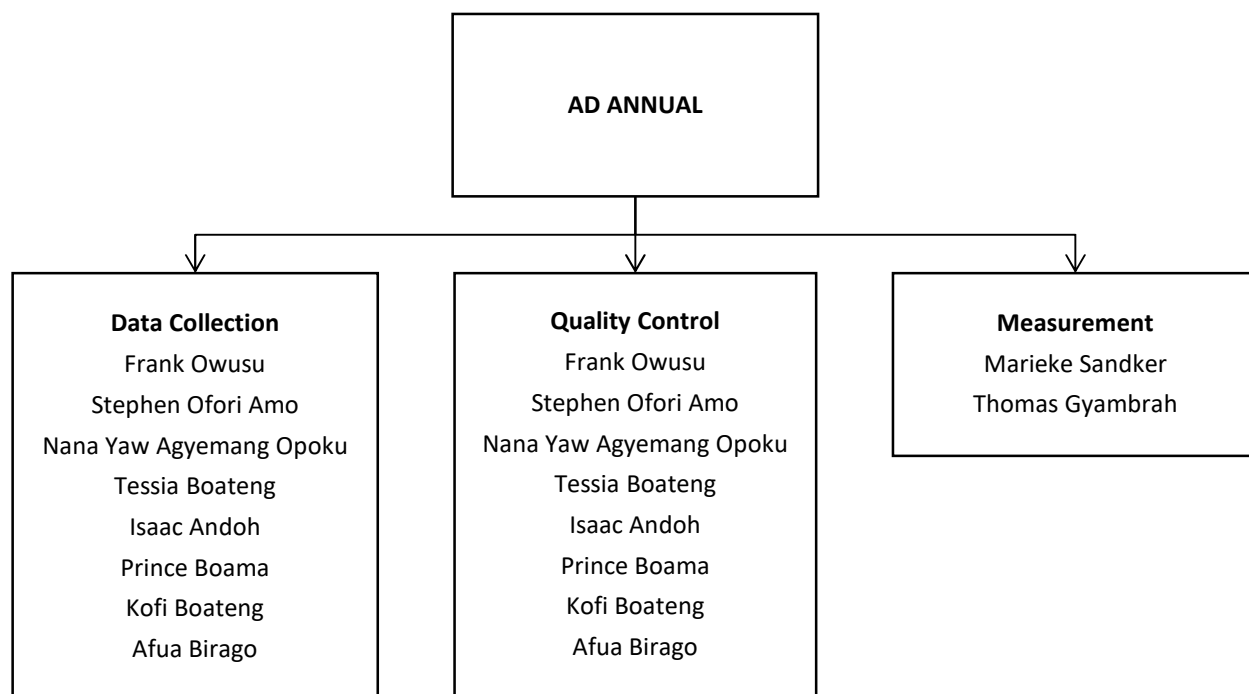


Figure 4: Organizational structure for Activity Data for annual reference level (2020/2021)

In 2012/3, Ghana implemented the Forest Preservation Programme (FPP). The objective of this programme was to map forest cover and estimate carbon stocks for all the ecological zones in the country. The emission factors developed for deforestation analyses under the FPP incorporated all the carbon pools including those that were identified as significant based on the IPCC recommended thresholds (i.e. the aboveground, belowground and soil carbon) and the other pools (litter, deadwood and herbaceous). The emission factors for deforestation analyses under the ER programme were sourced from the FPP and consequently included all the carbon pools.

In summary, for the estimation of emission factors, as described in the first monitoring report, 168 plots within the GCFRP landscape were visited in 2012 and field measurements were undertaken. Ghana has not yet put in place a National Forest Inventory with repeating cycles of data collection and putting this in place will be dependent on available funding as implementing an NFI on a regular basis is extremely costly.

For the estimation of activity data, 7,702 spatial plots have been assessed in 2022 by a team of remote sensing experts. The spatial design used was based on several quality assessment exercises. The spatial design, response design and quality management aspects are described in the first monitoring report. Data collections exercises are organized in 'residential' format, meaning all interpreters sit together during the assessment such that plots where the application of the hierarchical key is not straightforward can be jointly assessed through consensus among the experts.

Systems and processes that ensure the accuracy of the data and information are described in detail in Annex 4 of the Emission Reductions-Monitoring Report of first reporting period. In summary, for the field inventory, QA/QC

measures consisted of random blind re-measurements. For the SLMS data, QA/QC measures were applied as follows: before the data collection started, experts jointly revised the classification hierarchy and reviewed a number of sampling plots together to enhance internal consistency; to improve the quality of the plot interpretation. A random selection of plots were re-assessed.

Systems and processes that supports the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

The developed SOPs are:

- Sample Design – SOP 1
- Response Design – SOP 2
- Data Collection/QA/QC – SOP 3
- Data Analysis – SOP 4

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram

To address conditions raised by the Carbon Fund participants in 2017, Ghana applied technical corrections to the reference level (see Annex 4 of the first monitoring report). The measurement, monitoring and reporting approach used by Ghana to develop the corrected reference level is the same approach used for quantifying the emissions reductions reported.

This section visualizes the overview of the different steps that lead up to the Emission Reductions.

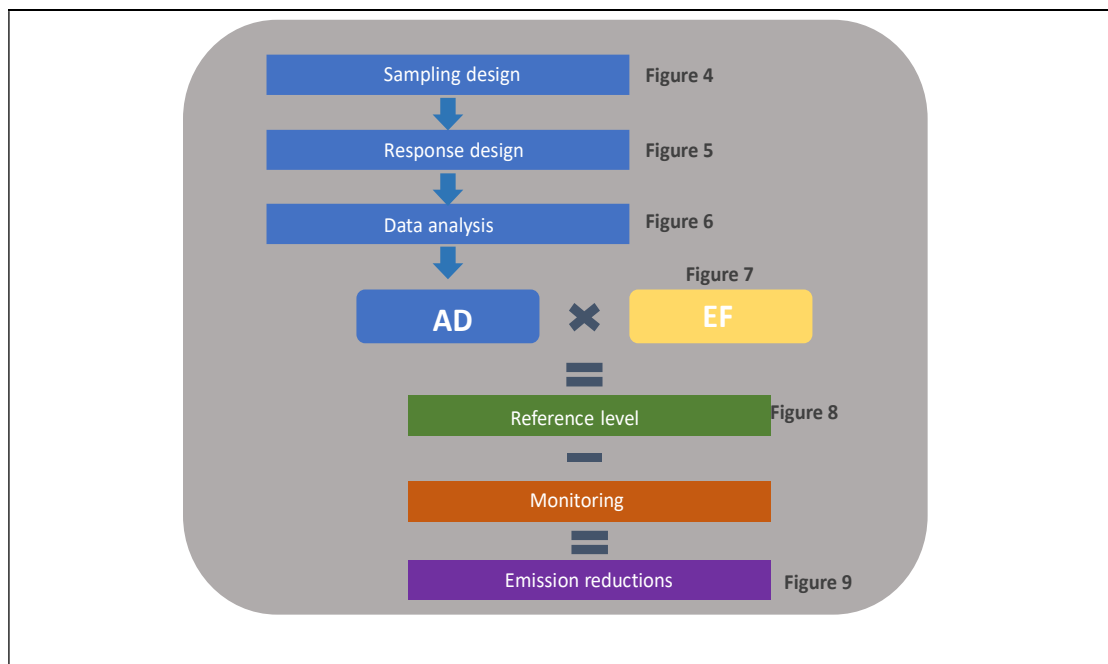
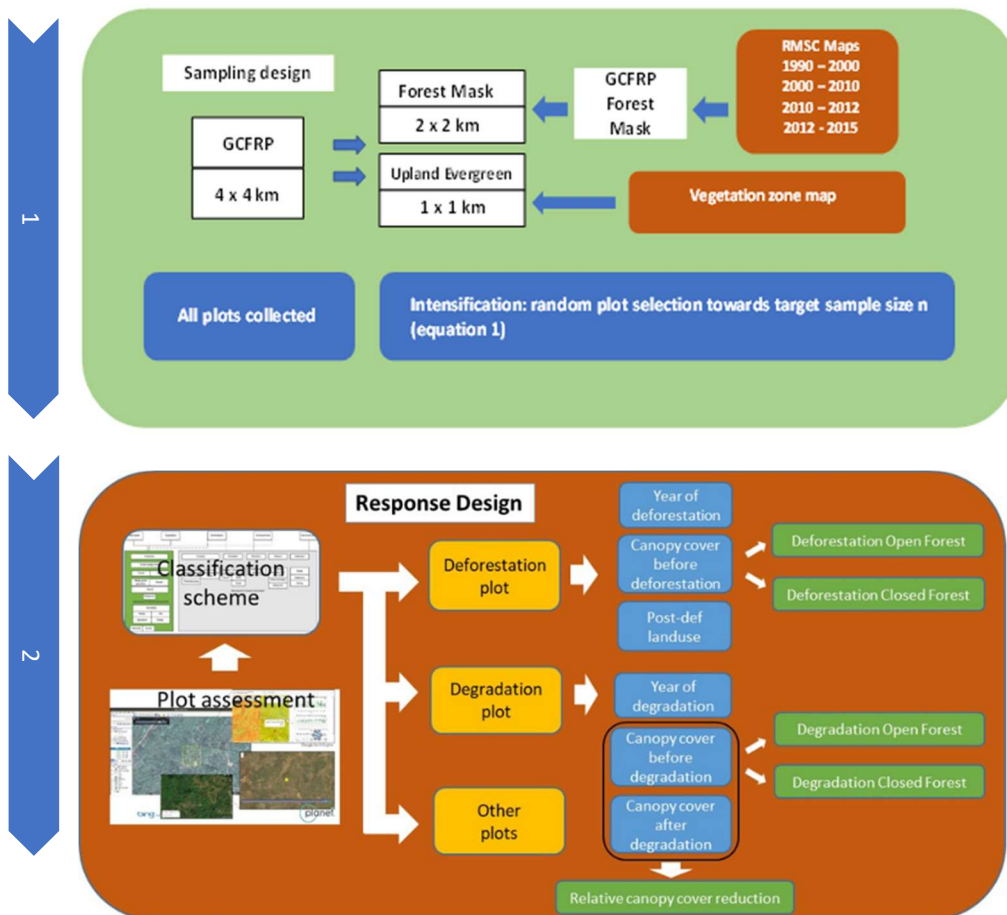


Figure 5: Overview of different steps

Activity Data

The SLMS is a sub-system of the National Forest Monitoring system and is used to produce activity data (Figures 3 & 4) required for both the reference level and the monitoring period. Ghana's SLMS primarily produces activity data estimates which are used to determine the overall forest loss estimates as well as deforestation rates for the periods of interest. The SLMS team is located in the Resource Management support Centre (RMSC) of Forestry Commission of Ghana.



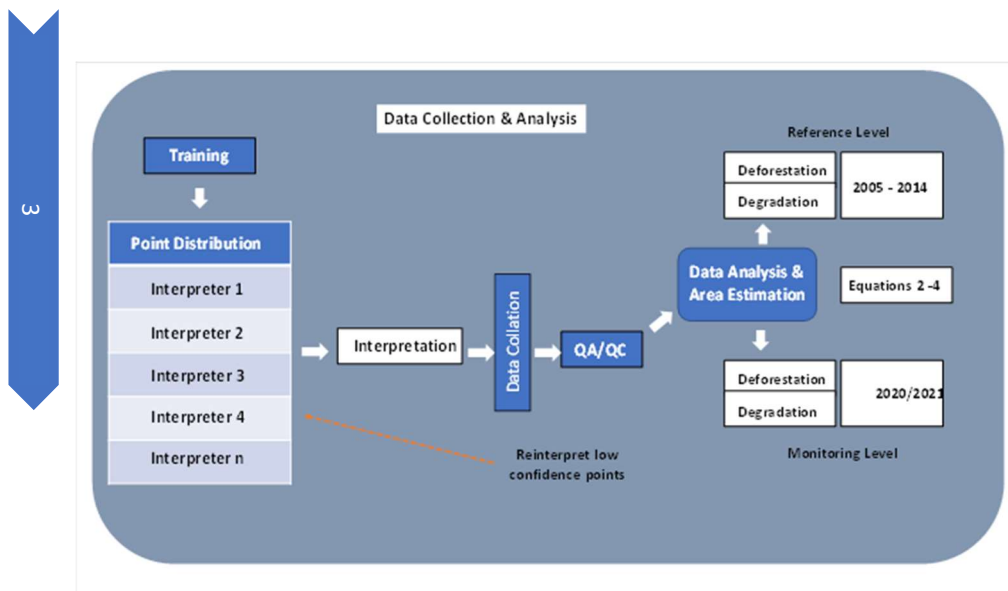


Figure 6: AD Data collection & analysis

Emission factors

The Forestry Inventory has not been revised from the first monitoring report.

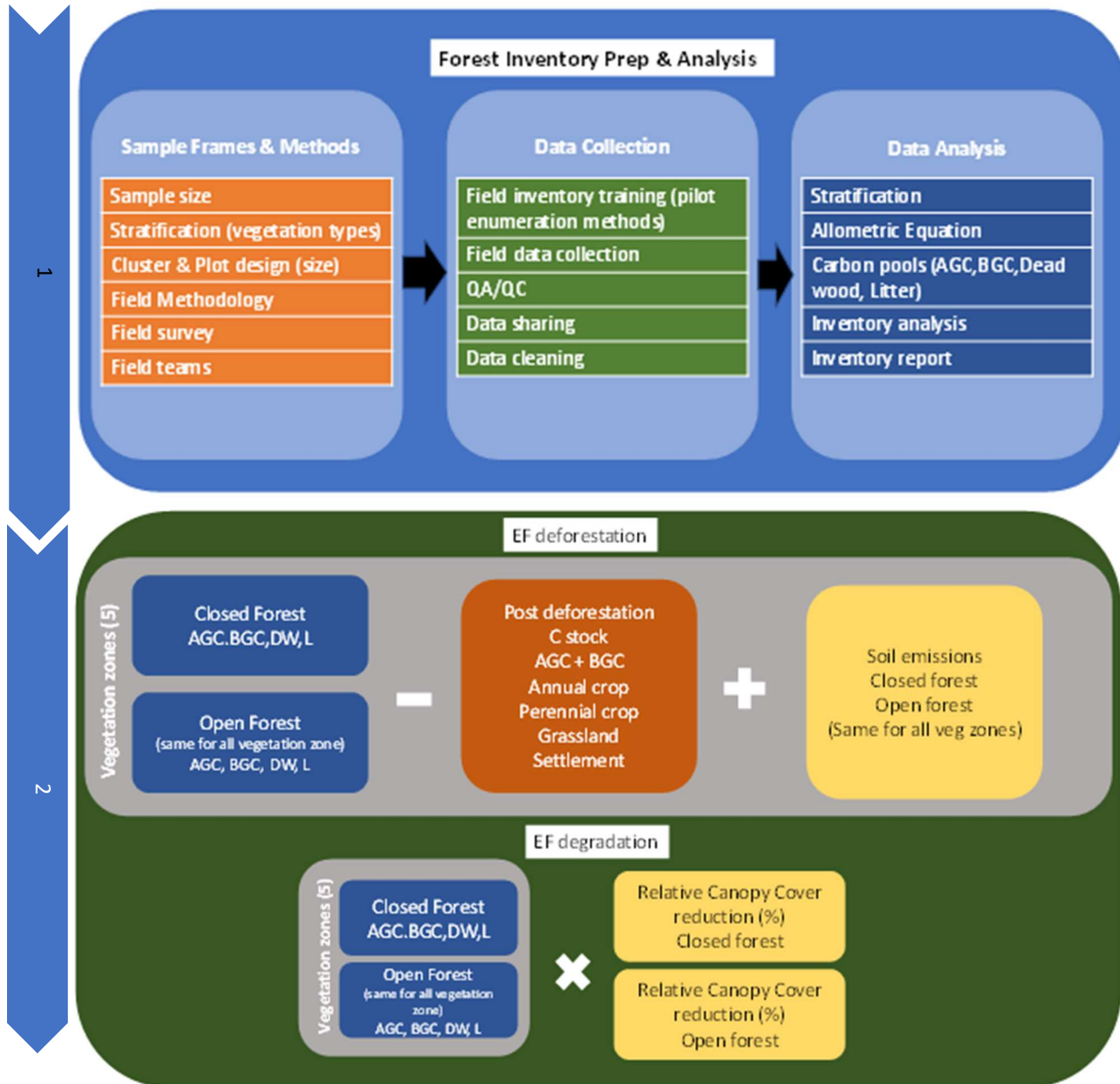


Figure 7: GCFRP Emissions Factors for deforestation and forest degradation

The following line diagrams (figures 8-9) provide a systematic representation of the different steps on how the analysis were done after the AD and EFs were derived

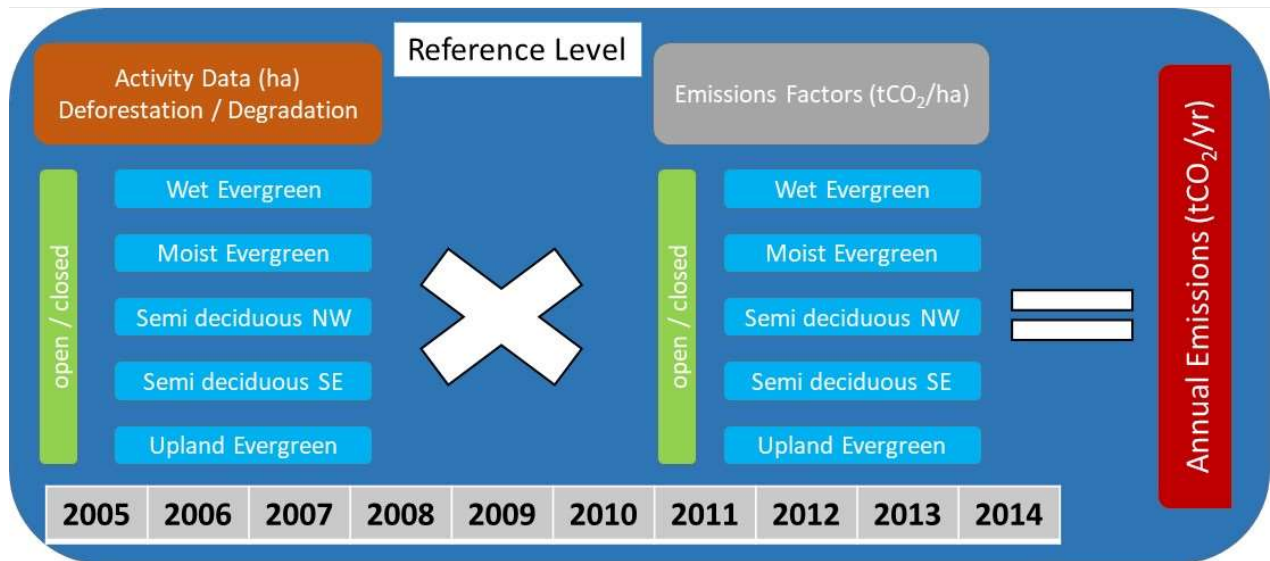


Figure 8: Ghana GCFRP Reference Level

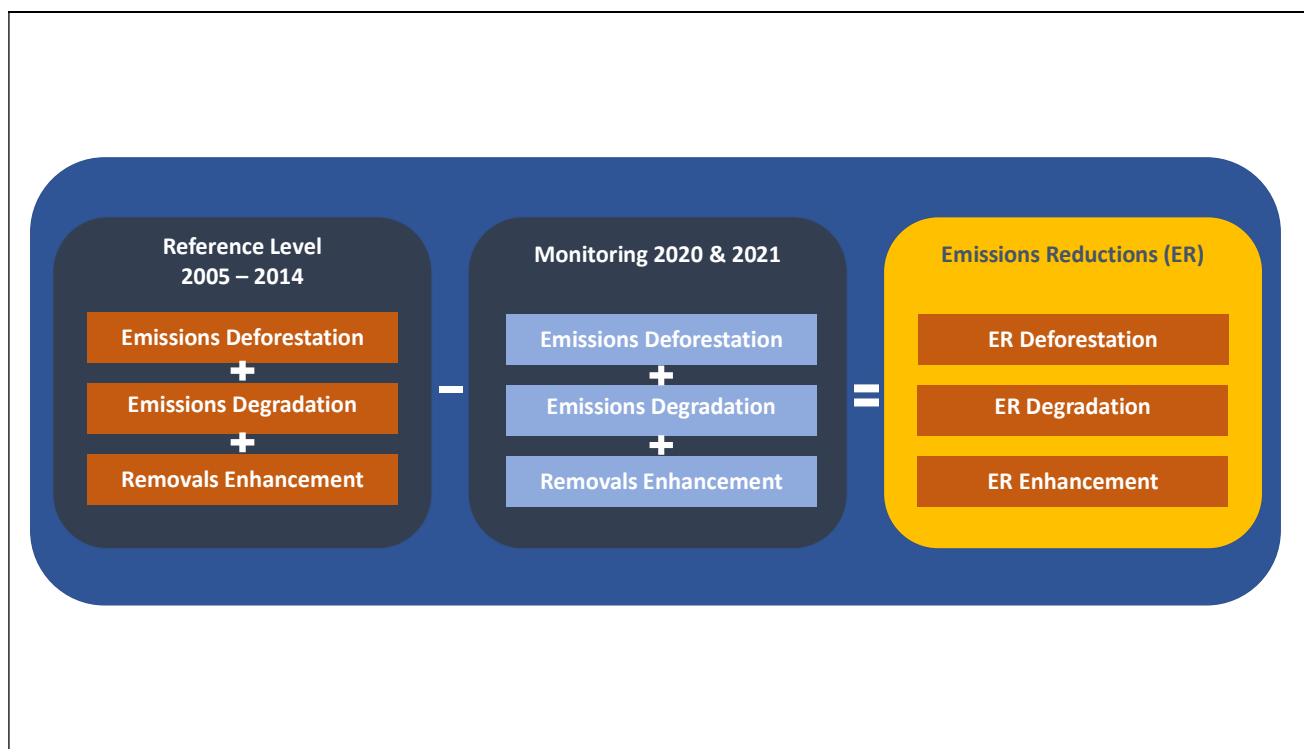


Figure 9: Ghana GCFRP Emissions reductions

2.2.2 Calculation
GCFRP emission reductions

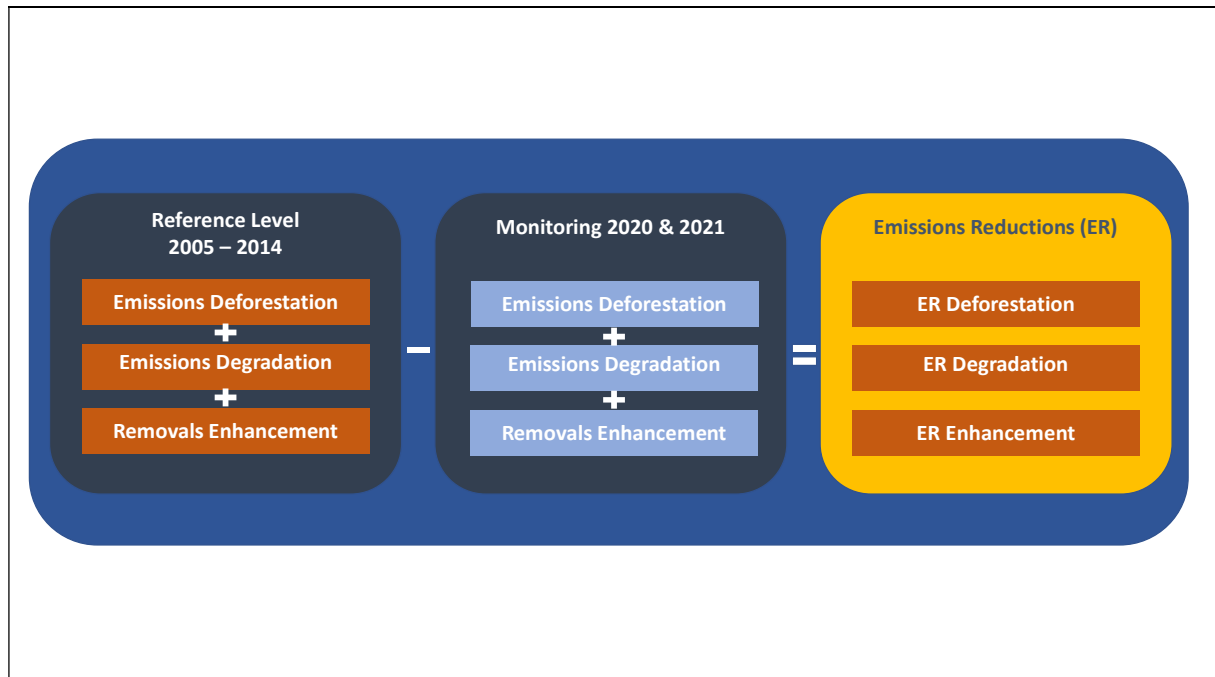


Figure 9: Ghana GCFRP Emissions reductions

Figure 9 above presents the final line diagram used for describing the methods used for calculating the final emissions reduction for the monitoring period. Both the Reference Level and the Monitoring period make use of the same approach whereby emissions from both degradation and deforestation are combined on an annual basis with removals/enhancements to calculate annual gross emissions. Gross annual emissions are subtracted from the annual reference level to give the final annual emissions reductions for the Ghana Cocoa Forest REDD+ program. See equation 1 below. The equation calculates emission reductions by deducting monitored emissions from historical average emissions over the reference period. Emissions reductions are calculated for the GCFRP landscape only.

Equation 1 Equation for emission reductions in year 2020 and 2021

$$ER_{GCFRP,t} = RL_{GCFRP} - GHG_{GCFRP,t} \quad (1)$$

where:

- $ER_{GCFRP,t}$ = Emissions Reductions under the ER program in year t ; $tCO_2e*year^{-1}$
- RL_{GCFRP} = Annual reference level emissions for the Ghana Cocoa Forest REDD+ Program area ; $tCO_2e*year^{-1}$
- $GHG_{GCFRP,t}$ = GHG emissions over monitoring period for the Ghana Cocoa Forest REDD+ Program area ; $tCO_2e*year^{-1}$
- t = Number of years in the monitoring period

Equation 2 Annual Reference level emissions for the GCFRP landscape ($tCO_2/year$)

$$RL_{GCFRP} = \sum_{e=1,5} \frac{(A_{def,e,s} \times EF_{def,e,s} + A_{degr,e,s} \times EF_{degr,e,s})}{t} + removals_{RL} \quad (2)$$

where

- $A_{def,e,s}$ = Area of deforestation, in vegetation zone e , in forest structure s
- $EF_{def,e,s}$ = Emissions factor for deforestation for vegetation zone e for forest structure s during both the reference and monitoring period
- $A_{degr,e,s}$ = Area of degradation, in vegetation zone e , in forest structure s
- $EF_{degr,e,s}$ = Emissions factor for degradation for vegetation zone e for forest structure s during both the reference and monitoring period
- t = Reference period, year 2005-2014

$removals_{RL}$ = This is the reference level value for removals calculated as the projected annual removals during the monitoring period from the average planted area over the period 2005-2014 (Annex 4 First Monitoring report)

Equation 3 **Monitored GHG** emissions for the GCFRP landscape (tCO₂/year)

$$GHG_{GCFRP} = \sum_{e=1,5} \sum_{s=1,2} \frac{(A_{def,e,s} \times EF_{def,e,s} + A_{degr,e,s} \times EF_{degr,e,s})}{t} + removals_{MP} \quad (3)$$

where

$A_{def,e,s}$ = Area of deforestation, in vegetation zone e , in forest structure s

$EF_{def,e,s}$ = Emissions factor for deforestation for vegetation zone e for forest structure s during both the reference and monitoring period

$A_{degr,e,s}$ = Area of degradation, in vegetation zone e , in forest structure s

$EF_{degr,e,s}$ = Emissions factor for degradation for vegetation zone e for forest structure s during both the reference and monitoring period

t = Years in the monitoring period, 2020, 2021

$Removals_{MP}$ = This is the monitored value for removals calculated as the actual removals from the crediting period occurring during the monitoring period 2020-2021 (see Annex 4 First Monitoring report)

Area of Deforestation and degradation

To calculate the deforestation and degradation area by vegetation zone the sample plots receive equal weights per vegetation zone and sampling density as shown in equation 5 and 6.

The area of deforestation, in vegetation zone e , in forest structure s is calculated as follows:

$$A_{def,e,s} = \sum_{i=1,2} p_{def,e,s,i} \times A_{e,s,i} \quad (4)$$

where

$p_{def,e,s,i}$ = the estimated probability of deforestation in vegetation zone e , forest structure s , falling in stratum i , calculated as $n_{v,e,s,i}/n_{e,s,i}$ where $n_{v,e,s,i}$ is the number of sample plots of deforestation in vegetation zone e , forest structure s , falling in stratum i and $n_{e,s,i}$ is the number of sample plots in vegetation zone e , forest structure s , falling in stratum i

$A_{e,s,i}$ = the area of stratum i in vegetation zone e and forest structure s

The area of degradation, in vegetation zone e , in forest structure s is calculated as follows:

$$A_{degr,e,s} = \sum_{i=1,2} p_{degr,e,s,i} \times A_{e,s,i} \quad (5)$$

where

$p_{degr,e,s,i}$ = the estimated probability of degradation in vegetation zone e forest structure s falling in stratum i , calculated as $n_{v,e,s,i}/n_{e,s,i}$ where $n_{v,e,s,i}$ is the number of sample plots of degradation in vegetation zone e forest structure s falling in stratum i and $n_{e,s,i}$ is the number of sample plots in vegetation zone e forest structure s falling in stratum i

$A_{e,s,i}$ = the area of stratum i in vegetation zone e and forest structure s

Equation 4 and 5 perform area-based weighting. This means that each plot receives the same weight for the stratum where it belongs, and the weight is calculated by dividing the area per stratum by the total number of plots in the stratum. This is the equivalent of equation 8 in Olofsson et al (2014)³. Equations 4 and 5 are applied for the forest types Wet Evergreen, Moist Evergreen, Moist Semi-Deciduous South-East and Moist Semi-Deciduous North-West. For the vegetation zone Upland Evergreen the same equation is applied only it has one single grid spacing (1 x 1 km) meaning $i = 1$ in this case.

For deforestation (Equation 4) the following conversions are possible:

- *Wet Evergreen closed forest to Non Forest type;*
- *Moist Evergreen closed forest to Non forest type;*
- *Moist Semi Deciduous North East closed forest to Non Forest type;*
- *Moist Semi Deciduous South West closed forest to non forest type ;*
- *Upland Evergreen closed forest to Non-forest type; and*
- *Open forest to Non-forest type*

For degradation (Equation 5) the following subpopulations are possible:

- *Degradation in Wet Evergreen closed forest;*
- *Degradation in Moist Evergreen closed forest;*
- *Degradation in Moist Semi Deciduous North East closed forest;*
- *Degradation in Moist Semi Deciduous South West closed forest;*
- *Degradation in Upland Evergreen closed forest; and*
- *Degradation in Open forest*

Emission factors for deforestation and forest degradation

The EF for deforestation was calculated as the difference between average pre-and post- deforestation carbon contents, with pre deforestation biomass estimates per vegetation type estimated based on data collected as part

³ Olofsson, P.; Foody, G.M.; Herold, M.; Stehman, S.V.; Woodcock, C.E.; Wulder, M.A. Good practices for estimating area and assessing accuracy of land change. Remote Sens. Environ. 2014, 148, 42–57.

of the FPP. Post deforestation estimates are based on both data from the FPP as well as data collected by the team undertaking the activity data analyses. Emissions factors used for both the Reference period and the Monitoring period have been calculated following guidance provided by the 2006 IPCC guidelines⁴ where post deforestation biomass (tC/ha) is subtracted from pre deforestation biomass estimates. This step is outlined in equation 7 below. This equation approximates emissions per hectare deforestation as the difference between the carbon (AGC, BGC, DW, L) in the forest before the deforestation event and the average carbon (AGB, BGB) in the land use following deforestation, plus the change in the soil carbon pool (where the change in soil carbon is calculated with equation 2.25 in IPCC, 2019).

Equation 6 Emissions factor for deforestation for vegetation zone *e* and forest structure *s* during both the reference and monitoring period:

$$EF_{deforestation_{e,s}} = (B_{before_{e,s}} - B_{after_e} + \delta S_e/20) \times \frac{44}{12} \quad (6)$$

where

$B_{before_{e,s}}$	=	Total carbon of vegetation zone <i>e</i> for forest structure <i>s</i> (open or closed) before conversion, which is equal to the sum of AGC, BGC, deadwood and litter. For open forest a single B_{before} value is used for all different vegetation zones.
B_{after_e}	=	see equation 7, total weighted carbon biomass (AGC + BGC) in land uses after conversion (deforestation) per vegetation zone <i>e</i> .
$\delta S_e/20$	=	Change in soil carbon as a result of deforestation, calculated with different soil reference values per vegetation zone <i>e</i> from FPP where the change in soil contents after conversion is calculated with IPCC Equation 2.25 (IPCC 2019, volume 4, chapter 2). The Tier 1 stock change factors are provided in Table 5). Accordingly, the emissions are projected over 20 years following the FCPF Guidance Note on accounting of legacy emissions/removals, v1 (2021).
$44/12$	=	Conversion of carbon to carbon dioxide

Table 5: Stock change factors for change in organic carbon in mineral soils

	Cropland	Grassland	Settlements
$F_{LU} \times F_{MG} \times F_I$	0.81	1.00	0.68

⁴ Intergovernmental Panel on Climate Change (IPCC) (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Hayama, Japan

Equation 7 Equation used for the weighted post-deforestation carbon contents ($Bafter_e$)

$$Bafter_e = \sum_{lu=1,4} \left(\frac{Adef_{lu,e}}{Adef_e} \times Bafter_{lu} \right) \quad (7)$$

Where:

- $Adef_{lu,e}$ = the total area of deforestation with post-deforestation landuse lu (either annual cropland, perennial cropland, grassland or settlement) in vegetation zone e
- $Adef_e$ = the total area of deforestation in vegetation zone e
- $Bafter_{lu}$ = biomass in the land use replacing forest (either annual cropland, perennial cropland, grassland or settlement)

Calculation EF forest degradation

Emissions factors for forest degradation were derived based on the relative plot level canopy cover reduction captured for degraded plots during the activity data analysis (see Figure 7 above). The remote sensing interpreters assessed the average tree cover prior to and after a degradation event, after which for each plot the relative percentage reduction of canopy cover was calculated. Accordingly, the average relative canopy cover reduction was calculated for open and closed forest for all vegetation zones combined. The relative percentage tree cover reduction was applied to the forest carbon stock (AGC, BGC, DW) to approximate the carbon loss associated with degradation. The pools AGC, BGC and DW were selected in the ERPD as associated with logging. Since this is the largest cause of degradation and since DW is a significant pool, this selection was applied here. The calculation of the EF for degradation is provided in equation 9. Reduction in canopy cover can be taken as a proxy for degradation according to FAO (2000)⁵.

Equation 8 Emissions factor for forest degradation for vegetation zone e during both the reference and monitoring period

$$EF_{degradation_{e,s}} = C_{before_{e,s}} \times reduction\ rate_s \times \frac{44}{12} \quad (8)$$

Where:

- $C_{before_{e,s}}$ = The pre-degradation carbon contents (AGC + BGC + DW) in vegetation zone e for forest structure s (open or closed). For open forest a single B before value is used for all different vegetation zones

⁵ FAO (2000). FRA 2000 – On definitions of forest and forest cover change. FRA programme, Working paper 33, Rome, Italy.

Reduction rate_s = Average relative canopy cover reduction in forest structure *s* (open or closed) as a result of forest degradation, which was identified as part of the activity data analyses

44/12 = Conversion of carbon to carbon dioxide

Of the detailed information collected through the sample unit assessment, the proportion of post-deforestation land-use (annual cropland, perennial cropland, grassland, settlement) is used to calculate the weighted post-deforestation carbon contents. Equation 8 shows how the weighted post-deforestation carbon contents is calculated: Post-deforestation biomass is estimated from weighted post-deforestation land use per vegetation class, where the biomass in the post-deforestation land use is assessed through field measurements from the FPP. The principle of estimating emissions from each land use change stratum as the difference between the forest carbon stocks per unit area before conversion and the forest carbon stocks per unit area for the new land use after conversion is in line with GFOI (2016, page 59)⁶ and IPCC (2003)⁷. The same weighted post-deforestation carbon content is applied to deforestation in open and closed forest.

Equation 9. Removals associated with average net area planted over the reference period projected over the crediting period

$$Removals_{RL} = (A_{RL,teak,on/off} \times RF_{teak} + A_{RL,n-teak,on/off} \times RF_{n-teak}) \times t_1 + (A_{RL,teak,on/off} \times RF_{teak} + A_{RL,n-teak,on/off} \times RF_{n-teak}) \times (t_1 + t_2) + (A_{RL,teak,on/off} \times RF_{teak} + A_{RL,n-teak,on/off} \times RF_{n-teak}) \times (t_1 + t_2 + \dots)$$

Where:

A_{RL,teak,on/off} = Average net annual area teak planted (ha/year) on- and off-reserve during the reference period, where net means the area has been discounted with the assessed survival rate

RF_{teak} = Removal factor teak, mean annual increment of teak plantations (tCO₂/ha/year)

A_{RL,teak,on/of} = Average net annual area non-teak planted (ha/year) on- and off-reserve during the reference period, where net means the area has been discounted with the assessed survival rate

RF_{teak} = Removal factor teak, mean annual increment of non-teak plantations (tCO₂/ha/year)

t₁, t₂, ... = Year 1 of the crediting period, year 2 of the crediting period, etc.

⁶ GFOI (2016) Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative, Edition 2.0, Food and Agriculture Organization, Rome.

⁷ Intergovernmental Panel on Climate Change (IPCC) (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., and Wagner F (Eds). IPCC/IGES, Hayama, Japan.

Equation 10. Removals associated with average net area planted over the reference period projected over the crediting period

$$Removals_{MP} = (A_{t1,teak,on/off} \times RF_{teak} + A_{t1,nteak,on/off} \times RF_{nteak}) + [(A_{t1,teak,on/off} \times RF_{teak} + A_{t1,nteak,on/off} \times RF_{nteak}) + (A_{t2,teak,on/off} \times RF_{teak} + A_{t2,nteak,on/off} \times RF_{nteak})] + \dots$$

Where:

$A_{t1,teak,on/off}$	=	Net annual area teak planted (ha/year) on- and off-reserve during year 1 of the crediting period, where net means the area has been discounted with the assessed survival rate
$A_{t2,teak,on/off}$	=	Net annual area teak planted (ha/year) on- and off-reserve during year 2 of the crediting period, where net means the area has been discounted with the assessed survival rate
RF_{teak}	=	Removal factor teak, mean annual increment of teak plantations (tCO ₂ /ha/year)
$A_{t1,nteak,on/off}$	=	Average net annual area non-teak planted (ha/year) on- and off-reserve during year 1 of the crediting period, where net means the area has been discounted with the assessed survival rate
$A_{t2,nteak,on/off}$	=	Average net annual area non-teak planted (ha/year) on- and off-reserve during year 2 of the crediting period, where net means the area has been discounted with the assessed survival rate
RF_{nteak}	=	Removal factor non-teak, mean annual increment of non-teak plantations (tCO ₂ /ha/year)
....	=	Continued cumulative removals for subsequent years following the same calculation

UNCERTAINTY PROPAGATION

To obtain the CI around the deforestation and degradation areas per vegetation zone ($A_{v,e}$) and for the entire GCFRP landscape (A_v), the errors are propagated using equation 11 (which is the equivalent of equation 3.2 of IPCC 2019)⁸.

Equation 11 Propagation of errors for summation

$$U_{total} = \sqrt{(U_1)^2 + \dots + (U_n)^2} \quad (11)$$

where

⁸ IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

- U_{total} = the absolute uncertainty in the sum of the quantities (half the 90 percent confidence interval), e.g. $CI (\pm)$ of $A_{v,e}$ or $CI (\pm)$ of A_v
- U_j = the absolute uncertainty associated with each of the quantities $j=1,..,n$, e.g. $CI (\pm)$ of $A_{v,e,i}$

Uncertainty calculation EF

The uncertainty of the average carbon contents in the individual pools was calculated based on the sampling error (Snedecor and Cochran 1989).

Equation 12 Confidence interval (\pm) around carbon contents in the different pools

$$CI \text{ of } C_{p,e,s} = t_{0.05} \times \sqrt{\frac{StDev C_{p,e,s}}{(n_{p,e,s}-1)}} \quad (12)$$

where

- $t_{0.05}$ = the t-value for the 90% confidence level; given the relatively small sample size for some of the plot data this value is calculated
- $C_{p,e,s}$ = the carbon contents in pool p (AGB, BGB, DW, L, SOC_{REF}) from plot level FPP data, in vegetation zone e for forest structure s (s being open or closed)
- $n_{p,e,s}$ = the total number of sample plot measurements for pool p in vegetation zone e and forest structure s

For the EF calculation, the errors of the individual pools are aggregated using equation 6 (simple error propagation).

3. DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	Emissions factor for deforestation for vegetation zone e and forest structure s , $EF_{deforestation_{e,s}}$
Description:	<p>Ghana uses 10 different emissions factors for deforestation. These emission factors do not change between the reference period and monitoring period assessments.</p> <p>The different EFs are as follows:</p> <p>Deforestation in open forest⁹ in Wet Evergreen, Moist Evergreen, Moist Semi-Deciduous South-East, Moist Semi-Deciduous North-West and Upland Evergreen vegetation zones.</p> <p>Deforestation in closed forest in Wet Evergreen, Moist Evergreen, Moist Semi-Deciduous South-East, Moist Semi-Deciduous North-West and Upland Evergreen vegetation zones</p> <p>Though the above mentioned 10 EFs for deforestation remain fixed, the average EF per deforested hectare over the reference and monitoring period will differ since deforestation may target forest structure (open or closed) and vegetation zones differently over both periods (see area of deforestation monitoring below).</p> <p>The EFs in open forest are calculated using the same forest carbon contents per vegetation zone but different post-deforestation carbon contents (see $Bafter_e$ in next parameter description) per vegetation zone resulting in factors that differ slightly.</p>
Data unit:	tons of CO ₂ equivalent per ha
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national,	<p>The forest inventory data is used for the EF calculation.</p> <p>Forest inventory data was collected as part of the Forest Preservation Programme (FPP), under a Japanese Aid Grant and with technical support from Arbonaut. This study performed field measurements in 252 plots in the year 2012, of this sample, 168 plots fell within the GCFRP landscape. Full details of the inventory are available in the FPP Report on Mapping of Forest Cover and Carbon Stock in Ghana (2013)¹⁰. The Annex 4 of the first monitoring report provides additional details on the processing of the forest inventory plot level data. Figure 5,6 & 7 provides the line diagram of the forest inventory preparation, data collection and analysis. This work was undertaken in 2012 and forms the basis for the derivation of Emissions Factors used for both the Reference Level and the Monitoring Report. The available dataset used contained per hectare average aboveground carbon (AGC), belowground carbon (BGC), deadwood (standing and downed) carbon (DW), and litter (L), non-tree and soil carbon (SOC) at plot level.</p>

⁹ Note that a single EF was used for open forest. Details are in annex 4 of the first monitoring report.

¹⁰ <https://drive.google.com/drive/u/4/my-drive>

international al):	The number of plot measurements underlying the average estimates of the carbon contents of the different pools were as follows:																							
	<div>➤ 97 plot measurements were available for AGC,</div> <div>➤ 80 plot measurements were available for BGC,</div> <div>➤ 88 plot measurements were available for DW,</div> <div>➤ 89 plot measurements were available for litter,</div> <div>➤ 96 plot measurements were available for SOC.</div>																							
	For post-deforestation carbon contents, the number of measurements available were as follows:																							
	<div>➤ 11 plot measurements were available for annual cropland,</div> <div>➤ 34 plot measurements were available for perennial cropland,</div> <div>➤ 3 plot measurements were available for grassland,</div> <div>➤ 2 plot measurements were available for settlements.</div>																							
	<p>The emission factor for deforestation considers emissions from all five carbon pools. The gross EF is calculated as the sum of above-ground carbon (AGC), below-ground carbon (BGC), dead wood (DW), litter (L) and emissions from soil organic carbon (SOC). The net EF is obtained by subtracting from the gross EF the carbon stock in the post-deforestation land-use. The carbon contents in the replacing landuses are also obtained from plot measurements and a single weighted value is established per vegetation zone (so the same post-deforestation carbon contents are applied to open and closed forest), which varies between 29.0 – 64.6 tCO₂/ha (depending on the vegetation zone <i>details found in ‘ADxEF-MR2-clean-harmonised;’sheet postDef C-content cells B2toF2)</i>).</p> <p>Soil emissions are estimated using GCFRP specific values for soil carbon in forest land (i.e., SOC_{REF} in IPCC equation 2.25 is provided through the FPP inventory) applying to this the IPCC equation and Tier 1 stock change factors. The assumptions and values used are elaborated in above section “Soil emissions from deforestation”. Ghana accounts for committed emissions, meaning the SOC emissions are not projected over 20 years but accounted as emission in the year of deforestation for the sake of transparency.</p> <p><i>Average carbon contents per pool in the different strata were derived from inventory measurements (Refer to “EFs deforestation and forest degradation” in the Annex 4 of the first monitoring report</i></p>																							
Value applied:	<table><tr><th colspan="5">Net Emission Factors deforestation</th></tr><tr><th colspan="2"></th><th>tCO₂/ha</th><th>±90% CI (tCO₂/ha)</th><th>±90% CI (in percentage)</th></tr><tr><td rowspan="2">Closed Forest</td><td>Wet Evergreen</td><td>401.3</td><td>502.3</td><td>125%</td></tr><tr><td>Moist Evergreen</td><td>862.3</td><td>280.0</td><td>32%</td></tr></table>					Net Emission Factors deforestation							tCO ₂ /ha	±90% CI (tCO ₂ /ha)	±90% CI (in percentage)	Closed Forest	Wet Evergreen	401.3	502.3	125%	Moist Evergreen	862.3	280.0	32%
Net Emission Factors deforestation																								
		tCO ₂ /ha	±90% CI (tCO ₂ /ha)	±90% CI (in percentage)																				
Closed Forest	Wet Evergreen	401.3	502.3	125%																				
	Moist Evergreen	862.3	280.0	32%																				

		Moist Semi-deciduous NW	435.9	76.3	18%
		Moist Semi-deciduous SE	665.7	312.4	47%
		Upland Evergreen	494.9	141.8	29%
	Open Forest	Wet Evergreen	169.3	102.4	61%
		Moist Evergreen	162.8	59.8	37%
		Moist Semi-deciduous NW	160.3	54.3	34%
		Moist Semi-deciduous SE	174.3	52.9	30%
		Upland Evergreen	196.0	64.0	33%
QA/QC procedures applied	The inventory data management workflow includes Quality Assurance and Quality Control procedures.12 plots were visited in the field for quality control, representing 4.1 per cents of the plots with measured data, details in Section 4 of FPP Report 2013. The average differences between the original and quality control measurements are found statistically insignificant (t-test), the maximum average diameter and height differences are found to be up to 11.5 cm and 8.5 meter based on the field measurements excluding the outlier plots. For 75 percent of the plots AGC and BGC values deviate less than 30 percent between two measurement times. There are two outlier plots where the large deviation compared to the original measurements suggests that the plot locations are not matching precisely. Some of the differences can be attributed to harvesting activities. Source: section 4.1.4 of The FPP Report on Mapping of Forest Cover and Carbon Stock in Ghana (2013). http://www.ghanaredddatahub.org/home/downloadreport/?docName=Ghana_Final_Report_Main.pdf&mime=application%2Fpdf Finally, the average carbon stock values per forest structure/vegetation zone have been compared against the IPCC default ranges available showing the values are within the expected ranges.				
	Uncertainty associated with this parameter:	The table above provides the 90% confidence interval for all fixed variables reported. The uncertainty of the individual pools was calculated with equation 8 (see section 2.2.2) and the uncertainties are aggregated through simple error propagation (see equation 4)			
Any comment:	Ghana does not have access to multiple inventory assessments over time. As such, the only component of the EF calculation that could change is the calculation of post-deforestation carbon contents since this is based on the AD observations of the LU replacing forest over the 2005-2014 period. Post-deforestation carbon contents are discussed in the following parameter box.				

Parameter:	Weighted post-deforestation carbon contents, <i>Bafter_e</i> (interim in EF calculation)																													
Description:	<p>This is the average weighted carbon contents in the landuse replacing forest in case of deforestation. This value is subtracted from the forest carbon stock to get the net per hectare emission factor associated with deforestation. The post-deforestation carbon contents are averaged at the vegetation zone level and the same average value is used when open- or closed forest is deforested. The same values are used for the reference and monitoring periods</p> <p>(see Comment below)</p>																													
Data unit:	tons of CO ₂ equivalent per ha																													
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>This information is a combination of the SLMS and FPP.</p> <p>In the sample unit assessment of the SLMS, for each deforestation plot the land-use after deforestation is assessed. Accordingly, the proportion of post-deforestation land-use (annual cropland, perennial cropland, grassland, settlement) is calculated, and these proportions are used to calculate the weighted post-deforestation carbon contents.</p> <p>In analyzing the FPP inventory data, the value of perennial and annual cropland is recalculated using only plots for which field observations were available. The analysis suggests an average carbon contents of 5 tC/ha for annual cropland and 27.3 tC/ha for perennial cropland.</p>																													
Value applied:	<table><tr><td></td><td>Wet Evergreen</td><td>Moist Evergreen</td><td>Moist Semideciduous NW</td><td>Moist Semideciduous SE</td><td>Upland Evergreen</td></tr><tr><td>Post-deforestation C contents</td><td>55.7</td><td>62.2</td><td>64.6</td><td>50.7</td><td>29.0</td></tr><tr><td>(in tCO₂/ha)</td><td>92.9</td><td>41.3</td><td>33</td><td>30.6</td><td>47.3</td></tr><tr><td>±90% CI</td><td>167%</td><td>66%</td><td>51%</td><td>60%</td><td>163%</td></tr></table> <p><i>CI's in the table are actual CI's, in the calculations this values is doubled (see comment under uncertainty associated with the parameter)</i></p>							Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen	Post-deforestation C contents	55.7	62.2	64.6	50.7	29.0	(in tCO ₂ /ha)	92.9	41.3	33	30.6	47.3	±90% CI	167%	66%	51%	60%	163%
	Wet Evergreen	Moist Evergreen	Moist Semideciduous NW	Moist Semideciduous SE	Upland Evergreen																									
Post-deforestation C contents	55.7	62.2	64.6	50.7	29.0																									
(in tCO ₂ /ha)	92.9	41.3	33	30.6	47.3																									
±90% CI	167%	66%	51%	60%	163%																									
QA/QC procedures applied	<p>The inventory data management workflow includes Quality Assurance and Quality Control procedures. 12 plots were visited in the field for quality control, representing 4.1 per cents of the plots with measured data, details in Section 4 of FPP Report 2013.</p> <p>.</p> <p>The average differences between the original and quality control measurements are found statistically insignificant (t-test), the maximum average diameter and height differences are found</p>																													

	<p>to be up to 11.5 cm and 8.5 meter based on the field measurements excluding the outlier plots. For 75 percent of the plots AGC and BGC values deviate less than 30 percent between two measurement times. There are two outlier plots where the large deviation compared to the original measurements suggests that the plot locations are not matching precisely. Some of the differences can be attributed to harvesting activities. Source: section 4.1.4 of The FPP Report on Mapping of Forest Cover and Carbon Stock in Ghana (2013)</p> <p>http://www.ghanaredddatahub.org/home/downloadreport/?docName=Ghana_Final_Report_Main.pdf&mime=application%2Fpdf</p>
Uncertainty associated with this parameter:	The tables above provide the 90% confidence interval for all fixed variables reported. However, the calculation of the confidence interval is simplified as it does not consider the proper weights of the different strata. To avoid under-estimating the uncertainty through this simplification, the confidence interval is doubled and its impact is assessed and evaluated as insignificant.
Any comment:	In the ERPD many different values are proposed for the post-deforestation carbon contents, originating from a mix of the FPP inventory, Kongsager et al 2013 and IPCC. The cropland estimates from the FPP inventory range between 30-51 tC/ha. The new analysis of the FPP inventory discussed above finds an average for open forest carbon stock in biomass at 37,7 tC/ha. Considering the description of cropland in the ERPD being “herbaceous and slash-and-burn”, the values between 30-51 tC/ha seem therefore too high. The newly calculated weighted average post deforestation carbon contents range between 29.0-64.6 tCO ₂ /ha for the five different vegetation zones for the period 2005-2014. There is however a lot of uncertainty in the determination of the post-deforestation landuse, especially for the more recent years where a time series of the post-deforestation landuse is not yet available and it may be challenging to distinguish between annual and perennial cropland. Also, for annual or biennial estimates (monitoring period) the uncertainty is much larger than for 10-year estimates (reference period) since the observations will be much fewer. Given the high uncertainties around the estimation of post-deforestation landuse over the monitoring period, it was opted to keep this variable stable such that it will not impact the ER calculation.

Parameter:	Emissions factor for forest degradation for vegetation zone <i>e</i> , forest structure <i>s</i> <i>EF_degradation_{e,s}</i>
Description:	<p>Ghana uses 6 different emission factors for forest degradation. These emission factors will not change between the reference period and monitoring period assessments.</p> <p>Different EFs have been used for degradation in closed forest in Wet Evergreen, Moist Evergreen, Moist Semi-Deciduous South-East, Moist Semi-Deciduous North-West and Upland Evergreen vegetation zones, and one EF for degradation in open forest (all vegetation zones)</p>
Data unit:	tons of CO ₂ equivalent per ha
Source of data or description	This information is a combination of the SLMS and FPP.

of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>Emissions factors were derived from inventory measurements multiplied by the relative percentage canopy cover reduction observed in all degradation plots over the reference period. Total forest carbon stock by vegetation zone for open and closed forest was collected under the Forest Preservation Programme (FPP), as explained in detail in the parameter description of EF for deforestation.</p> <p>To make sure that the estimated amount of CO₂ emitted per hectare forest that is degraded corresponds to the assessed hectares of forest degradation, the remote sensing interpreters assessed the average tree cover prior to and after a degradation event. The underlying assumption is that canopy cover reduction is a good approximation of biomass reduction in a plot. This way, the average canopy cover reduction in open forest and closed forest is assessed. In the data set, 64 points for which forest degradation was assessed over the years 2005-2014 fall in the GCFRP landscape. For 55% of the forest degradation points the cause of degradation was assessed to be logging. The majority of forest degradation emissions were assessed to originate from logging though representing <i>a much higher share (95%)</i>.</p> <p>The average relative canopy cover reduction in closed forest was 29.9 %, while the average relative canopy cover reduction in open forest was 48.0 %. The carbon pools affected by forest degradation are AGC, BGC and DW. The percentage reductions assessed (using activity data) are applied to these pools to calculate the change in AGC, BGC and DW pools resulting from degradation. The emission factors for degradation are calculated by multiplying the percentage reductions with the pre-degradation carbon contents in the pools provided.</p>																																				
Value applied:	<table><tr><th colspan="5">Emission Factors forest degradation</th></tr><tr><th colspan="2"></th><th>tCO₂/ha</th><th>±90% CI (tCO₂/ha)</th><th>±90% CI (in percentage)</th></tr><tr><td rowspan="5">Closed Forest</td><td>Wet Evergreen</td><td>132.3</td><td>203.0</td><td>153%</td></tr><tr><td>Moist Evergreen</td><td>271.7</td><td>107.6</td><td>40%</td></tr><tr><td>Moist Semi-deciduous NW</td><td>146.3</td><td>36.2</td><td>25%</td></tr><tr><td>Moist Semi-deciduous SE</td><td>210.6</td><td>133.5</td><td>63%</td></tr><tr><td>Upland Evergreen</td><td>154.1</td><td>60.3</td><td>39%</td></tr><tr><td>Open Forest</td><td>All vegetation zones</td><td>102.5</td><td>66.8</td><td>65%</td></tr></table>	Emission Factors forest degradation							tCO ₂ /ha	±90% CI (tCO ₂ /ha)	±90% CI (in percentage)	Closed Forest	Wet Evergreen	132.3	203.0	153%	Moist Evergreen	271.7	107.6	40%	Moist Semi-deciduous NW	146.3	36.2	25%	Moist Semi-deciduous SE	210.6	133.5	63%	Upland Evergreen	154.1	60.3	39%	Open Forest	All vegetation zones	102.5	66.8	65%
Emission Factors forest degradation																																					
		tCO ₂ /ha	±90% CI (tCO ₂ /ha)	±90% CI (in percentage)																																	
Closed Forest	Wet Evergreen	132.3	203.0	153%																																	
	Moist Evergreen	271.7	107.6	40%																																	
	Moist Semi-deciduous NW	146.3	36.2	25%																																	
	Moist Semi-deciduous SE	210.6	133.5	63%																																	
	Upland Evergreen	154.1	60.3	39%																																	
Open Forest	All vegetation zones	102.5	66.8	65%																																	
QA/QC procedures applied	Data are taken from SLMS and FPP project. See the FPP Report on Mapping of Forest Cover and Carbon Stock in Ghana (2013), section 4.1.4																																				

	<p>SLMS: It is good practice to implement Quality Assurance / Quality Control (QA/QC) procedures in the phases of design, implementation and analysis. QA/QC procedures contribute to improve transparency, consistency, comparability, and accuracy (IPCC, 2006). Experts in forestry and remote sensing with knowledge of the landscape were engaged to collect the sample data that was used to derive activity data. Training and calibration took place before the data collection, as well as during the data collection exercise to ensure consistency, comparability and accuracy. Before the data collection, a 6 day training¹¹ was carried out where experts jointly revised the classification hierarchy and reviewed several sampling plots together to enhance internal consistency.</p> <p>Experts documented examples of different land use and land use change classes in different sources of imagery in the SOP¹² to achieve a mutual understanding of the classification system and how to identify stable land use, land use change and degraded land use classes. The data collection efforts were conducted in a group setting, where experts gathered and interpreted the sample data in the same room. If an expert had any doubt in the sample classification, the plot was displayed on a projector and all experts intervened to accurately classify the sample.</p> <p>QA/QC measures were built into the response design, to avoid mistakes or inconsistencies in data collection. Errors such as inconsistencies according to the classification hierarchy, land cover classes adding up to more than 100% cover and missing information or incomplete responses are flagged with error messages and the expert must correct the errors before continuing to the next sample.</p> <p>To assess the level of interpreter agreement, 1052 plots (14%) were blindly re-assessed by a different interpreter. The overall agreement of this double-blind assessment was 87%, i.e. an improvement compared to the 2020 assessment, which saw an overall agreement of 82%.</p> <p>FPP project: The inventory data management workflow includes Quality Assurance and Quality Control procedures. 12 plots were visited in the field for quality control, representing 4.1 per cents of the plots with measured data, details in Section 4 of FPP Report 2013.</p> <p>The average differences between the original and quality control measurements are found statistically insignificant (t-test), the maximum average diameter and height differences are found to be up to 11.5 cm and 8.5 meter based on the field measurements excluding the outlier plots. For 75 percent of the plots AGC and BGC values deviate less than 30 percent between two measurement times. There are two outlier plots where the large deviation compared to the original measurements suggests that the plot locations are not matching precisely. Some of the differences can be attributed to harvesting activities.</p>
--	---

¹¹ <http://www.ghanaredddatahub.org/settings/uploadreports/>

¹² <http://www.ghanaredddatahub.org/settings/uploadreports/>

Uncertainty associated with this parameter:	The table above provides the 90% confidence interval for all fixed variables reported. These intervals were calculated propagating the errors around the pre-degradation carbon contents and the error around the average relative canopy cover reduction (Table 35 in Annex 4 of the first monitoring report, section 8.3).
Any comment:	

Parameter:	Removal factor for teak (RF_{teak})
Description:	Calculated removal factor for carbon stock enhancement through plantation of teak in forest reserves (AGB and BGB)
Data unit:	$t\ CO_2\ ha^{-1}\ yr^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>Published literature (Adu-Bredu S., et al. 2008, https://doi.org/10.1016/j.foreco.2007.12.052) on total tree carbon stocks in teak stands in Moist Evergreen forest in Ghana (98 Mg C/ ha) (included both aboveground and belowground carbon stocks).</p> <p>98 Mg C/ ha = 358 t CO₂/ha Annual removals: $358\ t\ CO_2ha^{-1} / 25\ yr = 14\ t\ CO_2ha^{-1}\ yr^{-1}$</p>
Value applied:	$14\ t\ CO_2\ ha^{-1}\ yr^{-1}$
QA/QC procedures applied	N/A
Uncertainty associated with this parameter:	<p>Adu-Bredu et al. (2008) was completed using temporary sample plots following standard operating procedures for the measurement of terrestrial carbon.</p> <p>While only the total tree carbon stocks were used for the development of removal factors, an estimation of statistical accuracy was offered in the form of the mean, minimum, and maximum carbon values for the total carbon stocks of the teak stands studied in the Moist Evergreen Forest strata, as well as the standard deviation:</p> <p>Mean: 138 Minimum: 133 Maximum: 144</p> <p>Based on these values, uncertainty could be 6% of the mean. However, to be more conservative, uncertainties in the removal factors are approximated using an average</p>

	standard error value for teak from Bombelli and Valentini 2011 ¹³ and a standard error value from IPCC 2019 ¹⁴ for the root-to-shoot ratio.
Any comment:	

Parameter:	Removal factor for other broadleaf species (RF_{ntek})
Description:	Calculated removal factor for carbon stock enhancement through plantation of trees (non-teak) in forest reserves (AGB and BGB)
Data unit:	$t\ CO_2\ ha^{-1}\ yr^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>IPCC AFOLU Vol. 4 table 4.8 above-ground biomass in forest plantations. Values for 'Africa broadleaf >20 years' for three ecological zones in the GCFRP Accounting Area (tropical rain forest, tropical moist deciduous forest, and tropical dry forest) were averaged, and converted to carbon ($81\ t\ C/ha$) using a carbon-to-biomass ratio of 0.47. The belowground biomass value was generated by applying a root-to-shoot ratio of 0.24 for tropical/subtropical moist forest/plantations $>125\ Mg\ ha^{-1}$ (Mokany et al.2006). This rendered a total stock of $101\ t\ C/ha$.</p> <p>$101\ Mg\ C\ ha^{-1} = 370\ t\ CO_2\ ha^{-1}$</p> <p>Annual removals: $370\ t\ CO_2\ ha^{-1} / 40\ yr = 9\ t\ CO_2\ ha^{-1}\ yr^{-1}$</p>
Value applied:	$9\ t\ CO_2\ ha^{-1}\ yr^{-1}$
QA/QC procedures applied	N/A
Uncertainty associated with this parameter:	<p>For the development of this parameter, IPCC defaults for aboveground biomass in forest plantations in Africa were applied. Given they are continental averages for all broadleaf species, uncertainty can be assumed to be high.</p> <p>Belowground biomass stocks are produced using a root-to-shoot ratio (Mokany et al., 2006), and therefore values are tied to the estimates for aboveground biomass</p> <p>Uncertainties are approximated using a standard error value from IPCC 2019¹⁵ for the biomass values and root-to-shoot ratios.</p>
Any comment:	

¹³ Bombelli A., Valentini R. (Eds.), 2011. Africa and Carbon Cycle. World Soil Resources Reports No. 105. FAO, Rome. <http://www.fao.org/3/i2240e/i2240e.pdf#page=108>

¹⁴ https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf#page=26

¹⁵ https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf#page=26

3.2 Monitored Data and Parameters

Parameter:	Area of deforestation, in vegetation zone e , in forest structure s , $A_{def,e,s}$ Area of degradation, in vegetation zone e , in forest structure s , $A_{degr,e,s}$
Description:	Area of forest converted to non-forest and area of forest experiencing forest degradation.
Data unit:	Hectares per annum
Value monitored during this Monitoring / Reporting Period:	<p><u>Sampling design</u></p> <p>Following extensive analyses of various maps, land use change products and combinations of land use change products, Ghana updated its SLMS to make use of a nested multi-scale systematic sampling grid, where the sampling intensities were as follows: outside the forest mask (and outside upland evergreen vegetation zone) the sampling intensity was 4 x 4 km, inside the forest mask (and outside upland evergreen vegetation zone) the sampling intensity was 2 x 2 km, and inside the upland evergreen vegetation zone the sampling intensity was 1 x 1 km. The forest mask is a combination of the four Landsat maps. The intensification on the forest mask was done to increase efficiency of the AD assessment since the expectation was to find more deforestation and forest degradation within the forest mask. The intensification in the upland evergreen was done since the upland evergreen constitutes a very small area, therefore a high plot intensity was needed for a statistically meaningful estimate. Not all plots on the 2 x 2 km and 1 x 1 km grids have been collected, instead a random selection of plots have been collected on this intensified grid until the overall sample size target was met, i.e. the intensified grid has random gaps. There are no gaps in the 4 x 4 km grid (see Figure 3). Given the confidence level (i.e., 90%), the significance level is $\alpha=1$-confidence level, an approximate estimated total sample size n is assessed by equation 1 (Cochran 1977¹⁶).</p> <p><i>Equation 1 Formula to determine overall sample size:</i></p> $n \approx \frac{z_{\alpha/2}^2 \cdot \hat{O} \cdot (1-\hat{O})}{d^2} \quad (3)$ <p>where</p> <p>\hat{O} = expected overall feature area expressed as a fraction</p> <p>z = percentile from the standard normal distribution ($z = 1.645$ for a 90% confidence in 1.64 is used in the simple error propagation)</p>

¹⁶ Cochran, W. G. (1977). Sampling techniques (3rd ed.). New York: John Wiley & Sons.

the allowable margin of error. This is the maximum half-width of the confidence interval we aim d = towards in our estimate. It is given as area fraction, not as percentage. It should be the precision level, taken as a confidence interval, required for the feature to measure.

Following a national data collection campaign as part of the “National Land Monitoring and Information System for a transparent NDC reporting” project, which made use of an 8 x 8 km grid, Ghana used equation 1 above to intensify the sampling grid using a nested multi-scale approach guided by a consolidated forest cover mask of the GCFRP area. Table 4 provides the sample size for each grid.

Table 6: Sample plot size and distribution in GCFRP

	# plots	Area (ha)	Proportion
Outside forest mask (4 x 4 km grid)	2070	2 555 905	0.4321
On forest mask (2 x 2 km grid)	5 239	3 295 919	0.5573
In upland evergreen ecozone (1 x 1 km grid)	393	62 601	0.0106
Total	7 702	5 914 425	1.0000

This sampling intensity will also be used for future monitoring periods (2020,2021).

Response design

The response design used for the collection of land use change data using the sampling grid mentioned above. A more detailed discussion regarding the decisions made by Ghana can be found in the FREL amendment document contained in Annex 4 to the first monitoring report. The same response design was used for both the Reference Level analysis and the Monitoring activities documented in this report.

	Deforestation	Open Forest		Closed Forest	
		2020 Def (ha/yr)	2020 CI (ha)	2020 Def (ha/yr)	2020 CI (ha)
	Wet Evergreen	-	-	-	-
	Moist Evergreen			1,271	2,084
	Moist Semideciduous NW	-	-		
	Moist Semideciduous SE	-	-	640	1,050
	Upland Evergreen	-	-	-	-
	Deforestation	Open Forest		Closed Forest	
		2021 Def (ha/yr)	2021 CI (ha)	2021 Def (ha/yr)	2021 CI (ha)
	Wet Evergreen				
	Moist Evergreen	638	1,046		
	Moist Semideciduous NW			3,094	2,266
	Moist Semideciduous SE			640	1,050
Upland Evergreen			159	261	
Degradation	Open Forest		Closed Forest		
	2020 Deg (ha/yr)	2020 CI (ha)	2020 Deg (ha/yr)	2020 CI (ha)	
	Wet Evergreen				
Moist Evergreen			638	1.046	

	Moist Semideciduous NW			619	1,015
	Moist Semideciduous SE			1,280	1,484
	Upland Evergreen				
	Degradation	Open Forest		Closed Forest	
		2021 Deg (ha/yr)	2021 CI (ha)	2021 Deg (ha/yr)	2021 CI (ha)
	Wet Evergreen			606	994
	Moist Evergreen			638	1,046
	Moist Semideciduous NW			3,688	2,840
	Moist Semideciduous SE	1,283	1,487	2,491	2,479
	Upland Evergreen			319	369
Source of data and description of measurement /calculation methods and procedures applied:	<p>Activity data estimates reflecting deforestation and forest degradation were derived from sample-point interpretation. The sample point data set consisted of 7702 samples points systematically located across the GCFRP region on a nested, multi-scale grid with random gaps. During the preparation of the ERPD as well as the amendment to the ERPD, Ghana explored the use of several different data sets and analysis methods for stratifying the area into suitable land cover change classes. Post stratification did not appear to improve the reported confidence intervals and as such, no change maps were used to stratify the area. A detailed description of the establishment of the sample size, sample design and response design is provided in Section 2.2 and Annex 4 of the first monitoring report (section 8.3).</p>				
QA/QC procedures applied:	<p>It is good practice to implement Quality Assurance / Quality Control (QA/QC) procedures in the phases of design, implementation and analysis. QA/QC procedures contribute to improve transparency, consistency, comparability, and accuracy (IPCC, 2006). In line with the SOP, before the data collection, experts in forestry and remote sensing with knowledge of the landscape were engaged to collect the sample data that was used to generate the activity data. With the training report from the 2019 data collection as an additional reference document, refresher training and calibration took place before the data collection, as well as during the data collection exercise to ensure consistency, comparability and accuracy.</p>				

	<p>Experts documented examples of different land use and land use change classes in different sources of imagery in the SOP to achieve a mutual understanding of the classification system and how to identify stable land use, land use change and degraded land use classes.</p> <p>QA/QC measures were built into the response design, to avoid mistakes or inconsistencies in data collection. Errors such as inconsistencies according to the classification hierarchy, land cover classes adding up to more than 100% cover and missing information or incomplete responses are flagged with error messages and the expert must correct the errors before continuing to the next sample.</p> <p>To assess the level of interpreter agreement, 1052 plots (14%) were blindly re-assessed by a different interpreter. The overall agreement of this double-blind assessment was 87%, i.e. an improvement compared to the 2020 assessment, which saw an overall agreement of 82%.</p>
Uncertainty for this parameter:	The uncertainty estimates (90% confidence intervals in hectares) are provided in the table above. The uncertainty around the areas of deforestation and forest degradation is calculated using equation 3 in section 2.2.2 and propagated using equation 4 in section 2.2.2 (simple error propagation).
Any comment:	The data collection efforts were conducted in a group setting, where experts gathered and interpreted the sample data in the same room and resolve sub-tile difference in the landuse and associated changes. If an expert had any doubt in the sample classification, the plot was displayed on a projector and all experts intervened to accurately classify the sample.

Parameter:	Teak and broadleaf areas of on- and off-reserve planting for the reference level and monitoring period, discounted with failure rate ($ARL_{teak,on}$, $ARL_{teak,off}$, $ARL_{nteak,on}$, $ARL_{nteak,off}$, $AMP_{teak,on}$, $AMP_{teak,off}$, $AMP_{nteak,on}$, $AMP_{nteak,off}$)				
Description:	Area of non-forest converted to forest area (enhancement)				
Data unit:	Hectares per annum				
Value monitored during this Monitoring / Reporting Period:		NFPDP data			
		Off-reserve planted area (ha)	Survival Rate	On-reserve planted area (ha)	Survival Rate
	2020	12,696	55%	6,566	55%
	2021	43,635	55%	12,282	55%
Source of data and description of	The activity data used for the estimation of removals was derived from national census data, reported by the National Forest Plantation Development Programme. Plantation's				

measurement /calculation methods and procedures applied:	Department of Forestry Commission undertakes an annual survival survey of all planted sites from which the survival rates were derived.																							
QA/QC procedures applied:	<p>Data from National Forest Plantation Development Program (NFPDP).</p> <p>The plantation statistics are first collected at the Forest District Levels. These are then sent to the National through the Regional Levels. In the succeeding year of data collection. Teams are sent from the national level to verify the survival rate of each area planted. These are then used in annual plantation reports. The links to the annual plantation reports are indicated below:</p> <p>2020 plantation annual report</p> <p>https://fcghana.org/?p=3362</p> <p>2021 plantation annual report</p> <p>https://fcghana.org/?p=3501</p>																							
Uncertainty for this parameter:	<p>Being national statistics, no sampling error can be calculated to approximate an associated confidence intervals around the area statistics. As such, no uncertainty is assumed around AD.</p> <p>Moreover, neither the FCPF Methodological Framework nor the 2020 guidelines on uncertainty analysis speak to plantation data, no guidance is provided on how to treat national census data</p>																							
Any comment:	<table border="1"> <thead> <tr> <th>Reference level</th><th></th><th>Average ha/year</th><th>Projected removals in 2020 & 2021 (tCO₂)</th></tr> </thead> <tbody> <tr> <td rowspan="4">Reference level projected reforestation in 2020</td><td>Teak</td><td>1,340</td><td>-19,203</td></tr> <tr> <td>Non-Teak</td><td>574</td><td>-5,318</td></tr> <tr> <td>Teak</td><td>1,340</td><td>-19203</td></tr> <tr> <td>Non-Teak</td><td></td><td>-5318</td></tr> <tr> <td>Total carbon stocks changes (tCO₂)</td><td></td><td></td><td>-49,041</td></tr> </tbody> </table>			Reference level		Average ha/year	Projected removals in 2020 & 2021 (tCO ₂)	Reference level projected reforestation in 2020	Teak	1,340	-19,203	Non-Teak	574	-5,318	Teak	1,340	-19203	Non-Teak		-5318	Total carbon stocks changes (tCO₂)			-49,041
Reference level		Average ha/year	Projected removals in 2020 & 2021 (tCO ₂)																					
Reference level projected reforestation in 2020	Teak	1,340	-19,203																					
	Non-Teak	574	-5,318																					
	Teak	1,340	-19203																					
	Non-Teak		-5318																					
Total carbon stocks changes (tCO₂)			-49,041																					

		Reference level projected reforestation in 2021	Teak	1,340	-19,203	
			Non-Teak	574	-5,318	
			Teak	1,340	-19,203	
			Non-Teak	574	-5,318	
			Teak	1,340	-19,203	
			Non-Teak	574	-5,318	
		Total carbon stocks changes (tCO ₂)			-73,561	

Monitoring period		ha/year	Actual removals in 2020 & 2021
Actual reforestation in 2020	Teak	9,505	-136,181
	Non-Teak	4,073	-37,713
	Teak	7416	-106,255
	Non-Teak	3,178	-29,425.3
	Total carbon stock changes (tCO ₂)		-309,574
	Teak	9,505	-136,181
	Non-Teak	4,073	-37,713

		Actual reforestation in 2021	Teak	7,416	-106,255	
			Non Teak	3,718	-29,425	
			Teak	21528.09	-308,452	
			Non-Teak	9226.32	-85,419.7	
		Total carbon stock changes (tCO₂)			-703,445	

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring / Reporting Period covered in this report

Year of Monitoring/Reporting period t	Average annual historical emissions from deforestation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO ₂ -e/yr)	Adjustment, if applicable (tCO ₂ -e/yr)	Reference level (tCO ₂ -e/yr)
2020	3,737,815	867,069	-49,041		4,555,843
2021	3,758,091	867,069	-73,561		4,551,598
Total	7,495,906	1,734,138	-122,602		9,107,441

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

Section 2.2 provides all explanations, data and equations used for the quantification of the emissions

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO ₂ -e/yr)	If applicable, emissions from forest degradation (tCO ₂ -e/yr)*	If applicable, removals by sinks (tCO ₂ -e/yr)	Net emissions and removals (tCO ₂ -e/yr)
2020	1,526,956	533,350	-309,574	1,750,732
2021	1,967,315	1,497,898	-703,445	2,761,768
Total	3,494,271	2,031,248	-1,013,019	4,512,500

4.3 Calculation of emission reductions

The Reporting Period concerns the period 01-01-2020 to 31-12-2021

Total Reference Level emissions during the Reporting Period (tCO₂-e)	9,107,441
Net emissions and removals under the ER Program during the Reporting Period (tCO₂-e)	4,512,500
Emission Reductions during the Reporting Period (tCO₂-e)	4,594,941

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

As per the requirements in criterion 7 of the methodological framework, a Monte Carlo simulation was undertaken.

The “Guideline on the application of the Methodological Framework Number 4 On Uncertainty Analysis of Emission Reductions” lays out the following sources of (residual) uncertainty (details in table 6 below) that must be included in this analysis:

- Activity data:
 - Measurement
 - Representativeness
 - Sampling
 - Extrapolation
 - Approach 3
- Emission factors:
 - DBH measurement
 - H measurement
 - Plot delineation
 - Wood density estimation
 - Biomass allometric model
 - Sampling
 - Other parameters (e.g., carbon fraction, root-to-shoot ratios)
 - Representativeness
- Integration:
 - Model
 - Integration

These sources of uncertainty were considered as follows.

- Activity data sampling uncertainty was taken into account by estimating the mean area change and its standard error from the systematic sampling of land-use change. The means and standard errors were estimated separately on a per forest stratum basis.
- Emission factor sampling uncertainty was taken into account by estimating the mean biomass and its standard error from the forest inventory plots. The means and standard errors were estimated separately for each forest stratum and separately for the carbon pools.
- The uncertainty related to the biomass allometric equations was not taken into account (see below)
- Other parameters related to emission factors that were modelled include the biomass of post-deforestation land use, the Carbon Fraction of biomass in tree plantations, the root-shoot ratio in tree plantations, the average carbon stock in tree plantations, the relative biomass reduction upon forest degradation. Where relevant, these parameters were modelled separately for carbon pools and for forest strata. Regarding the deforestation and forest degradation emission factors, the carbon fraction and the root-shoot ratio could not be separately modelled because biomass was calculated at the plot level and plot-level measurements were not available. Hence both are used as fixed parameters.

The absence of reliable tree level data in the 168 plots used for the emission factor estimation in the area, together with a lack of some basic error parameters in the allometric equations used, such as mean squared errors at the very least, make the calculation of errors at the tree scale impossible. Even counting on the original tree level data (as opposed to the current plot-level aggregates) the number of assumptions necessary to derive model errors might involve undesirable levels of risk.

Correlation between the input parameters was handled by ensuring that each parameter appears only once in the model. For example, the forest AGB of a given stratum is only simulated once and all other instances of forest AGB refer to it. This made the use of covariance matrices unnecessary.

- Probability density functions for the modelled parameters were defined following the decision tree provided in the guidance. Accordingly, a goodness-of-fit test was undertaken where raw data were available, and an expert elicitation was undertaken where raw data were not available. Most PDFs chosen were based on Gaussian curves. Although in some cases with very low figures a Gaussian fit with a large standard error may give rise to unrealistic negative numbers, truncated normal approaches were discarded since they would be only useful for a handful of cases and, if correlations are to be taken, the computational complexity of choosing multivariate truncated normal becomes cumbersome. For degradation, a natural beta distribution¹⁷ of canopy cover reduction as an indicator of biomass reduction was used for the fraction of plots that underwent degradation. The choice of a beta model distribution encompasses the quantity of cover reduction. The choice may introduce some degree of bias. However since it is such a rare event, its contribution to overall uncertainty is small. Although the parallels are not clear, the beta distribution can ease the propagation of random errors, although biases are likely to appear because of the more than possible non-linear relationship between canopy cover and biomass reductions, (Ferrari, S. & Cribari-Neto, F. 2004) ; <https://doi.org/10.1080/0266476042000214501>

• ¹⁷ Ferrari, S. & Cribari-Neto, F. 2004; <https://doi.org/10.1080/0266476042000214501>

Table 7: Sources of Uncertainty to be considered under the FCPF Methodological Framework

Source s of uncerta inty	System atic/ Rando m	Analysis of contribution to overall uncertainty	Contribu tion to overall uncertai nty (High / Low)	Addre ss throu gh QA/Q C	Residual uncertai nty estimat ed?
Activity Data					
Measur ement	S/R	<p>Source of error still being subject of academic research. It is potentially subject to both bias and random error and may also potentially contribute significantly to overall uncertainty. It was addressed through QA/QC protocols by :</p> <ol style="list-style-type: none"> 1. Developing specific manuals (SOPs) and through several capacity building workshops. These materials were used as guidance for refresher training for data collectors. <p><i>Link to the specific SOP and training workshop reports and presentations indicated in the link below</i></p> <p>http://www.ghanaredddatahub.org/doclibrary/sops/</p> <p>https://drive.google.com/drive/folders/1VjluJSro01r0mbroWM6OK3nCIAXDyEXC?usp=share_link</p> <ol style="list-style-type: none"> 2. Dubiously identified sampling plots were discussed through consensus among interpreters. 3. Use of high resolution imagery (through different sources) that minimizes possible interpretation errors 4. Data collectors have gained experience in interpretations due to consistency in the personeel who collect the data <p>Other measurement errors may potentially be applicable, such as those associated to remote sensors and their spectral and spatial resolutions. However these are almost never applied beyond some academic exercises.</p>	H (bias/ran dom)	YES	NO

		The contribution of measurement error to the overall uncertainty is potentially high (both through random and systematic error) but the QA/QC (refer to points 1 -4 above) applied should have minimized this as much as practicable. No residual uncertainty is included in the estimate.			
Representativeness	S	<p>The sampling design followed strict procedures through the use of systematic grids (refer to SOPs), with the aim to produce proper allocation according to strata. As such, only possible errors in the definition of strata from satellite imagery seem plausible in regard to producing potential biases. However, the sampling methodology within the strata was robust.</p> <p>The expected impact from representativeness on the overall uncertainty is low (through systematic error) but the QA/QC applied within the strata should have minimized the remaining error in as much as practicable. No residual uncertainty is included in the estimate.</p>	L (bias)	YES	NO
Sampling	S/R	<p>The choice of estimator was based on a ratio-based approach, which is in principle tend to provide higher biases, but the high number of samples in the stratified scheme is expected to minimize that bias. Random error has been shown to be lower than with the use of purely regression-based estimators or simple means. Yet, sampling errors in AD are in practical large-scale applications always high overall. QA/QC procedures (http://www.ghanaredddatahub.org/settings/uploadreports/) led to intensification and an increase in sampling size to minimize sampling errors, including revision of sample allocation through the strata.</p> <p>The contribution of sampling error to the overall uncertainty is high (both through random and systematic error) but the QA/QC applied should have minimized this as much as practicable. Residual uncertainty is included in the estimate.</p>	H (bias/random)	YES	YES
Extrapolation	S	This source of error has been minimized due to the alignment between forest types as reporting domains with strata in the design. Hence, for example deforestation is calculated independently for each stratum that is also a certain forest type reported.	L(bias)	YES	NO

		The expected impact from extrapolation on the overall uncertainty is low (through systematic error) but the QA/QC applied within the strata should have minimized the remaining error this as much as practicable. No residual uncertainty is included in the estimate.			
Approach 3		The approach taken is a sampling approach that allows land-use conversions to be tracked on a spatially explicit basis			
Emission factor					
DBH measurement error	R	<p>Absence of tree-level data. Errors in DBH measurements are usually small (Picard 2015) and considered to cancel out when aggregation from tree to plots take place (Yanai et al. 2010, Holdaway et al. 2014).</p> <p>The expected impact from DBH measurement on the overall uncertainty is low (through random error). QA/QC (SOP 1.1 and 1.2 prescribes the use of combining uncertainties) has been applied and should have minimized the remaining error as much as practicable. No residual uncertainty is included in the estimate.</p>	L(random)	YES	NO
H measurement error	S/R	<p>Absence of tree-level data. Tree height tends to present lower precisions, and it is highly variable and site-dependent. Clinometer-measured heights have also shown to present consistent biases of approx. 1 m. for trees > 20 m. As a consequence per ha scale, it has been reported to give AGB uncertainties of 5-6% that can also present high biases. Although precision is reduced when aggregating at large scales due to cancelling out random errors, biases do propagate, in some cases reportedly showing 4% overestimation in AGB (Hunter et al. 2013). Field trainings took place with Arbonaut, linked to LIDAR measurements.</p> <p>(Refer to manuals 5.1.2, 5.3 and 5.4, link same as above)</p> <p>This linkage implicitly helps quality assurance through contrasting tree height measurements with those from LIDAR. As an add-on, risk for height measurement errors was already taken into account in the AGB model selection, minimizing even more this source of error.</p> <p>The expected impact from H measurement on the overall uncertainty is high where this concerns systematic error and low where this concerns random error. QA/QC has been applied and should have minimized the errors as much as practicable. No residual uncertainty is included in the estimate.</p>	H (bias) & L(random)	YES	NO

Plot delineation	S/R	<p>No analysis took place regarding plot delineation, which can also be considered a measurement error on its own. Systematic bias can be expected because crews in the field might aim to avoid large obstacles and deviate slightly from the originally designed plot boundaries.</p> <p>The expected impact from plot delineation on the overall uncertainty is low (through random and systematic error). As part of QA/QC, Systematic plots of 3 plots per cluster with 500 m distance among plots and 1,000 m between clusters. Within an inventory team there was navigational team and field measurement team. The two teams worked together but were independent. The navigational team extracted the center coordinate of each plot from the LIDAR strip in Arcmap, uploaded to handheld GPS and use that to locate the field plot. This was to ensure that the location of the plot remained unchanged. However, inaccessible plots such as flooded areas, mangroves were abandoned.</p> <p>Furthermore, when a plot laid the GNSS was used to pick the center coordinate and the four corners of the plot. The essence was to crosscheck the coordinates from the field and the ones extracted from the LIDAR image; see details in FPP Report: section 2.5¹⁸. Ground control points (GCP) with their associated coordinates were supplied by the Survey and Mapping Division. These were used to coordinate the survey of the plots.</p> <p>No residual uncertainty is included in the estimate.</p>	L(bias/random)	NO	NO
Wood density measurement error	S/R	<p>Wood density was not considered for live trees, since AGB models developed did not take it into account. However, it had to be used to estimate AGB of dead standing trees. For that, species identity is needed. Lacking tree-level data, this source cannot currently be used in this exercise. However, it is known that taxonomies were used (hence QA/QC was ensured), although average WD estimates per plot were produced. This may have masked some of the taxon WD variability, which can often be high. However, because deadwood carbon is very low compared live carbon, very low errors would be expected from WD.</p>	L(bias/random)	YES	NO

¹⁸ <https://drive.google.com/drive/u/4/my-drive>

		(The expected impact from wood density estimation on the overall uncertainty is low (through random and systematic error). Information on QA/QC is found in manual 5.3 and 5.4. (<i>all manuals in link provided above</i>) No residual uncertainty is included in the estimate.			
Biomass allometric model	S/R	<p>The absence of tree-level data makes extremely difficult to provide a quantitative estimation of the level of uncertainty at plot-scale due to this source of uncertainty. While RMSE exists for all models used, there is presently no information of the abundance of the different species in a plot. Hence the tree-based biomass model uncertainties cannot be properly propagated at plot level. Thus, neither the model choice error nor the model coefficients uncertainty can be used. As a counterargument and possible justification, the use of local BGB models like the ones used for this report has been shown to reduce possible biases as opposed to pantropical models (van Breugel et al. 2011), although pantropical models, such as Chave (2014) can significantly reduce precision. Thus we expect this source of uncertainty to have a low contribution to bias but possibly high to random error in a static estimation. In the case of emission reductions, the full correlation assumption will point to minimal effects of this source of error.</p> <p>The expected impact from the biomass allometric models (AGB and BGB) on the overall uncertainty is low (for systematic error) to medium (for random and systematic error) but the QA/QC (manuals 5.3 and 5.4) applied should have minimized this as much as practicable. No residual uncertainty is included in the estimate.</p>	L(bias), H/L (random)	YES (local models)	NO
Sampling	S/R	<p>Plots were distributed along LIDAR transects and randomly located along the lines, stratified by vegetation types. Estimators were SRS (over a systematic configuration of plots along LIDAR transects, by ecological zone) within each stratum, and carbon stock was expanded to a per ha. basis. The plots can be considered as a quasi-transect sample of the forests. The field plots have a square shape of 40 m by 40 m (Chen et al. 2015)</p> <p>Sampling could result in both systematic and random errors. Information is missing on the QA/QC applied. No residual uncertainty is included in the estimate. The within plot uncertainty should be low, the between plot uncertainty should be high.</p>	L (bias/random)	NO	YES

Carbon fraction	S/R	<p>Value taken from the literature. Hence it could lead to both random and systematic errors. The random error is usually considered to be low but the aggregated effect might be high. Different carbon fractions were applied to different parts of the tree in the plot measurements for the different pools so the expectation is that the aggregated value is as representative as possible.</p> <p>The carbon fraction could result in both systematic and random errors but by using different fractions for different pool components this error is expected to have been minimized. No residual uncertainty is included in the estimate.</p>	H (bias/random)	NO	NO
Decomposition values	S/R	<p>Uncertainty from decomposition values is assumed to have a low contribution because of the very small fraction of deadwood usually present in the forest. However in the specific case of this study some doubts were raised because of extremely high values of deadwood in some cocoa areas. This was raised during the QA/QC revision and alternative default values were instead used. Yet we cannot calculate quantitatively the uncertainty because of the absence of within-plot data.</p> <p>The expected impact from the decomposition value on the overall uncertainty is medium (through random error) but the QA/QC (refer to SOPs) applied should have minimized this as much as practicable. No residual uncertainty is included in the estimate.</p>	H/L(random)	YES	NO
Removal aboveground biomass	S/R	<p>Plantation AGB estimates are obtained from local documentation (for teak plantations) or IPCC default values (for other species) and are subject to random variation whose origins are difficult to identify and were given as a range. As such, they may increase total uncertainty. However, they are going to represent a small fraction of the overall uncertainty.</p> <p>The expected impact from the removal aboveground biomass estimates on the overall uncertainty is low (through both random and systematic error). No QA/QC was applied since these values were taken from literature and IPCC.</p>	L (bias/random)	NO	YES

Root-to-shoot for removal factors	R	<p>Root-to-shoot ratios tend to follow lognormal distributions. The mean value was taken from the refined IPCC (2019) default tables, which take them from Mokany et al. (2006). The IPCC tables take a SE value with asymmetric extreme values due to the lognormality of residuals stated by Mokany et al. (2006). Both mean and SE are used to calculate the lognormal distribution, after which values are back-transformed to natural (antilog) scales.</p> <p>Given the low contribution of removals overall to final emission reductions, they represent a very small contribution to overall uncertainty. The expected impact from the root-to-shoot values on the overall uncertainty is low (through random error). No QA/QC was applied since these values were taken from IPCC. No residual uncertainty is included in the estimate.</p>	L (random)	NO	YES
Relative canopy cover reduction for degradation	S/R	<p>Degradation is based on detected canopy cover reduction in a very small set of plots where it was detected. The variation is likely to be due mostly from sampling error over rare events. Since it is such a rare event, its contribution to overall uncertainty is small.</p> <p>The expected impact from the relative canopy cover reduction estimates on the overall uncertainty is low (through both random and systematic error) but the QA/QC (refer to SOPs) applied should have minimized this as much as practicable. No residual uncertainty is included in the estimate.</p>	L (random/bias)	NO	YES
Representativeness error	S	<p>LIDAR (see FFP Report 2013, link provided above) transect lines were parallel. Hence, a systematic approach relies over the overlapping of plots on these transect lines. As such we expect the possible bias due to representativeness to be minimized. Out of a total area of 15,153 km² of the study area, LiDAR scanning was required for only 770 km² (sampling intensity being 5.1%) (Sah et al. 2012)</p> <p>The expected impact from representativeness on the overall uncertainty is low (through systematic error). Information is missing on the QA/QC applied. No residual uncertainty is included in the estimate.</p>	L (bias)	YES	NO
Integration					

Model	S/R	<p>Integration of AD and EF through Monte Carlo can present potential biases and the random errors are naturally propagated. The combination of AD & EF does not necessarily need to result in additional uncertainty. Usually, sources of both random and systematic error are the calculations themselves and model errors in integration may arise because of the implicit simplifications in the actual multiplication of AD x EF. Currently no correlations are considered in the calculations. While this may increase the random and systematic errors, it is a conservative approach. QA/QC processes in the preparation of the tool involved several revision processes and consultations in regard to the best PDFs to apply for every component of the simulation.</p> <p>The expected impact from the model (AD x EF) on the overall uncertainty is high (through both systematic and random error) but the QA/QC applied to the AD and EF calculations as described above should have minimized this as much as practicable. No residual uncertainty is included in the estimate.</p>	H(bias/random)	YES	NO
Probability Density Functions	S/R	<p>The model followed a parametric MC approach given the unreliability of a bootstrap for those rare cases which are present due to the relatively low sample size of the ground plots. The choice of PDF's may be a source of uncertainties. Most of the variables were fitted as Gaussian distributions and relative canopy cover reduction was fitted with a beta distribution. While ideally both should be truncated to avoid either rare negative numbers or fractions of canopy cover reduction above those permitted by the forest definitions, the lack of within-plot mean and standard error estimates considering truncated distributions makes the task impossible. However, overall these small deviations are likely representing very small errors, probably slightly biasing the overall median result.</p> <p>Hence the expected impact is likely to be overall low regarding both bias and random error. No residual uncertainty regarding the choice of PDF was included.</p>	H (bias/random)	YES	NO
Integration	S	<p>This source of uncertainty is related to the lack of comparability between the transition classes of the AD and those of the EF. AD is estimated through remote-sensing observations, whereas EFs for a specific ecological zone were based on ground-based observations of the ecological zone. These may not be comparable, and it may represent a source of bias. QA/QC involved the fine tuning</p>	H (bias)	YES	NO

		<p>coordinates alignment of LIDAR transects and field plots (Chen et al. 2015). Furthermore, the assessment of forest degradation is as harmonized as possible since information on relative canopy cover reduction is used to approximate biomass loss. The difference between open and closed forest average biomass contents to approximate the degradation EF is a much poorer estimate since the observed plots show that in many cases of degradation in closed forest, the post-degradation canopy cover is not below 60%.</p> <p>The expected impact from integration on the overall uncertainty is high (through systematic error) but the QA/QC applied should have minimized this as much as practicable. No residual uncertainty is included in the estimate.</p>			
--	--	---	--	--	--

The following references are used in above table:

- Chave, J., Réjou - Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B., ... & Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, 20(10), 3177-3190.
- Chen, Q., Laurin, G. V., & Valentini, R. (2015). Uncertainty of remotely sensed aboveground biomass over an African tropical forest: Propagating errors from trees to plots to pixels. *Remote Sensing of Environment*, 160, 134-143
- Holdaway, R. J., McNeill, S. J., Mason, N. W., & Carswell, F. E. (2014). Propagating uncertainty in plot-based estimates of forest carbon stock and carbon stock change. *Ecosystems*, 17(4), 627-640.
- Hunter, M. O., Keller, M., Victoria, D., and Morton, D. C..(2013) Tree height and tropical forest biomass estimation, *Biogeosciences*, 10, 8385–8399, <https://doi.org/10.5194/bg-10-8385-2013>, 2013.
- Picard, N., Bosela, F. B., & Rossi, V. (2015). Reducing the error in biomass estimates strongly depends on model selection. *Annals of forest Science*, 72(6), 811-823.
- Sah, B. P., Hämäläinen, J. M., Sah, A. K., Honji, K., Foli, E. G., & Awudi, C. (2012). The use of satellite imagery to guide field plot sampling scheme for biomass estimation in Ghanaian forest. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 4, 221.
- Van Breugel, M., Ransijn, J., Craven, D., Bongers, F., & Hall, J. S. (2011). Estimating carbon stock in secondary forests: decisions and uncertainties associated with allometric biomass models. *Forest ecology and management*, 262(8), 1648-1657.
- Yanai, R. D., Battles, J. J., Richardson, A. D., Blodgett, C. A., Wood, D. M., & Rastetter, E. B. (2010). Estimating uncertainty in ecosystem budget calculations. *Ecosystems*, 13(2), 239-248

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

Monte Carlo simulations were generated using Excel. Including all the parameters highlighted in the section below and the probability density functions justified in the table, 16,000 random values for each parameter were generated. While often MC simulations involve 10,000 values, we forced the number of values to the maximum limit allowed by Excel, to reduce the small deviations coming out from different runs. Although full stability of estimates was still not achieved, final ER uncertainties were seen to deviate with maximum values 0.2% every time random values are refreshed, which was considered precise enough for the uncertainty reporting, given that these deviations are always far from crossing the resulting uncertainty discount threshold for 12%. Following IPCC (2006) chapter 3, Ghana deemed that only two parameters needed non-Gaussian (i.e., non-normal) PDF's (see table below): those regarding root-to-shoot ratios, and those regarding canopy cover reduction for the detection of forest degradation. Since non-normal PDFs are used, the Monte Carlo approach is justified. Correlations in EFs were not considered, due to a lack of within-plot uncertainty data availability. Following the guidelines, the MC approach generated trend estimates through simulation of activity data each year, while maintaining constant EFs due to assumed full correlations of EFs between years.

Table 8: Parameters in Monte Carlo

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
General factors				
Ratio of molecular weights	3.667	Not applicable	Fixed	
Carbon fraction	0.470	Uncertainty ranges as provided in sources	Normal	IPCC (2006). Chapter 4. Table 4.3. Normality assumption following Chabi et al. (2019)
Biomass measurements				
AGB (tC /ha) Open All forest	27.4	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)

AGB (tC /ha) Closed Wet Evergreen	81.3	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
AGB (tC /ha) Closed Moist Evergreen	202.9	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
AGB (tC /ha) Closed Moist Semideciduous SE	100.5	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
AGB (tC /ha) Closed Moist Semideciduous NW	75.9	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
AGB (tC /ha) Closed Upland Evergreen	74.6	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
BGB (tC /ha) Open All forest	10.4	Sampling error	Normal	Representative, raw data not available. Normality assumption from the multiplication of a constant root:shoot ratio times AGB
BGB (tC /ha) Closed Wet Evergreen	10.5	Sampling error	Normal	Representative, raw data not available. Normality assumption from the multiplication of a constant root:shoot ratio times AGB
BGB (tC /ha) Closed Moist Evergreen	26.8	Sampling error	Normal	Representative, raw data not available. Normality assumption from the multiplication of a constant root:shoot ratio times AGB
BGB (tC /ha) Closed Moist Semideciduous SE	25.8	Sampling error	Normal	Representative, raw data not available. Normality assumption from the

				multiplication of a constant root:shoot ratio times AGB
BGB (tC /ha) Closed Moist Semideciduous NW	19.0	Sampling error	Normal	Representative, raw data not available. Normality assumption from the multiplication of a constant root:shoot ratio times AGB
BGB (tC /ha) Closed Upland Evergreen	24.1	Sampling error	Normal	Representative, raw data not available. Normality assumption from the multiplication of a constant root:shoot ratio times AGB
DW (tC /ha) Open All forest	20.5	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent line transects, as in Affleck et al. (2005)
DW (tC /ha) Closed Wet Evergreen	29.0	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent line transects, as in Affleck et al. (2005)
DW (tC /ha) Closed Moist Evergreen	18.3	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent line transects, as in Affleck et al. (2005)
DW (tC /ha) Closed Moist Semideciduous SE	65.8	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent line transects, as in Affleck et al. (2005)
DW (tC /ha) Closed Moist Semideciduous NW	38.6	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent

				line transects, as in Affleck et al. (2005)
DW (tC /ha) Closed Upland Evergreen	41.9	Sampling error	Normal	Representative, raw data not available. Normality assumption from the mean estimator of independent line transects, as in Affleck et al. (2005)
L (tC /ha) Open All forest	2.6	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
L (tC /ha) Closed Wet Evergreen	3.0	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
L (tC /ha) Closed Moist Evergreen	3.3	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
L (tC /ha) Closed Moist Semideciduous SE	2.9	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
L (tC /ha) Closed Moist Semideciduous NW	2.4	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
L (tC /ha) Closed Upland Evergreen	1.4	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Tuomi et al. (2009)
SOC (tC /ha) Open All forest (20-year total)	10.6	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)

SOC (tC /ha) Closed Wet Evergreen (20-year total)	18.2	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)
SOC (tC /ha) Closed Moist Evergreen (20-year total)	18.0	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)
SOC (tC /ha) Closed Moist Semideciduous SE (20-year total)	6.6	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)
SOC (tC /ha) Closed Moist Semideciduous NW (20-year total)	11.8	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)
SOC (tC /ha) Closed Upland Evergreen (20-year total)	17.2	Sampling error	Normal	Representative, raw data not available. Normality assumption as in the IPCC EF database (https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php)
post-Def LU (tC /ha) Open All forest (simplified average)	14.3	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables.

post-Def LU (tC /ha) Closed Wet Evergreen	15.2	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables
post-Def LU (tC /ha) Closed Moist Evergreen	17.0	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables
post-Def LU (tC /ha) Closed Moist Semideciduous SE	13.8	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables
post-Def LU (tC /ha) Closed Moist Semideciduous NW	17.6	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables
post-Def LU (tC /ha) Closed Upland Evergreen	7.9	Sampling error	Normal	Representative, raw data not available. Normality assumption from error propagation between two random normal variables
Monitored values deforestation 2005-2014				
AD (ha /yr) Open All forest	4,756	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Wet Evergreen	304	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Evergreen	1,728	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.

AD (ha /yr) Closed Moist Semideciduous SE	1,078	Sampling error	Normal	Representative, raw data available . Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous NW	1,171	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Upland Evergreen	160	Sampling error	Normal	Representative, raw data available . Central limit theorem: binomial approaches normal.
Monitored values deforestation 2020 and 2021				
AD (ha /yr) Open All forest	638	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Wet Evergreen	0	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Evergreen	1,272	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous SE	1,282	Sampling error	Normal	Representative, raw data available . Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous NW	3,101	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Upland Evergreen	159	Sampling error	Normal	Representative, raw data available . Central limit theorem: binomial approaches normal.

Planting (net areas, discounted for annual survival rates)				
Area established (ha) teak 2005 (ha)	1,419	Not applicable	Fixed	
Area established (ha) teak 2006 (ha)	1,419	Not applicable	Fixed	
Area established (ha) teak 2007 (ha)	1,422	Not applicable	Fixed	
Area established (ha) teak 2008 (ha)	1,422	Not applicable	Fixed	
Area established (ha) teak 2009 (ha)	1,422	Not applicable	Fixed	
Area established (ha) teak 2010 (ha)	1,388	Not applicable	Fixed	
Area established (ha) teak 2011 (ha)	1,589	Not applicable	Fixed	
Area established (ha) teak 2012 (ha)	1,534	Not applicable	Fixed	
Area established (ha) teak 2013 (ha)	1,185	Not applicable	Fixed	
Area established (ha) teak 2014 (ha)	602	Not applicable	Fixed	
Area established (ha) non teak 2005 (ha)	608	Not applicable	Fixed	
Area established (ha) non teak 2006 (ha)	608	Not applicable	Fixed	
Area established (ha) non teak 2007 (ha)	609	Not applicable	Fixed	
Area established (ha) non teak 2008 (ha)	609	Not applicable	Fixed	
Area established (ha) non teak 2009 (ha)	609	Not applicable	Fixed	
Area established (ha) non teak 2010 (ha)	595	Not applicable	Fixed	

Area established (ha) non teak 2011 (ha)	681	Not applicable	Fixed	
Area established (ha) non teak 2012 (ha)	658	Not applicable	Fixed	
Area established (ha) non teak 2013 (ha)	508	Not applicable	Fixed	
Area established (ha) non teak 2014 (ha)	258	Not applicable	Fixed	
Removal factors				
Average stock AGB+BGB (tC /ha) teak	97.690	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
Growth period (years) teak	25	Not applicable	Fixed	
Average stock AGB (t d.m. /ha) non teak	173.300	Sampling error	Normal	Representative, raw data not available. Normality assumption as in Chave et al. (2004)
RSR non teak	0.240	Uncertainty ranges as provided in sources	Lognormal	Representative, raw data not available. Log-normality assumption as in Mokany et al. (2006)
Growth period (years) non teak	40	Not applicable	Fixed	
Removals from planting 2020 and 2021				
Area planted (ha) teak 2020 & 2021 (ha)	28,944	Not applicable	Fixed	
Area planted (ha) non teak 2020 & 2021 (ha)	12,405	Not applicable	Fixed	
EF forest degradation				

Relative canopy cover reduction Open	0.480	Sampling error	Beta	Representative, raw data available. Beta distribution as in Ferrari & Cribari-Neto (2004) and Korhonen et al. (2007)
Relative canopy cover reduction Closed	0.299	Sampling error	Beta	Representative, raw data available. Beta distribution as in Ferrari & Cribari-Neto (2004) and Korhonen et al. (2007)
Monitored values degradation 2005-2014				
AD (ha /yr) Open All forest	437	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Wet Evergreen	304	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Evergreen	1,153	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous SE	1,270	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous NW	1,293	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Upland Evergreen	80	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
Monitored values degradation 2020 & 2021				

AD (ha /yr) Open All forest	1,283	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Wet Evergreen	606	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Evergreen	1,276	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous SE	3,777	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Moist Semideciduous NW	4,317	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.
AD (ha /yr) Closed Upland Evergreen	319	Sampling error	Normal	Representative, raw data available. Central limit theorem: binomial approaches normal.

References quoted in Table 8 above :

- Chabi, A., Lautenbach, S., Tondoh, J. E., Orekan, V. O. A., Adu-Bredu, S., Kyei-Baffour, N., ... & Fonweban, J. (2019). The relevance of using in situ carbon and nitrogen data and satellite images to assess aboveground carbon and nitrogen stocks for supporting national REDD+ programmes in Africa. *Carbon Balance and Management*, 14(1), 1-13.
- Chave, J., Condit, R., Aguilar, S., Hernandez, A., Lao, S., & Perez, R. (2004). Error propagation and scaling for tropical forest biomass estimates. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 359(1443), 409-420.
- Affleck, D. L., Gregoire, T. G., & Valentine, H. T. (2005). Design unbiased estimation in line intersect sampling using segmented transects. *Environmental and Ecological Statistics*, 12(2), 139-154.
- Tuomi, M., Thum, T., Järvinen, H., Fronzek, S., Berg, B., Harmon, M., ... & Liski, J. (2009). Leaf litter decomposition—estimates of global variability based on Yasso07 model. *Ecological Modelling*, 220(23), 3362-3371.
- Mokany, K., Raison, R. J., & Prokushkin, A. S. (2006). Critical analysis of root: shoot ratios in terrestrial biomes. *Global Change Biology*, 12(1), 84-96.

- Ferrari, S. & Cribari-Neto, F. 2004. Beta regression for modelling rates and proportions. *Journal of Applied Statistics* 31(7): 799–815.
- Korhonen, L., Korhonen, K. T., Stenberg, P., Maltamo, M., & Rautiainen, M. (2007). Local models for forest canopy cover with beta regression. *Silva Fennica* 41(4), 671-685

The following summarizes the selection of PDF through testing the goodness of fit:

- Deforestation area: Deforestation area is measured through binary observations of deforestation / no-deforestation over a large number of sample plots. The total deforestation area corresponds to the counts of deforestation observations multiplied with an area factor. Such binary observations are, evidently, binomially distributed, a formal goodness-of-fit test is not necessary. The probability of deforestation is then calculated from several thousand such binary distributions. Since it is the sum of a large number of random variables, it is normally distributed. The simulation of the deforestation area can therefore employ a normal distribution with the sample mean and its standard error as coefficients.
- Root-to-shoot ratio for removal factors in non-teak: Root-to-shoot ratios tend to follow lognormal distributions. The mean value was taken from the refined IPCC (2019) default tables, which take them from Mokany et al. (2006). The IPCC tables take a SE value with asymmetric extreme values due to the lognormality of residuals stated by Mokany et al. (2006). Both mean and SE are used to calculate the lognormal distribution, after which values are back-transformed to natural (antilog) scales.
- Relative canopy cover reduction: The relative canopy cover reduction upon forest degradation was measured for 137 sample locations. A sample mean and sample standard deviation could be estimated. In a first step, five statistical distributions were tested for their goodness of fit (normal, exponential, Poisson, uniform and beta), with the beta distribution having the best chi-squared statistic. It was therefore chosen to most accurately represent the distribution of relative canopy cover reduction. In a second step, the fitted beta distribution was employed to simulate the means over 137 sample locations for 1000 iterations. In a third step, the resulting statistical distribution of 1000 sample means was again fitted to the beta distribution, which could be used for the Monte Carlo model.
- Forest degradation area: The same reasoning applies as for the deforestation area as the same measurement approach was used.

Quantification of the uncertainty of the estimate of Emission Reductions

In Table 9 below the emission reduction estimates in the first column include forest degradation. For the uncertainty discount, the value of the aggregate estimate in the first column has been used.

Table 9: Quantification of Uncertainty of the estimate of ERs

		Reporting Period	Crediting Period
		Total Emission Reductions	Total Emission Reductions
A	Median	4,702,703	5,988,465
B	Upper bound 90% CI (Percentile 0.95)	7,988,636	9,751,006
C	Lower bound 90% CI (Percentile 0.05)	1,676,638	2,591,608
D	Half Width Confidence Interval at 90% (B – C / 2)	3,155,999	3,579,699
E	Relative margin (D / A)	67.1%	59.8%
F	Uncertainty discount	12%	8%

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

Referring to criterion 7 and indicators 9.2 and 9.3 of the Methodological Framework and the Guideline on the application of the Methodological Framework Number 4 On Uncertainty Analysis of Emission Reductions, a sensitivity analysis was undertaken to identify the relative contribution of each parameter to the overall uncertainty of Emission Reductions. The sensitivity analysis was conducted by “switching off” the sources of uncertainty one at a time and assessing the impact on the overall uncertainty of emission reductions.

The results of the sensitivity analysis were the following:

Scenario	ER Uncertainty 90%	Difference to ER Uncertainty 90% of all parameters
All parameters	67.9%	0.0%
No Deforestation	21.4%	-46.5%
No Forest degradation	64.7%	-3.2%
No Enhancement	67.9%	0.0%
No EF	62.7%	-4.8%
No AD	25.0%	-42.9%
No Deforestation AD	21.4%	-46.5%
No Deforestation EF	61.7%	-6.2%
No Forest degradation AD	64.8%	-3.1%
No Forest degradation EF	67.7%	0.2%
No Enhancement AD	67.9%	0.0%
No Enhancement EF	68.2%	0.3%

The difference in the uncertainty of emissions reductions (right column in the table) with respect to the uncertainty in the reference level where all parameters are considered clearly shows a possible hierarchy of parameter importance when it comes to consideration of important error sources open for improvement in monitoring. Improvements in AD estimation have, for example, the potential to reduce the current ER uncertainty by 42.9% (overall ER uncertainty for all parameters being 67.9.0% vs. overall ER uncertainty when AD presents no errors being 25%). Given this prioritization, several overall improvements can be perceived.

Improved monitoring of activity data is likely to largely contribute to uncertainty decreases in emission reductions; higher-resolution imagery will likely be available for future years. Again, Ghana's current Standard Operating Procedures for area estimation reinforce the training of interpreters to minimize both systematic and random errors in area estimation:

6 TRANSFER OF TITLE TO ERs

6.1 Ability to transfer title

The ability of the Forestry commission (FC) to transfer title of Emission Reductions is clear and there is no contesting party to that effect. Evidence demonstrating the FC's ability to transfer title has already been submitted to the Carbon Fund via letter referenced FC/A.10/sf.21/v.6/139 dated 3rd February 2020 (attached as appendix 1). The FC has transferred the verified and validated Emission Reductions (ERs) for the first monitoring report under the Emission Reductions payment Agreement with the Carbon Fund through the International Bank for Reconstruction and Development (IBRD)

6.2 Implementation and operation of Program and Projects Data Management System

Currently in Ghana, no entity has the right to claim¹⁹ ownership of title to ERs. Therefore, there is no threat of multiple claims to an ER title. The Forestry Commission working in close collaboration with the Ghana Cocoa Board is authorized by the Government of Ghana through the Minister of Finance to implement the Program. There are currently two VCS registered projects, but they are both outside of GCFRP.

The FC has developed a Ghana REDD+ Data Hub (www.ghanaredddatahub.org) that provides information on the Program including details on the geographic boundaries of the program, the carbon pools, and the reference level. The reference level has subsequently been amended. The data hub would display the amount of ERs that would be transferred to the Carbon Fund with the associated reversal and uncertainty buffer accounts. This would ensure transparency of the process.

6.3 Implementation and operation of ER transaction registry

The Government of Ghana through the FC has communicated to the Carbon Fund to use the FCPF's ER Transaction Registry so the responsibilities of the Registry Administration and buffer management will fall on the trustee of the Carbon fund.

6.4 ERs transferred to other entities or other schemes

No ERs has been transferred to a third party. After the verification and Validation of the Monitoring Report (MR), all the volume would be transferred on 100% basis in line with the ERPA. No ERs would be transferred to third parties until the contractual ERs under the ERPA are met.

¹⁹ There exist two registered ARR Projects by Form Ghana and Miro Ghana, but these are all outside the GCFRP area.

7 REVERSALS

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

There have not been any major events or changes in ER Program circumstances that have led to the Reversals during the Reporting Period

7.2 Quantification of Reversals during the Reporting Period

Intentionally left blank

7.3 Reversal risk assessment

The reversal risk assessment using the CF Buffer Guidelines has changed from 18% to 13% since the preparation of the revised final ERPD. The change is due to the risks associated with institutional capacity for implementation and sustainability. The risk was reduced due to several implementations that strengthen the institutional capacity for implementation as outlined in the table below:

Table 10: Reversal Risk Assessment

Risk Factor	Risk indicators	Default Reversal Risk Set- Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	N/A	10%	N/A	10%
Lack of broad and sustained stakeholder support	<p>There is low stakeholder risk as the programme has clearly identified its main stakeholders and a high degree of formal and informal consultations were undertaken during the design phase (reference ERPD Section 5 pgs 70-81). Extensive further engagements /consultations/capacity building on specific issues (Benefit Sharing, Safeguards, governance) have continued across the HIAs (https://reddsis.fcghana.org/documents.php)</p> <p>In line with the program design, the in-depth participation of cocoa farmers, their rural communities, women, and the private sector and farmer associations, and the HIA-Consortium structure ensures a high degree of buy-in. This is evident in the development of governance structures for 5 out of 6 HIAs (details in 1.1 above)</p> <p>There was a risk that broad support would not be provided during the early phase of implementation, this risk was mitigated early in the project cycle through official launch of the programme by the President of</p>	10%	<p><i>Reversal risk is considered low</i></p> <p>10%-10%=0% discount</p>	0%

	<p>Ghana²⁰, broad community consultation involving all stakeholders, especially traditional authorities, community elders, and other key persons. The consultation process served to manage community expectations, increase ownership, inclusiveness, and ensure sustainability while garnering broad community support (refer to table 1 which gives further details of work in the various HIAs). These activities were buttressed by the implementation of safeguards and grievance redress mechanisms under the programme (details of safeguards and grievance redress mechanisms in annexes 1 & 2).</p> <p>In addition the existence of the following mitigates this risk:</p> <ul style="list-style-type: none"> • Benefit Sharing Plan, which is being operationalized • Existence of Process Framework Document • Signing of Memorandum of Understanding with partner institutions²¹ 			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	<p>The risks associated with institutional capacity for implementation and sustainability are listed as low. At the start of REDD+ and the GCFRP in Ghana, institutional capacity was relatively low, however, capacity is being strengthened through numerous trainings and workshops (https://reddsis.fcghana.org/documents.phphttps://reddsis.fcghana.org/documents.php) at the National and landscape levels, and Ghana's capacity to implement this programme has further improved.</p> <p>For example, in the past, there was weak cross-sectoral coordination amongst the lead institutions, the Forestry Commission and the Ghana Cocoa Board. This has now changed as evidenced by the coordination required to design and implement this programme as well as the Forest Investment Program (FIP). Moreover, The CEOs of the FC and Cocobod sign the framework agreements with the HMBs</p>	10%	Reversal risk is considered low: 10% - 10% = 0% discount	0%

²⁰ <https://www.ghanaweb.com/GhanaHomePage/business/Ghana-signs-agreement-with-cocoa-and-chocolate-companies-to-protect-and-restore-forests-1234705>

²¹ <https://www.confectionerynews.com/Article/2021/04/15/Cocoa-companies-forge-new-partnership-with-Ghana-to-protect-and-restore-forests>

	<p>Since the GCFRP began, Ghana continues to identify interventions²²/initiatives (cocoa & forest Initiative), which enhance annual work planning and budgeting across sectors and projects operating within the GCFRP. In addition, the program has sought to enhance safeguards implementation (annex 1 of this report) and has ensured delivery of operational and coordination requirements.</p> <p>Finally, the programs strategy focuses on interventions in decentralized deforestation hotspots (table 1), which given the emissions reductions reported in this document highlights that the program has successfully mitigated the risk associated with institutional capacity.</p> <p>In addition, the following also mitigate this risk</p> <ul style="list-style-type: none"> • Forestry Commission and Ghana cocoa Board Regional and District Offices are located in all the programme areas and thus have the requisite staff to execute the programme and coordinate activities at the landscape level • FC has lots of experiences in the implementation of projects that involve other agencies in Ghana. The projects include the Forest Investment Programme, Natural resources Environment Programme, Sustainable Land and water Management Project) • Existence of the GCFRP Implementation Committee with membership from FC, Cocobod and World Cocoa Foundation to guide operational activities <p>In the addition to the above, in the years under review, the following activities have been undertaken to deepen the institutional capacities</p> <ul style="list-style-type: none"> • Broadened engagement with the development of governance structures for 5 out of the 6 HIAs and the signing of Framework agreements²³ with the 5 			
--	---	--	--	--

²² <http://reddsis.fcghana.org/projects.php?id=4> ,

²³ <https://www.reddsis.fcghana.org/dmeeting.php>

	<ul style="list-style-type: none"> Enhanced collaboration between private sector and government agencies; World Cocoa Foundation is a member of the RDA Steering committee to represent the Private Sector. Set of all REDD+ Dedicated Account at the national level as well as HIA accounts²⁴ at the sub national level for onward transfer of Carbon Payments. Set up of RDA Steering Committee to provide transparency for the transfer of funds to all beneficiaries. Minutes of first meeting can be found here²⁵. Capacity building of functional governance structures to prepare them adequately for the administration and disbursement of Carbon Payments²⁶. Trainings carried by the World Bank on Safeguards for all landscape actors ; details from annex 1.²⁷ Good institutional arrangements for the development of Second MR, as a follow up to the first MR (kindly refer to section 2 of Monitoring Report) 			
Lack of long term effectiveness in addressing underlying drivers	The programme interventions have directly focused efforts on two of the main drivers and agents of deforestation and degradation in the region (cocoa/subsistence farming and unsustainable logging). The risks from cocoa farming and subsistence agriculture have been mitigated through the direct engagement of agents in programme interventions through the formation of the HMBs and signing of framework agreements (table 1) These agents are also unlikely to migrate within or outside the program area and thus the risk of displacement is low. This is because Cocoa production mainly thrives in the Programme area in Ghana ²⁸	5%	Reversal risk is considered Medium: 5% - 2% = 3% discount	3%

²⁴ <https://www.dropbox.com/s/s15nxmcwvf4c437/HIA%20accounts%20opening.zip?dl=0>

²⁵ <https://www.reddsis.fcghana.org/admin/controller/publications/Minutes%20of%20RDA%20Steering%20Committee%20Orientation.pdf>

²⁶

²⁷ <https://www.reddsis.fcghana.org/admin/controller/publications/WB%20SAFEGUARDS%20TRAINING%20%20REPORT%20final.pdf>

²⁸ Ghana Cocoa Board Research and Monitoring Department.

	<p>Risks associated with illegal logging was considered low. As indicated in the ERPD, the risk of illegal logging is mitigated by both hard and soft approaches. The FC has increased its law enforcement role by deploying the Rapid Response Unit to augment the roles of Resource Guards in flash points where there are constant reports of illegal logging. As part of the VPA FLEGT process, there has been a reform in the regulation of timber utilization in Ghana, thus there is a new legislative Instrument to regulate the utilization of timber resources (http://www.fao.org/faolex/results/details/en/c/LEX-FAOC173919/).http://www.fao.org/faolex/results/details/en/c/LEX-FAOC173919/). Through this process, there is a legal assurance for timber production and utilization in Ghana. Ghana looks forward to issuing the first FLEGT License by end of first quarter 2022.</p> <p>Also, as part of the by-laws of HMBs, they assist in the protection of the forest resources</p> <p>The risk from illegal small-scale mining was also considered medium. Landowners were not considered migratory, though some of the agents were. Increased income from climate-smart agriculture and other benefits is helping to mitigate the opportunity cost.</p> <p>Again, Government has also introduced community mining schemes²⁹ to guide community level mining in sustainable manner.</p> <p>In addition, lessons learnt from the successful implementation of the FIP which is a pilot to the GCFRP are being used to address the underlying drivers (provision of Alternative/ additional livelihood options, key legislative reforms).</p> <p>The REDD+ strategy and the ERPD give a clear direction (at least 20 years) on the implementation of the program beyond the ERPA period.</p> <p>The program primarily targets sustainable cocoa productions and this commodity is a high exchange earner for Ghana. Therefore, governments always pay</p>			
--	---	--	--	--

²⁹ <https://presidency.gov.gh/index.php/briefing-room/news-style-2/1653-new-community-mining-schemes-to-create-12-000-jobs-at-aboso-gwira-akango-president-akufo-addo>

	attention to this sector and hence the programme would persist the ERPA period.			
Exposure and vulnerability to natural disturbances	<p>This risk associated with natural disturbances remains low. The main natural risk in the GCFRP accounting area is forest fires. Generally, the occurrence of uncontrolled forest fires may happen as a result of illegal practices related to , land clearing, charcoal production, and as a result of dry years (El Nino events).</p> <p>The programme has mitigated the risk of forest fires by strengthening fire management and control units at the Forestry Commission, district assemblies, and fire volunteers etc.</p> <p>The FC also implemented the Wild Fire Management Project (2000-2008) and has therefore gained lots of experience in the management of wildfires in Ghana.</p> <p>A Manual of Procedure to guide FC staff in the management of fires has also been produced.</p> <p>Better land use planning with the development and operationalization of HIA management plans would ensure forests remain healthy and less susceptible to fires. The HIA management plans for both Juaboso/Bia and Asutifi/Asunafo HIAs are ready.</p> <p>Again, the promotion of Climate Smart Cocoa practices is one of the pillars of this programme and this would mitigate the effect of climate change on cocoa production systems (ERPD page 55).</p>	5%	<i>Reversal risk is considered Low</i> 5% - 5% =0%	0%
		Total reversal risk set-aside percentage		13%
		Total reversal risk set-aside percentage from ERPD or previous monitoring report (whichever is more recent)		13%

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	Emission Reductions during the Reporting period (tCO ₂ -e)	<i>from section 4.3</i>	4,594,941
B.	If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)		-
C.	Number of Emission Reductions estimated using measurement approaches (A-B)		4,594,941
D	Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested	<i>from section 6.1</i>	100%
E	ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes	<i>From section 6.4</i>	-
F	Total ERs (B+C)*D-E		4,594,941
G	Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period	<i>from section 5.2</i>	12%
H	Quantity of ERs to be allocated to the Uncertainty Reversal Buffer $(0.15*B/A*F)+(G*C/A*F)$		551,392
I	Total reversal risk set-aside percentage applied to the ER program	<i>From section 7.3</i>	13%

J	Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)		323,484
K	Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%		202,177
L	Number of FCPF ERs (F-H-J-K).		3,517,888

The following annexes are being completed and will be made public as soon as they are available:

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS