Cooperative Republic of Guyana

1st REDD+ Technical Annex

Submitted to the 1st Biennial Transparency Report, which includes the REDD+ results achieved from Reducing Emissions from Deforestation and Forest Degradation for REDD+ Results-based payment for the period 2013-2022

2024

Contributors

The Government of Guyana has prepared this publication with support from the Global Green Growth Institute (GGGI).

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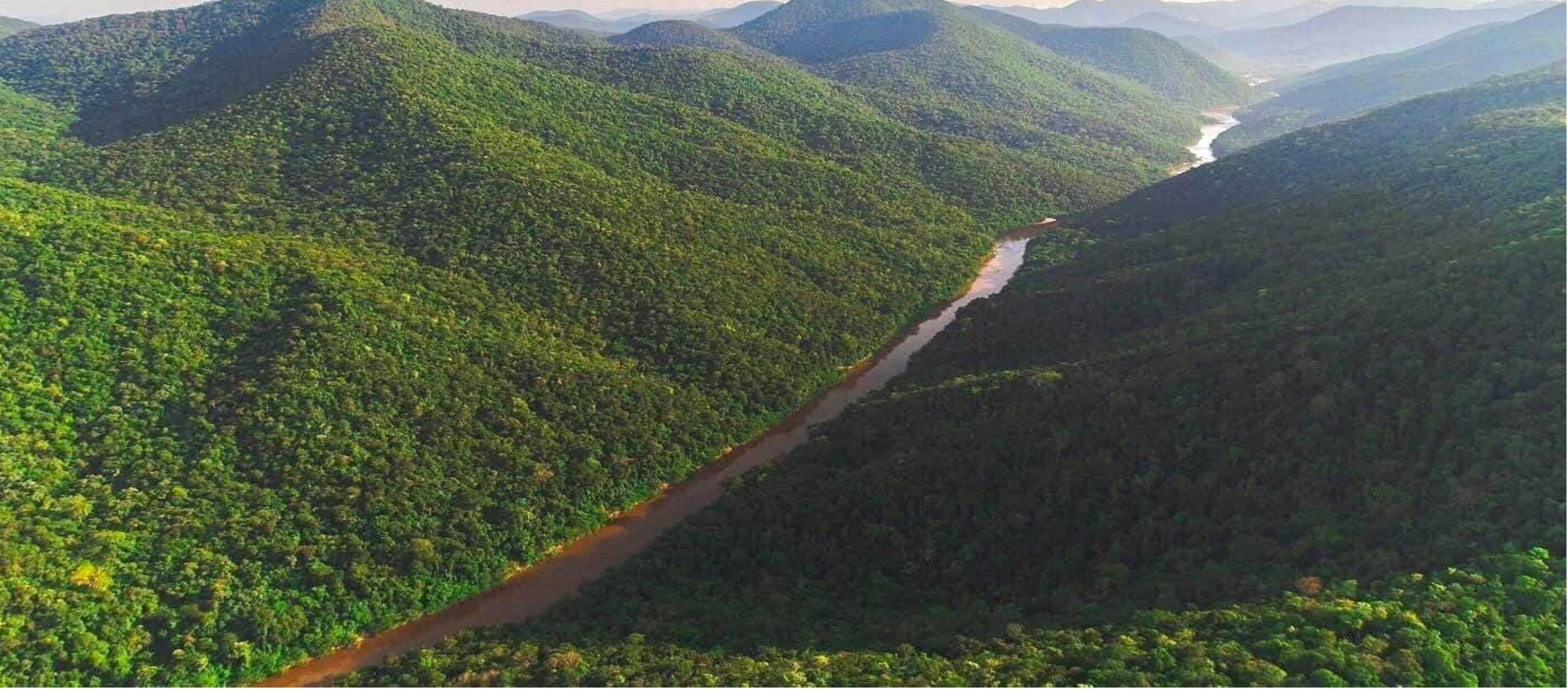
Acronyms

ART	Architecture for REDD+ Transactions
AT	Assessment Team
COP	Conference of the Parties
FRL	Forest Reference and Emissions Level
GFC	Guyana Forestry Commissions
GHG	Greenhouse Gas
GoG	Government of Guyana
HFLD	High Forest Cover/Low Deforestation
IPCC	Intergovernmental Panel on Climate Change
LCDS	Low Carbon Development Strategy
MRV	Measurement/Monitoring Reporting and Verification
NDC	Nationally Determined Contribution
NFMS	National Forest Monitoring System
REDD+	Reducing Emissions from Deforestation and Forest Degradation
TA	Technical Analysis
TREES	The REDD+ Environmental Excellence Standard
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market



INTRODUCTION

This Technical Annex provides additional information to Guyana's first Biennial Transparency Report of results achieved from Reducing Emissions from Deforestation and Forest Degradation REDD+. This annex has been developed per Decision 14/CP.19 (2013), requiring developing country Parties that wish to receive REDD+ results-based payments to submit their estimated calculation of GHG emissions reduction and removal enhancements related to forests to the United Nations Framework Convention on Climate Change (UNFCCC) as a technical annex to the BTRs. This technical annex provides the information and data as requested in the Annex to Decision 14/CP.19, which provides guidance on the elements to be included in the technical annex as per paragraph 7 of Decision 14/CP.19, including six following contents: (1) Overview of FRL, (2) GHG emission reduction results, (3) consistency in methodology between REDD+ results calculation and FRL construction, (4) National forest monitoring system and responsibilities of relevant authorities, (5) Necessary information to allow for the reconstruction of the results, and (6) Compliance with paragraphs 1 (c)5 and 1 (d)6 of Decision 4/CP.15.

The Conference of the Parties encourages developing countries, such as Guyana, to contribute to mitigation actions in the forest sector by undertaking REDD+ activities: reducing emissions from deforestation, reducing emissions from forest degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks (decision 1/CP.16, paragraph 70). The activities are intended to contribute to the achievement of Article 2 of the convention, which aims at strengthening the global response to climate change within the context of sustainable development and fulfilling commitments made in the National Determined Contributions proposed by the Party in fulfillment of the obligations set out in Article 4, paragraph 3.

Countries participating in REDD+ are encouraged to develop national strategies or action plans outlining their approach to reducing emissions from deforestation and forest degradation, the conservation and sustainable management of forests, as well as the enhancement of forest carbon stocks. Establishing a forest reference level (FRL) is a crucial aspect of REDD+. The FRL serves as the benchmark against which emission reductions can be measured. One of the key aims of REDD+ is to provide financial incentives for developing countries to reduce emissions from deforestation and forest degradation. It also emphasizes the importance of implementing robust and transparent forest monitoring systems to track changes in forest carbon stocks. This requires the building of institutional and human capacity to effectively implement REDD+ activities, including systems for monitoring, reporting, and verification (MRV) and building the capacity of relevant stakeholders to ensure transparency and accountability in the implementation of the national REDD+ program.

Guyana is considered a member of the Small Island Developing States (SIDS) and is therefore granted flexibility (Decision 18/CMA.1 , 2018) in fulfilling its commitment to the Paris Agreement (PA) (PA, 2015). Guyana has utilised Article 5.2 of the PA where REDD+ was recognized, by taking action to implement and support, including through results-based payments, the existing framework for activities relating to reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Guyana is submitting this Technical Annex, which outlines the efforts made by the country in safeguarding its environmental integrity and promoting sustainable use of its forest resources to leverage the promotion of sustainable development along a low carbon pathway following national priorities and international obligations.

As such, Guyana is presenting this first REDD+ Technical Annex to its first Biennial Transparency Report, where the results achieved by the country are reported for the period 2013 to 2022. This is following the successful submission of the FRL in 2015, which covers a historic period ending in 2012. This reporting period (2013-2022) was selected to facilitate information consistency and adherence to reporting requirements, aligning with the updated GHG Inventory and reporting periods of the BTR, to which this REDD+ Technical Annex is attached.

This submission presents the results achieved following the national jurisdictional approach since 2009 to establish the robust MRV system that generates consistent and accurate information with improvement over time to estimate Guyana's anthropogenic forest-related emissions by source and removals by sinks, forest carbon stocks and forest area changes following the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines.

National Circumstances

Guyana has the second highest percentage of forest cover on earth (85%), storing approximately 19.5 billion tons of CO2 e, and is one of four countries in the world verified to have a sustained High Forest Low Deforestation (HFLD) state, containing high levels of biological diversity and endemism (LCDS, 2022). It is home to a variety of known animal species, including the iconic Amazonian species: jaguar, giant river otter, harpy eagle, tapir, giant anteater, and giant armadillo. From the earlier FRL submission, Guyana has refined its mapping of agriculture areas, including potential areas for shifting agriculture, and this has been excluded from the forest cover map in keeping with Guyana's forest definition. Additionally, the forest carbon stock inventory was finalized to cover all areas of Guyana, resulting in an updated stock inventory. The country is also home to large numbers of plant species and natural savannahs, giving Guyana exceptionally high levels of endemism, according to the IUCN[1]. Guyana's ocean area, which is more than half of Guyana's terrestrial area, offers a new frontier for sustainable development through the expansion of the Ocean/Blue Economy. These ecosystems support diverse species to the extent that as of 2010, Guyana's species status was estimated at 8,000 plant species; 467 fishes; 130 amphibians; 179 reptiles; 814 birds; 225 mammals; 1,673 arthropods; over 1,200 fungi; 33 bacteria; 13 nematode; 44 algae; 17 molluscs; and, an estimated 30 viruses (EPA, 2014) According to the FAO[2] , Guyana has 1,182 native tree species. Guyana's biodiversity provides an essential basis for climate regulation, poverty reduction, provisioning of freshwater, economic growth and development in areas such as agriculture, forestry, and fisheries, payment for forest climate services, and community-based economies, particularly in hinterland communities. Loss of biodiversity and any disruption in the provision of ecosystem services would negatively impact the economy and, more particularly, the quality of life of the people of Guyana.

[1] IUNC: https://www.iucn.org/about-iucn

[2] FAO, Global Forest Resources Assessment, 2005. http://www.fao.org/forestry/country/20807/en/guy/.

Guyana has approximately 18 million hectares of forest and has continuously worked with partners to sustain 99.5% of its forest while building the foundation of and developing a low carbon economy. Guyana's deforestation rates are among the lowest in the world, reported at 0.036% for 2022 (GFC, 2023).

Guyana's forest plays an essential role in addressing the global problem of climate change and its effects. At the same time, recognizing that these forest resources are a valuable natural asset for obtaining revenue for growth and development, in 2009, Guyana launched the first Low-Carbon Development Strategy (LCDS), which sets out a vision for inclusive, sustainable development while maintaining the country's forests, about 85% of the country's territory, to help meet some of the world's most urgent challenges. This commitment has not changed over the subsequent years and is further strengthened with the now-extended LCDS 2030, finalized in 2022.

The original LCDS 2009 set out a three-phase plan for accessing financing for forest climate services. This commenced with results-based payments under the Guyana-Norway Agreement (Phase 1), and in 2022, this transitioned to access to the voluntary and compliance markets (Phase 2) with a plan to transition to a fully-fledged UNFCCC market mechanism once this has been operationalized (Phase 3).

During Phase 1, the Guyana-Norway Agreement saw Guyana receive over US$220 million for its REDD+ performance during the period 2010-2015. Phase 2 has seen payments from the voluntary carbon markets received for performance from 2016 onwards, albeit the first payments were received in 2022. To date in Phase 2, Guyana has earned US$237.5 million from sales in the voluntary carbon market (for results in the period 2016-2020), with a further US$100 million to come for the remainder of the period covered in this Technical Annex (2021 and 2022).

Building on this strong foundation, the expected opportunity to access carbon financing for forest climate services and other ecosystem services will continue to enable Guyana to participate in emissions reduction while, at the same time, growing its economy five-fold over 20 years, keeping energy emissions flat, investing in its people, both indigenous in the hinterland communities and the vast majority living along the coast, from climate change; create jobs; and integrate Guyana's economy with its neighbours (LCDS, 2022).

Guyana remained steadfast to the vision in 2009 to create a model low-carbon economy for the world and submitted its reference level for REDD+ to the UNFCCC in 2015. Based on Guyana’s performance, incentivized by results-based payments and then access to the voluntary carbon market, the country maintained an average annual low deforestation rate below 0.06% in the last ten years, with the latest being 0.036% in 2022.

1 OVERVIEW OF GUYANA'S FRL

Guyana submitted its national proposed forest reference emission level (FRL) on December 8, 2014, in accordance with decisions 12/CP.17 and 13/CP.19. Following the process contained in the guidelines and procedures of the same, a draft version of the technical analysis (TA) report was communicated to the Government of Guyana, during which the facilitative exchange between the assessment team (AT) and Guyana enables the country to provide clarifications and information considered by the AT. Guyana submitted an updated version of its FRL on April 27, 2015, which took into consideration the technical input by the AT, and it is on the revised FRL that the technical assessment was conducted. The technical assessment report was published on October 13, 2015 (FCCC/TAR, 2015).

Guyana's FRL is based on a "combined reference level approach," which provides incentives for all categories of forest countries and encompasses REDD+ in its entirety. A full explanation of the background was set out in Guyana's initial submission in section 6.2 (page 44), but its rationale was summarized in the Eliasch Review[3], which was produced for the Government of the United Kingdom: "The combined [reference level] has the potential to be sufficiently comprehensive to attract countries at all stages of the deforestation process over both the short and long term. Countries with high historical rates of deforestation receive strong and realistic incentives to reduce forest emissions. At the same time, countries with standing forests and a track record of avoided deforestation would receive incentives to keep deforestation rates low, zero or negative (if, for example, rates of ARR are high). This rewards countries with a history of responsible forest policies while reducing the risk of international leakage of deforestation to these countries."

The FRL uses a global forest carbon emissions loss of 0.435%, the historical annual forest carbon emissions percentage of Guyana for the period 2001–2012 (0.049%), resulting in the FRL being 0.242%, which is the average of the two. Guyana includes emissions from deforestation and forest degradation due to timber harvesting

[3] Eliasch Review - GOV.UK (www.gov.uk)

practices in its FRL. At that time, it excluded removals from carbon stock enhancements, though it should be noted that more than 80% of the national territory is forested. Historically, there have been few activities related to enhancing forest carbon stocks, for which the reference level was developed, covering the period 2001-2012. The FRL considers national circumstances and Guyana's ongoing development in creating new economic and social incentives, which can significantly impact rates of forest cover. Table 1 lists the main features of Guyana's FRL (FCCC/TAR, 2015).

Table 1 Summary of the Main Features of Guyana's FRL

Features of the FRL		Description
Proposed FRL ($t\ CO_2e\ yr^{-1}$)	46 301 251	Calculated from the estimated combined Guyana and global reference emissions percentage of 0.242%. The reference level is represented as the number of emissions.
Type and duration of FRL	Combined reference level approach	Guyana's historical period of 2001–2012 is considered and adjusted for national circumstances combined with the global average reference level approach.
National/subnational	National	Guyana's FRL is of national coverage.
Gases included	CO_2	Only CO_2 gases are included in the combined FRL.
Carbon pools included	Aboveground biomass, belowground biomass, Deadwood	All five carbon pools were considered for Guyana, but owing to limitations in the global data used to construct the combined FRL, only three pools were used.
Activities included	Deforestation Forest degradation	Includes the gross emissions from deforestation (excluding regrowth from deforestation and forest degradation), including all types of land conversion to non-forest land, and the gross emissions from selective logging under forest degradation.
Forest definition	Included	Minimum tree canopy cover of 30 per cent, minimum land area of 1 ha, and minimum tree height of 5 m in situ
Relationship with the latest GHG inventory	Methods used for FRL differ from the latest GHG inventory (2012)	The difference in methods is due to the use of updated data and the 2006 IPCC Guidelines used in the FRL as compared to 1996 used in compiling the GHG inventory reported in the Second National Communication.
Adjustment for national circumstances	Yes	The global emission levels were used for adjustments as Guyana's historical emission trend is unlikely to predict future emissions accurately.
Description of relevant policies and plans	Included	Included in section 6.1 of the FRL submission
Description of assumptions on future changes in policies	Included	The national circumstances and future perspective describe ongoing policy frameworks and planned new policies and measures.
Future improvements identified	Yes	Some technical improvements are identified, and their submission is planned.

Source: (FCCC/TAR, 2015), Annex

1.1 Information on Forest Definition and Land Tenure

In Guyana, the forest is defined as having "*a minimum area of land of 1 ha with tree crown cover of more than 30% with the potential to reach a minimum height of 5 m at maturity in situ*" (GFC, 2010). This definition is guided by the Marrakech Accords (UNFCCC 2001[4]) and the components suggested by the FAO. Guyana's forests are categorized as tropical rainforests, including high-density forests, secondary forests, mangroves, etc. Approximately 50% of Guyana's State Forest Estate is unallocated, while the remaining 50% is subject to sustainable utilization for commercial operation, whereby extraction levels are strictly monitored based on approved guidelines.

Forests in Guyana are managed and administered under the Guyana Forestry Commission Act 2007 and the Forest Act 2009. There are four main forest tenure classifications in Guyana distributed across the national territory of 21.1 million hectares spanning from 2 to 8° N and 57 to 61° W, with a coastline running along the Atlantic Ocean of approximately 16km wide and 459 km long.

- ✓ **State Forest Area** - According to the Forest Act Section 3, Chapter 61:01, it is defined as "an area of State Land that is designated as a State Forest" as per the gazette.
- ✓ **Titled Amerindian Lands** - The Amerindian Act 2006 provides for areas that are titled Amerindian villages. It includes lands initially titled and the extensions for which titles are issued.
- ✓ **Protected Areas -** These are areas that fall under the scope of the Protected Areas Act. To date, Iwokrama, Shell Beach, Kanuku Mountains, and Kaieteur National Park, which account for a total of 1.1 million ha, have been designated as Protected Areas (see Figure 1).

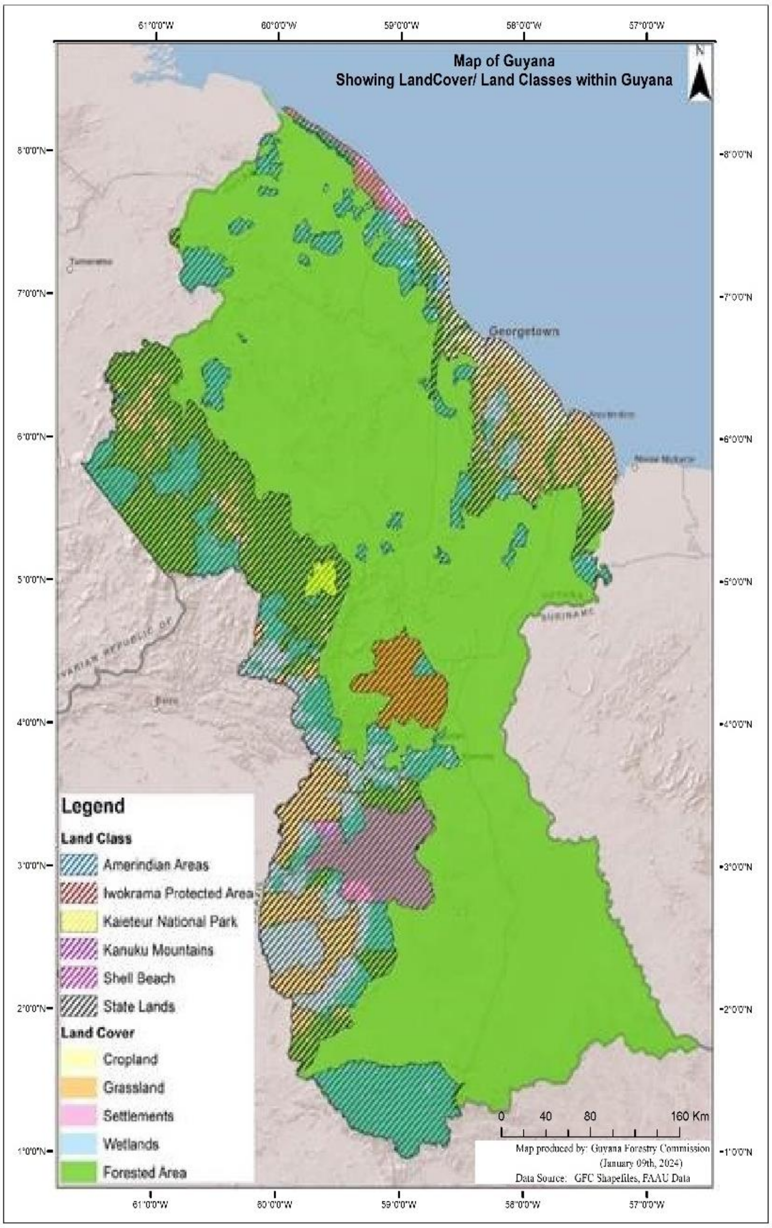


Figure 1 Guyana's Land Use Classes

[4] Marrakech Accords (2001): https://unfccc.int/cop7/documents/accords_draft.pdf

- ✓ **State Lands** - State Lands are identified as areas that are not included as part of the State Forest Area that is under the mandate of the State. This category predominantly includes State Lands, with isolated pockets of privately owned land, excluding titled Amerindian lands.

1.2 Setting the FRL

Guyana's FRL is set at the national scale in compliance with the various UNFCCC requirements and is based on the detailed and robust analysis of historic emissions from deforestation and forest degradation for the period 2001 to 2012. Table 2 lists the multiple variables and attributes used in developing Guyana's FRL in compliance with the UNFCCC modalities and the various Decisions.

Table 2 UNFCCC Modalities Relevant to Guyana's National FRL

Guidelines	Description	Guyana's FRL
Decision 12/CP.17 Paragraph 10	Allows for a stepwise approach	FRL is at a national scale and includes all drivers of deforestation and forest degradation due to selective logging only.
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases included	**Pools:** • Aboveground and belowground biomass • Deadwood is included in degradation from timber harvest only. **Gases:** ✓ CO_2
	REDD+ Activities: deforestation and forest degradation	**Deforestation Drivers:** Agriculture, mining, forestry infrastructure, and other infrastructure. **Forest Degradation** from timber harvesting only
Decision 12/CP.17 Annex, paragraph (d)	The definition of forest used is the same as that used in the national GHG inventory.	✓ Minimum tree cover: 30% ✓ Minimum height: 5 m ✓ Minimum area: 1 ha
Decision 12/CP.17 Annex	IPCC guidelines and Guidelines used	IPCC 2003 and 2006 guidelines.
Decision 12/CP.17 II. Paragraph 9	To submit information and rationale on the development of forest RLs/RELs, including details of national circumstances and how the national circumstances were considered.	Guyana is an HFLD country (having over 85% forest cover and an average deforestation rate of below 0.06%). The FRL uses a holistic methodology that includes countries like Guyana, as well as other categories of forest countries and therefore avoids perverse incentives so as to act as an incentive against leakage and in support of additionality and permanence in countries like Guyana.

1.3 Construction of the FRL

Guyana's Reference Level for REDD+ illustrated in Figure 2 is based on the Combined Reference Level Approach, in which a global forest carbon emissions loss ((Baccini, et al., 2012) was used, along with Guyana's historic emissions level for the same pools and period 2001 to 2012. The FRL was derived by averaging the global percentage of forest carbon emissions of 0.435% and Guyana's historical annual average of 0.049%, resulting in Guyana's proposed FRL being set at 0.242%, which is equal to 46,301,251 t CO_2 e yr^{-1}.

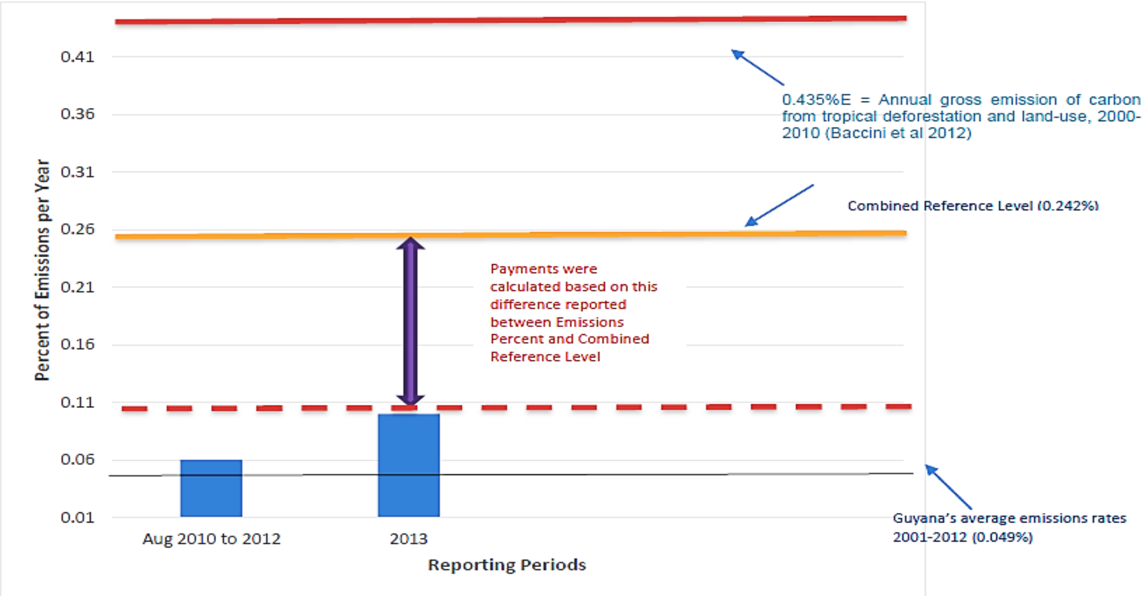


Figure 2 Guyana's for Reference Level for REDD. Source: (GoG, 2015) Fig. 8

1.4 Emissions Drivers Considered in the FRL

Emissions are calculated for each driver considered in Guyana's FRL and projected impacts. These drivers include forestry, mining, agriculture, infrastructure, and other developments. Table 3 lists the projected allocation of emissions each driver will contribute to the reference level. While the FRL is built on historical data, it is understood that adjustments will be made over time as existing and new policies are implemented, new data becomes available, methodology evolves, and national circumstances change.

Table 3 Guyana's FRL by Drivers

Drivers of Projected Emissions Level	Policies	Percentage of Contribution to Reference Level (%)	Total Emissions attributed to driver (thousand tCO_2)
Forestry	EU FLEGT, Reduced Impact Logging and SFM, National Log Tracking and Chain of Custody Management.	20	9,260
Mining	EITI, Codes of Practice, Reduced Use of Mercury, More Efficient Technologies.	49	22,688
Infrastructure, including Brazil/Guyana Road	Scoping of Development, Environmental and Social Impact Assessment (ESIA).	9	4,167
Agriculture	Scoping of Development, ESIA.	4	1,852
Other Developments, such as in Alternative Energy	Scoping of Development, ESIA.	18	8,334
TOTAL			**46,301**

Source: (GoG, 2015) Table 13b

1.5 Annual REDD+ Performance Based on Reference Level

Annual Reported Emissions per cent under the FRL is computed by dividing the annual reported forest carbon emissions loss by the total forest carbon stock of Guyana that is concluded following measurement and verification, inclusive of the establishment of accuracy levels, which is then subtracted from the Combined Average of 0.242%. The total carbon stocks in life biomass (aboveground and belowground pools) for Guyana is 5,218 million t C (area weighted average is 283 t C ha^{-1}), and the total emissions are 2.55 million t C yr^{-1}, giving an average rate of loss of 0.049%/year (GoG, 2015). These average carbon emissions of 46,301,251 t CO_2e yr^{-1} or 0.242% are used as the baseline for computing and reporting on Guyana's REDD+ activities. The Annual performance is measured against the proposed emissions by the drivers listed in Table 3Table 3.

1.6 Technical Evaluation of FRL

The UNFCCC Technical Assessment Report (TAR) of Guyana's proposed FRL recognized that the information used in its construction for reducing emissions from deforestation and reducing emissions from forest degradation is transparent and complete and is in overall accordance with the guidelines for submissions of information on FRLs (as contained in the annexe to decision 12/CP.17) (FCCC/TAR, 2015).

As a result of the facilitative interactions with the assessment team (AT) during the technical assessment (TA) session, Guyana submitted a modified submission considering the technical input by the AT, resulting in improvement in the transparency and completeness of the information, an effort the AT noted as commendable. The AT noted that the data used in the construction of the FRL were considered accurate. Guyana was encouraged to continually build on GHG datasets in the preparation of subsequent GHG inventory on forest-related emissions report submissions.

Guyana was commended for the information provided on its ongoing work in the development of FRLs to improve the accuracy and coverage of the estimations by the assessment team. The TAR also acknowledged that Guyana included in the FRL the most significant activity and pools in terms of emissions from forests and that the FRL covers the entire national territory of Guyana, complying with decision 1/CP.16, paragraph 70, on activities undertaken, paragraph 71(b), and decision 12/CP.17, paragraph 10, on implementing a stepwise approach.

The TAR acknowledged that the combined reference level approach used by Guyana in its submission was developed in 2009 before any of the relevant COP decisions were adopted. The AT concluded that the combined reference level approach applied by Guyana was appropriate as an interim approach.

A partnership between Guyana and Norway was agreed to and detailed in a joint concept note outlining the basis of Guyana receives results-based payments in accordance with agreed performance measures with one of the main measures being the annual deforestation rate, measured against Guyana's FRL.

The intention expressed by Guyana to continue monitoring forest and its related emissions, continued efforts to estimate emissions from other drivers of forest degradation in addition to selective logging, which had not been quantified at that time; efforts to estimate removals due to regrowth, which has also not been quantified at that time; carrying out research and gathering information in order to improve the transparency and accuracy of the approach used to estimate its FRL; and efforts to prevent any double counting between deforestation and forest degradation in its future monitoring system, was commended by the TA in the TAR. Future technical improvements include improving the way effects of national circumstances, policies and programs are quantified and reflected in the FRL, assessing pools and gases included in the FRL, and considering non-CO_2 gas emissions when additional sources of emissions are included in the FRL was reported by Guyana.

2 GHG EMISSION REDUCTIONS AND REDD+ RESULTS

Guyana's unique position as a country with vast forests and diverse ecosystems provides significant opportunities for REDD+. Guyana balances its economic development goals with sustainability and takes a proactive approach to addressing emissions to mitigate the impacts of climate change. For consistency, transparency, and comparability purposes, this submission will only consider emissions covering the period 2013 to 2022. As such, the results presented herein will reflect this period. Notably, there have been improvements since the submission of the FRL in 2015, which are reflected in the current BUR and BTR submission and this technical annex. Some of these improvements are reflected in the drivers of deforestation and degradation, the methodology, and emissions factors used and are presented in the improvement section, Chapter 7 of this report.

Guyana developed a framework for a national Monitoring Reporting and Verification System for REDD+ in 2009, outlining progressive steps over three phases to build and implement a complete MRV system, with the first year of reporting being 2010. From this period, the country generated annual REDD+ results, tracked and verified by a third party as part of its verification process embedded in its standard operating procedures, adding a layer of transparency to the results published annually. To date, twelve (12[5]) annual MRV reports have been published, for which initial feedback is received and addressed before their finalization and publication. The primary purpose of these reports is to report on the country's annual REDD+ performance on deforestation and forest degradation and provide critical information to inform and shape national policies and strategies.

2.1 Annual Emissions from Deforestation and Degradation

In Guyana, forest is defined as "Land exceeding 1 hectare with trees exceeding 5m in height and 30% crown cover but not classified as agriculture, infrastructure or settlements" (GFC, 2017). An area is deemed deforested once the cover falls and remains below the elected crown cover threshold of 30%, which is guided by the GOFC-GOLD, 2010[6] definition of "the long-term or permanent conversion of land from forest use to other non-forest uses."

[5] Guyana MRVS Annual Reports

[6] GOFC-GOLD (2010): https://redd.unfccc.int/uploads/63_33_redd_20120509_gofc-gold.pdf

Figure 3 presents Guyana's annual REDD+ performance by deforestation and forest degradation for the accounting period 2013-2022. Despite having information for all five IPCC-recommended carbon pools available, Figure 3 only includes emissions for the aboveground and belowground carbon pools to ensure alignment with the FRL.

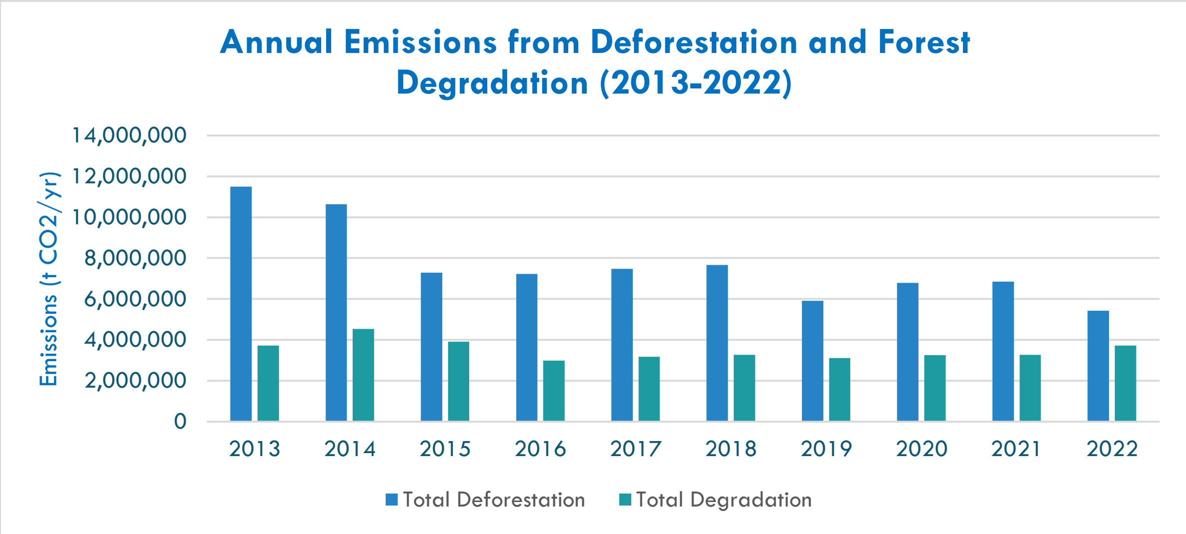


Figure 3 Annual Emissions from Deforestation and Forest Degradation as per FRL

During the reporting period, emissions from deforestation and forest degradation fluctuated. However, deforestation emissions remain twice that of forest degradation, a trend that continued throughout the reporting period until 2022. Gold mining is the main forest loss driver, accounting for over 85% of the change. Changes in the gold price, availability of alternative income sources, and accessibility likely impact deforestation rates in any year.

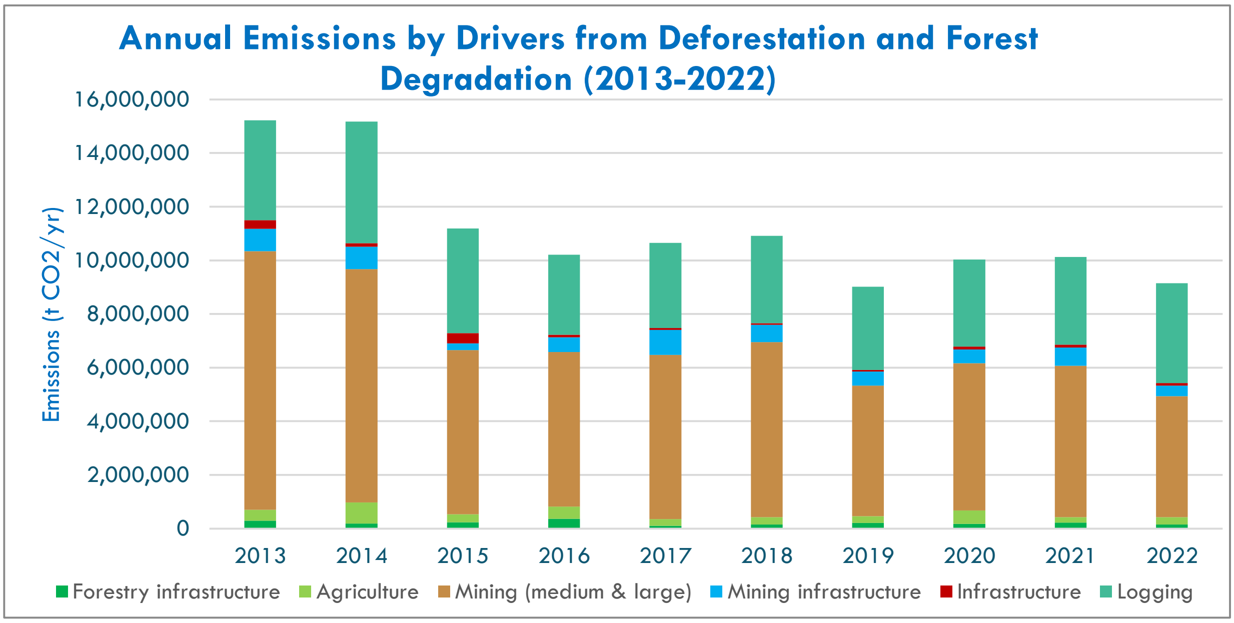


Figure 4 Annual emissions by drivers of deforestation and forest degradation

Deforestation peaked in 2012 as seen in Figure 5 for reference and slowly decreased in subsequent years, which is in line with the price of gold, peaking in 2011/2012. The heightened activity aligns with this trend and is further reinforced by mining as the driver, which had the largest increase during this period. Furthermore, the price of gold has increased significantly since 2022, as seen in Figure 5. The forest loss and gold price are shown in Figure 5. Forest loss slowed between 2020 and 2021, which coincided with the COVID pandemic, and then increased again. Mapping year 2023 shows a notable increase in activity, whilst the same sensor (Sentinel 2) was retained. This further supports the change, which is driven by the impacts of the supply and demand of gold, as opposed to a change in sensor.

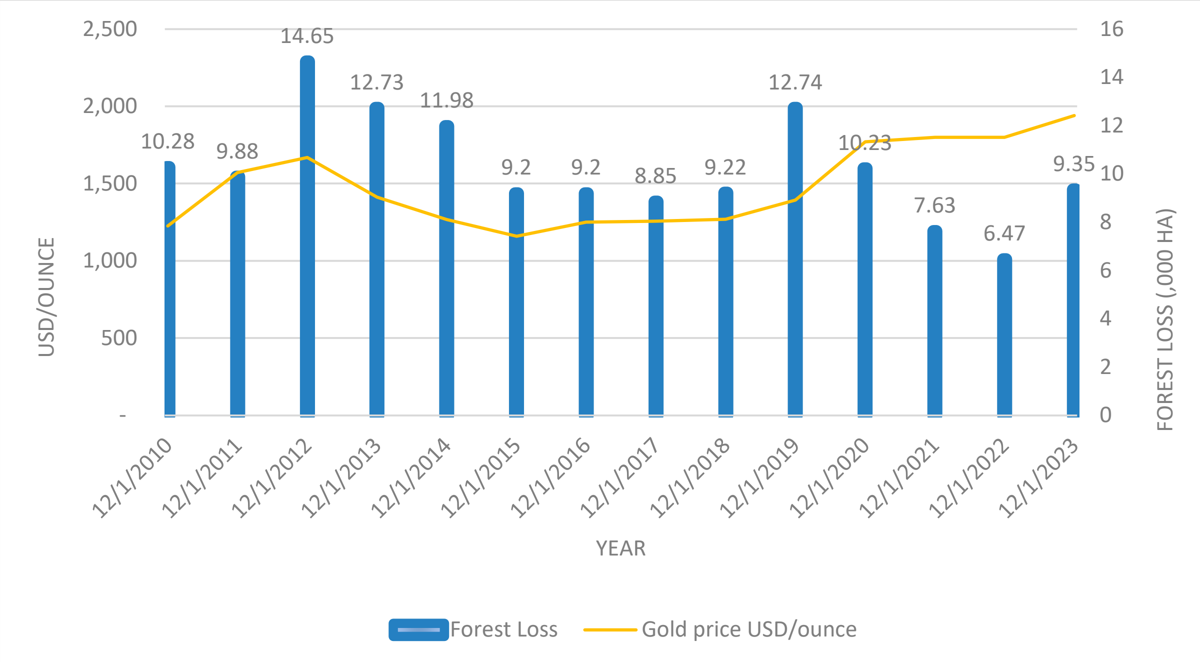


Figure 5 2010-2023 Annual forest loss relative to gold price

In 2022, there was a significant decrease in deforestation and a notable increase in emissions from forest degradation, narrowing the gap seen in Figure 3. The reduction in degradation can be attributed to the significant interest generated in the new oil and gas sector, which affects the mining sector, as seen in Figure 4. Despite this, mining remains the major emissions driver in Guyana.

It should be noted that the emissions from deforestation and forest degradation for these years presented in this REDD+ TA will not align completely with those reported in the greenhouse gas inventory chapter attached to the BUR/BTR, as the BUR/BTR includes the methodological advancements made since 2015 and revisions made to the crediting baseline. Since submitting the FRL, Guyana has improved its data collection and expanded the drivers, carbon pools, and gases covered to enhance the completeness and accuracy in reporting of the country's REDD+ Performance.. These improved areas are presented in Chapter 7 of this report.

Like deforestation, degradation has also experienced fluctuation, as illustrated in Figure 6. During the reporting period, the sharp increase in forest degradation attributed to logging in 2014 is a direct result of the increased issuance of small concessions coupled with the prolonged dry season experienced in Guyana. This allowed for extended accessibility into areas that enabled increased production, which reoccurred in 2022. However, there was also a significant decrease in 2015 and 2016, which can be attributed to the slowing down and exit of two large concession operations.

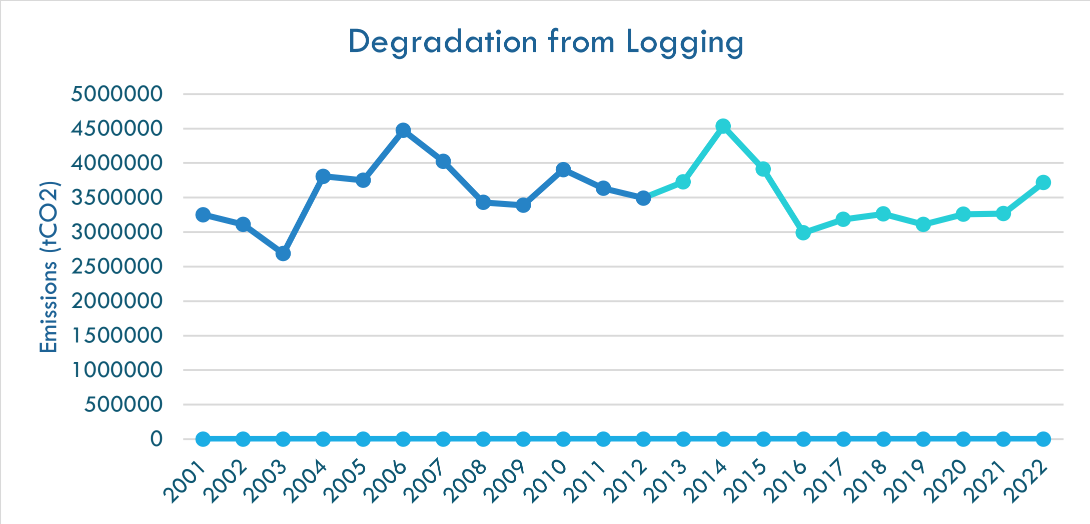


Figure 6 Emissions from degradation

2.2 REDD+ Results Relative to FRL

For the reporting period 2013 to 2022, Guyana's average annual deforestation emissions, as per the FRL, is 7,674,705 t CO_2 e, while the average yearly emissions from forest degradation is 3,494,098 t CO_2e. Of the average emissions, 69% are attributed to deforestation, while 31% is to forest degradation. The average annual reduction as per Guyana's FRL baseline of 46,301,251 t CO_2 e is 35,132,449 t CO_2 e.

The results generated show in Figure 7 Guyana's FRL is well below its FRL baseline, with an average of 79% reduction against the baseline. Considering the evolving national circumstances and data availability, Guyana is revising its FRL, which is expected to be submitted in 2024.

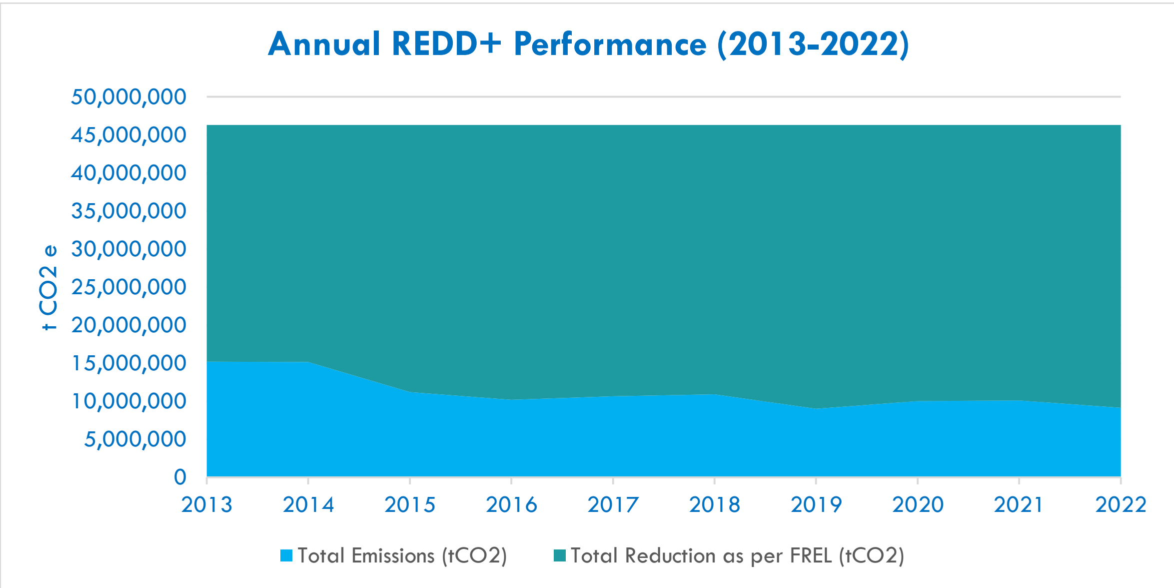


Figure 7 Annual REDD+ Performance as per the FRL Baseline

2.3 REDD+ Results-based Finance Received

Guyana's performance to date in relation to the baseline set in the FRL, illustrates its performance well below that set, which has resulted in the country being rewarded with carbon financing. For the period 2009-2015, Guyana received carbon financing based on bilateral results-based payments. One of the key considerations in Guyana's FRL for REDD+ was the integration of a financial incentives baseline with payment computation, which Guyana has successfully done to date. In the mechanism used in the bilateral agreement between Guyana and Norway, a sliding scale was integrated as part of the incentive mechanism. The performance generated by Guyana's forests was monitored, reported, and verified under the national-scale Monitoring, Reporting and Verification System (MRVS) put in place by the Guyana Forestry Commission (GFC).

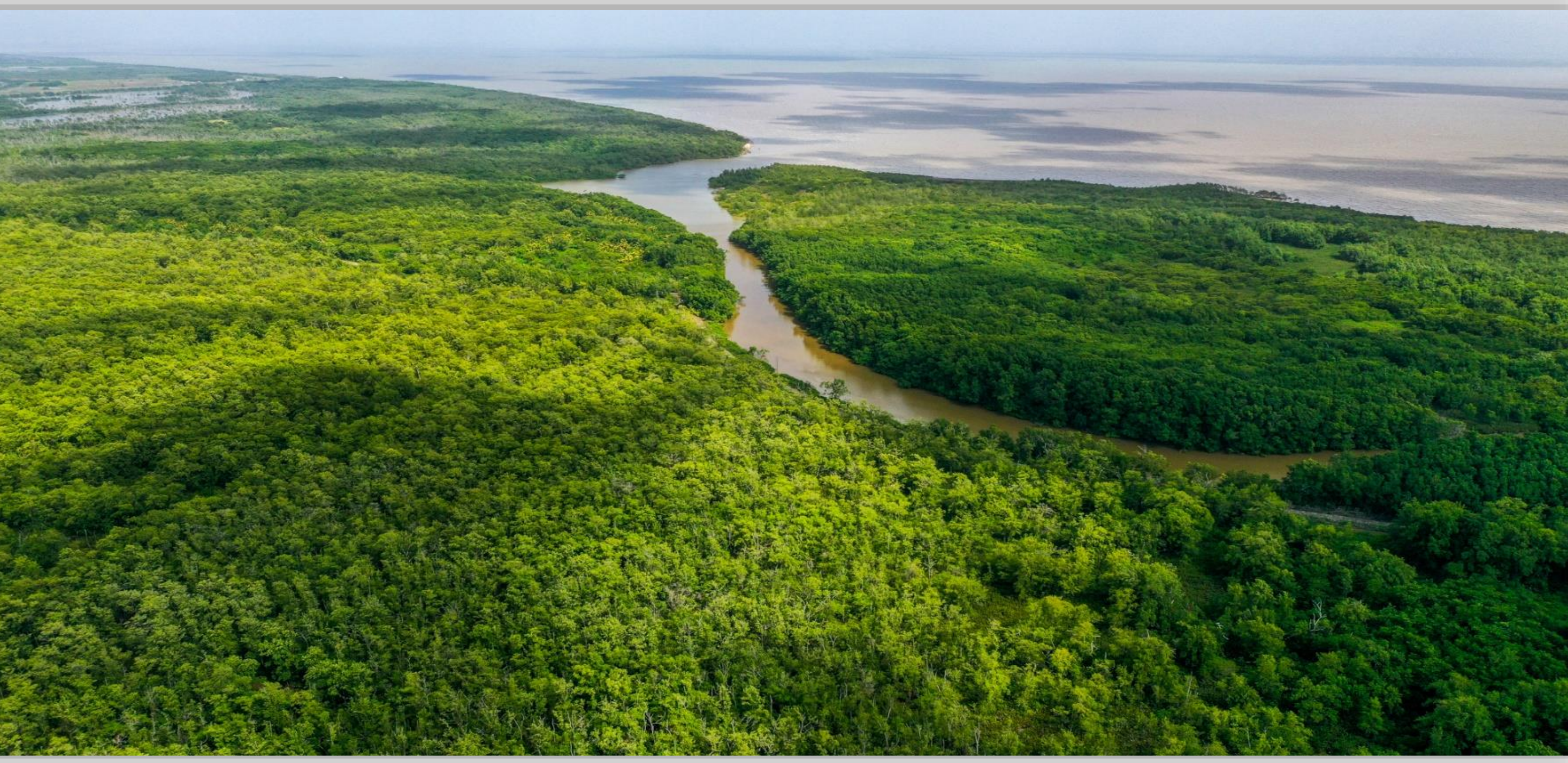
In expressing Guyana's commitment to REDD+ and prioritizing this action, the 0.056% deforestation cap ceiling for emissions levels for the payment period was established on which payments were made. In the years that Guyana exceeded this 0.056 % rate, the payments were reduced on a sliding scale up to the rate of 0.1%, at which point, there are no payments made. On the signing of the Guyana Norway Bilateral Agreement in 2009, the first climate finance payment was made. While the payments were received and country performance stands outside of this reporting period for emissions covered in this report, they are included for clarity and completeness purposes and listed in Table 4. From this partnership, Guyana received a total of USD220,800,000 for the performance period 2010 to 2015 (LCDS, 2022).

While no other finance was generated under this agreement outside of those listed in Table 4, Guyana maintained its MRV system to ensure permanence, which continues to generate results. This system has allowed Guyana to access the voluntary carbon market in 2022 and to sell carbon credits for the period 2016-2030, including the period covered by this TA, for which it has successfully received USD237500,000 to date. Guyana intends to continue to advance its system and pursue additional avenues for generating carbon financing while simultaneously fulfilling its obligation under the Paris Agreement of the UNFCCC.

Table 4 Performance-based Carbon Finance

Year	Channel of Disbursement	Results-based payment
2009 Performance Payment	GRIF	30,355,594
2010 Performance Payment	GRIF	39,474,415
2011 & 2012 Performance Payment	IDB	80,034,965
2013 Performance Payment	GRIF	43,886,657
Direct Disbursement for Capacity Building and EU-FLEGT Projects	CI	14,815,886
Direct Disbursement for Village Sustainable Plans	CI	4,000,000
TOTAL RECEIVED FROM NORWAY		**212,597,518**
Investment Income – GRIF (World Bank Trustee Account)	-	3,200,000
Iinvestment Income – IDB Renewable Energy Account	-	5,100,000
TOTAL REDD+ FINANCE		**220,800,000**

Source (LCDS, 2022)



3 CONSISTENCY OF METHODOLOGIES BETWEEN THE REDD+ RESULTS AND THE ESTABLISH FRL

The method used to generate the REDD+ results is consistent with the FRL. Both methods use the same forest definition and land use classification and share the same REDD+ activities, maintaining the same carbon pools, gases, and national scales. However, a few improvements can be found in developing the activity data and emissions factors, owing to the availability of updated national data. These were a direct follow-up to the recommendations made by the Technical Review of the Second National Communication. This chapter presents the information necessary to reconstruct the results in chapter 2 following the methodologies consistency used for their generation.

3.1 Use of the Most Recent IPCC Guidance and Guidelines

The FRL and this REDD+ Technical Annex (REDD+TA) used the 2006 IPCC Guidelines. (IPCC, 2006); and while many improvements have occurred since the submission of the FRL, the information used to generate the results remains the same, and all improvements are listed and presented in Chapter 7. Table 5**Error! Reference source not found.** Summarises the consistency of methods used in the FRL and the REDD+ TA to enable reconstructions of the estimate's calculations.

Table 5 Comparison of FRL and REDD+TA for the reconstruction of calculation

Parameters	Description	FRL	REDD+TA
IPCC Guidelines	2006 IPCC Guidelines	✓	✓
REDD+ Activities	Reduction from deforestation and forest degradation	✓	✓
Forest Definition	30% canopy cover, >1ha, >5m in situ	✓	✓
Carbon Pools	-Aboveground -Belowground biomass -Deadwood included in degradation from timber harvest only.	✓	✓
Gas	CO_2	✓	✓

Parameters	Description	FRL	REDD+TA
Deforestation Drivers	-Forestry infrastructure -Agriculture -Mining (medium and large scale) -Mining infrastructure -Infrastructure	✓	✓
Degradation Drivers	-Logging volume harvested	✓	✓
Forest Stratification	High Potential for Change More Accessible Area High Potential for Change Less Accessible Area Medium Potential for Change More Accessible Area Medium Potential for Change Less Accessible Area High Potential for Change More Accessible Area Low Potential for Change Less Accessible Area	✓	✓
Activity Data	Disaggregated by deforestation and forest degradation drivers by stratum	✓	✓
Spatial Mapping	1ha minimum mapping unit	✓	✓
Emissions Factor	Developed by stratum (Tier 2).	✓	✓
Data Source	-GFC Annual MRV Reports -GFC tools	✓	✓

3.2 Methodology for Deriving the Activity Data

Guyana developed its activity data for deforestation and forest degradation using spatial and non-spatial methods. The spatial method is applied to track deforestation and some degradation, depending on the area size, against the forest definition. In contrast, the non-spatial method is applied to forest degradation resulting from logging based on production. The activities developed and tracked in the GIS systems and databases are summarised and listed in Table 6 (GFC, 2023).

Table 6 Activities by Drivers of Deforestation and Degradation captured in the Activity Data

	Activity	Driver	Criteria	Supporting Info	Spatially Mapped
Deforestation	Roads	Infrastructure	Roads > 10m	Mapped layers, satellite imagery	Yes
	Mining	Infrastructure	Roads >10 m	Existing road network, satellite imagery	Yes
	Agriculture	Deforestation	Deforestation sites >1 ha, including shifting cultivation occurring outside the village buffer extent	Registered agricultural leases, satellite imagery	Yes
Forest Degradation	Forestry	SFM	Harvested timber volumes and illegal logging totals.	Annual harvest plans, GIS extent of timber concessions	No

Source: GFC, 2023.

For synergy and ease of reporting under the IPCC, the land use changes from forests are now being classified as transitioning to one of the other five land use classes (croplands, grassland, wetlands, settlement, and other lands). Natural events considered non-anthropogenic change are excluded from the deforestation or degradation estimates, which are typically non-uniform in shape and have no evidence of anthropogenic activity nearby. These are mapped in the GIS for completeness and classified following the Standard Operating Procedures for Forest Change Assessment.[7].

Methodology for Deriving the Spatial Activity Data for Deforestation

The datasets used for deriving the activity data from the change analysis have evolved as more tools and methods become available. The historical change analysis from 1990-2009 was initially conducted using Landsat imagery. In 2010, a combination of DMC and Landsat, 2011 onwards, was superseded with high-resolution images, including RapidEye and Sentinel. For 2015 and 2016, a combination of Landsat and Sentinel data was used, which is the preferred combination to ensure sustainability and consistency in generating the activity data. During the reporting period, the forest/non-forest boundaries were improved, but the forest area also changed, particularly at two points in time, 2012 and 2014, which was done using wall-to-wall RapidEye imagery. While the data sets have changed regarding the satellite image utilized, the methodology for change detection remains the same.

Guyana developed a process that tracked changes in areas of more than 1 ha spatially over time and by drivers. This means only changes 1 ha (continuous) or greater contribute to the annual deforestation figure. The minimum mapping rule eliminates most bias between satellite image sources varying in spatial resolution. All satellite data used in Guyana's MRV System can reliably map activity at or above 1 ha. It is worth mentioning that the true pixel resolution of RapidEye is 6.5 m versus Sentinel's 10 m. The system is primarily built to track forest area changes in keeping with international best practices.

The method utilizes a wall-to-wall approach that enables complete, consistent, and transparent monitoring of land use and land-use changes across the forest over time. The wall-to-wall mapping, which drives the reporting figures for the MRV System uses satellite images carefully reviewed by GFC's mapping experts. The process uses ESRI's ArcMap/Pro GIS software and has remained unchanged since 2009. Forest loss events are manually digitized and attributed to a forest loss driver. The technique used allows for land cover change greater than one hectare in size to be tracked through time and attributed by its driver (i.e. mining, agriculture, infrastructure, or fire). The approach employed is to divide the country into a series of regularly spaced 24 x 24 km tiles. The mapping process involves a systematic manual review of each 24 x 24 km tile, divided into 1 km x 1 km tiles at a resolution of 1:8000. If a cloud is present, multiple images over that location are reviewed. The automated tools and dataset created using Google Earth Engine (GEE) are only used to support the mapping team by providing additional layers that they can reference in the GIS. The additional layers created include quarterly cloud-free Sentinel 2 image composites and forest change alerts created from the same image composite.

Guyana's GIS-based monitoring system is designed to map change events in the year of their occurrence and then monitor any changes over the area each year. If an area remains constant, the land-use class and change driver are updated to stay consistent with the previous analysis. However, where change is detected, this is recorded using the appropriate driver. Each change is attributed to the acquisition date of the pre- and post-change image, the driver of the change event, and the resultant land-use class. Upon completion of the change detection per tile, they undergo a quality assurance quality control process, after which they are stitched together. After stitching, the total area per driver is generated, and this total undergoes the final level of quality assurance.

The mapping criteria are set and dictated by a set of mapping rules on how each event is classified and recorded in the GIS under a standard operating procedure guideline developed as part of the MRV system. The input

[7] Standard Operating Procedures For Forest Change Assessment

process is standardized using a customized GIS tool, which provides a series of pre-set selections that are saved as feature classes. The mapping process is divided into mapping and QC. The QC team operates independently of the mapping team and is responsible for reviewing each tile as it is completed. Additional GIS layers are also included in the decision-making process to reduce uncertainty. The decision-based rules are outlined in the mapping guidance documentation or Standard Operating Procedures (SOPs) (GFC, 2021).

All mapped results are subjected to an independent Accuracy Assessment conducted by Durham University. Correspondingly, the accuracy assessment work completed by Durham University shows the same forest loss trends. Durham's forest loss assessment uses a completely independent sample based on high-resolution data (0.5 to 1m resolution) specifically flown or tasked for this assessment. The use of high-resolution data has been a feature of the accuracy assessment since 2010 and has remained unchanged. As the deforestation rates always aligned well with the confidence intervals derived from the external accuracy assessment (which has used higher resolution 0.5 m data), the increases in the deforested areas reflected true change rather than an artifact of source data and is guided by a decision tree in Figure 8.

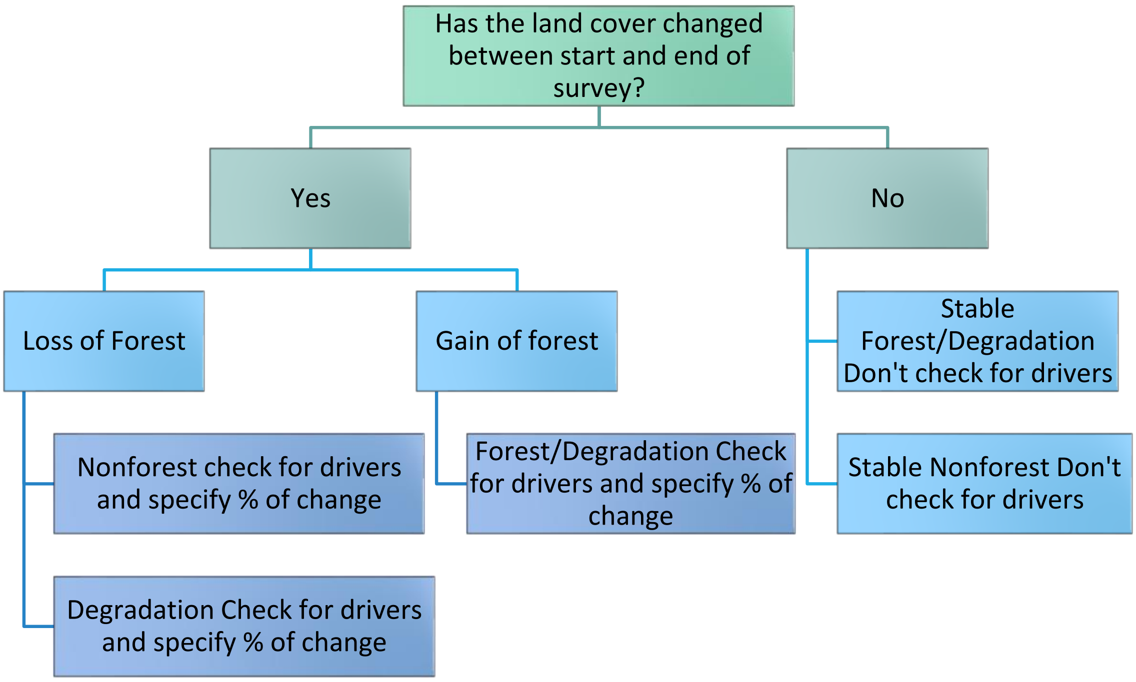


Figure 8 Decision tree for sample-based change estimation

Figure 8, outlines the flow of thought regarding the sample-based change estimation approach. When forest loss is more than 70%, the end-state is Non Forest. When the forest loss is less than 70% but more than 25%, the end-state is Degradation. When the forest loss is less than 25%, then the end-state remains the forest. There is an exception to this rule when non-forest land cover categories occupy part of the SSU. In this case, the decision-making depends on the amount of forest remaining and not on the amount of forest loss.

In 2020, a paper was published that compared the deforestation estimates from the University of Maryland (UMD) Global Forest Change Datasets, Durham University (DU) sample-based estimate, and GFC's wall-to-wall approach. The Figure 9 copied from the paper provides a comparison of the three approaches. Of interest is that the forest loss estimates for GFC and DU for the 2012-2014 period are very close (blue and orange bars on the graph below).

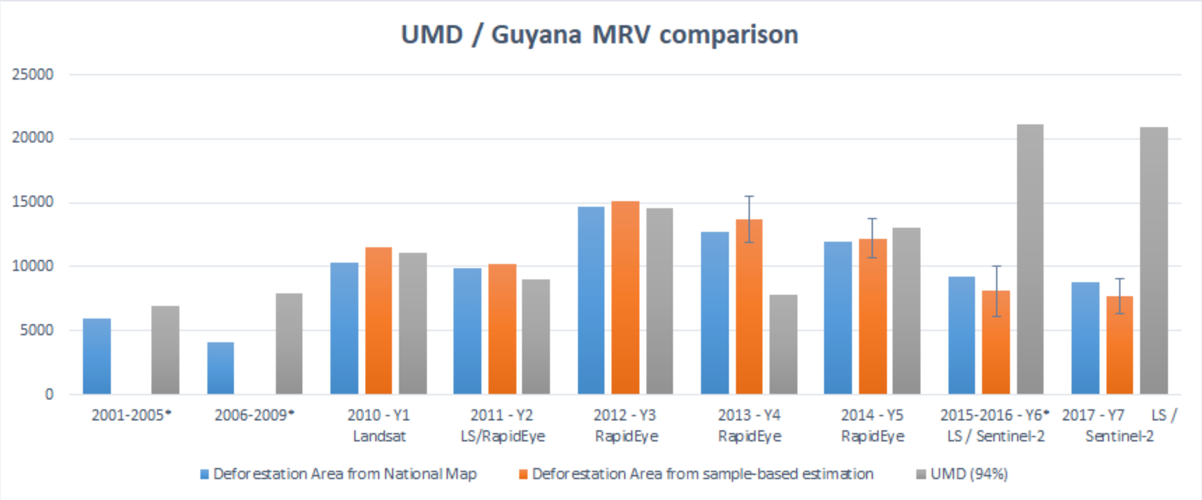


Figure 9 Annual forest loss estimates between 2001 and 2017 in Guyana estimated from UMD[8]

Annual forest loss estimates between 2001 and 2017 in Guyana were estimated from UMD (i.e., Global Forest Change) maps, Guyana-MRV maps, and sample-based estimation. The Y-axis denotes forest loss in hectares (ha)* annual average.

Methodology for Deriving Non-Spatial Activity Data for Degradation

The primary sources of degradation are those associated with logging, including forest management-related losses, selective timber harvesting, logging damage, and illegal harvesting. This information is non-spatial and extracted from a database administered and managed by the Guyana Forestry Commission (GFC).

Forest Management and Production Data

Forest management includes selective logging activities in primary or semi-primary forests. The requirement is that areas under sustainable forest management (SFM) be rigorously monitored and activities documented, including harvest production data used to estimate degradation. By applying the gain-loss method of the 2006 IPCC Guidelines, the production data is used in combination with default expansion factors to account for the loss.

Production volumes are recorded on declaration/removal permits issued by the GFC to forest concession and private property holders. Upon declaration, the harvested produce is verified, and permits are collected, checked, and sent to the GFC's Head Office, followed by data input into the central database. The permits include details on the product, species, volume, log tracking tag number used, removal and transportation information, and, in the case of large timber concessions, more specific information on the location of the harvesting. Production reports are generated by various categories, including total volume, submitted to multiple stakeholder groups and used in national reporting.

Following receipt of removal permits and production registers, monthly submissions are made to the GFC's Management Information System section, where the data collection, recording, and quality control are performed. Data is entered in SQL databases custom-designed for production totals. This database has built-in programmatic QA/QC controls that allow automatic validation and red flagging of tags. These checks include tags being used by unauthorized operators or permits being incorrectly, incompletely or otherwise misused. The

[8] An Assessment of Global Forest Change Datasets for National Forest Monitoring and Reporting

system also allows for the cross-checking of basic entry issues, including levels of production conversion rates. The production data are disaggregated by types and declared volumes of primary products, including logs, lumber (chainsaw lumber), roundwood (piles, poles, posts, spars), splitwood (shingles, staves), and fuelwood (charcoal, firewood). These production data by type are then used to estimate the degradation emissions. Accounting for the impact of selective logging on carbon stocks involves the estimation of several different components:

- Biomass removed in the commercial tree felled – emission.
- Incidental dead wood created as a result of tree felling – emission.
- Damage from logging skid trails – emission.
- Carbon stored in wood products from extracted timber by product class – removal.
- Regrowth resulting from gaps created by tree felling - removal.

Illegal Logging

Though there is a robust system in place, the monitoring approach provides for continuous improvements to capture illegal logging that may occur though the risk of this is quite low. To account for this possibility, areas and processes of illegal logging are monitored and documented as far as practicable. The measurement of these activity data is done by assessing the volumes of illegally harvested wood. In 2020, the rate of illegal logging was informed by a custom-designed database updated monthly and subject to routine internal audits. This database records infractions of unlawful logging in Guyana in all areas.

Reporting on illegal logging activities is done via the GFC's 36 forest stations, located strategically countrywide, and by field monitoring and audit teams through the execution of both routine and random monitoring exercises. The application of standard GFC procedures determines illegal logging activities. The infractions are recorded, verified and audited at several levels. All infractions are summarised in the illegal logging database and result in a total volume being reported as illegal logging annually.

3.3 Methodology in Deriving the Emission Factor

Over the years, Guyana has established specific emissions factors within its national REDD+ Monitoring, Reporting, and Verification (MRV) System to address deforestation and forest degradation. These factors help quantify greenhouse gas emissions accurately, aligning with the FRL to ensure consistency in reporting. Using country-specific data, Guyana's MRV System enhances the accuracy of emissions assessments, supporting the country's commitment to reducing emissions from deforestation and degradation.

Emission Factors for Deforestation

The development of country-specific emissions factors for deforestation in Guyana was done through a combination of spatial data and field data (Petrova, Goslee, Harris, & Brown, 2013). In 2010, methodologies were tested to determine the most appropriate emissions factor that allows for a confident estimation of Guyana's carbon stock (Casarim, et al., 2017), which ultimately contributed to the development of its emissions factors. Guyana's Forest Carbon Monitoring System (FCMS) for REDD+ activities, development which was guided by Winrock International, provides the methodology used in developing the emissions factors by applying the following:

1. Stratification of the Country forest
2. Designing the sampling approach within the strata
3. Collecting and analysing the data to achieve a set level of confidence

The emission factor for deforestation used by Guyana in Equation 1 is the sum of all carbon stocks from aboveground biomass and belowground live biomass pools.

Equation 1 Emissions Factor for Deforestation

$$EF_{deforestation} = \{C_{AGB} + C_{BGB}\} * \frac{44}{12}$$

Where:
$EF_{deforestation}$ = Emission factor for deforestation; t CO2 ha-1
C_{AGB} = Carbon stock in aboveground biomass pool; t C ha-1
C_{BGB} = Carbon stock in belowground biomass pool; t C ha-1

Stratification of the Country Forest

Guyana's forested area was stratified using a Tier 2[9] approach (see Figure 10), the method that was reported in the FRL. The first stratification stratified the country into high, medium and low potential for change. These potentials for change were driven by indicators that are driving changes in Guyana. The indicators were the historical drivers of deforestation, such as roads, settlements, rivers, land under different management practices, elevation, etc., using heuristic and empirical approaches in a spatial modelling framework design. Using the heuristic approach, areas close to the factor feature were ranked with higher values for change than areas further away from the factor feature.

All maps of deforestation factors created using both approaches were evaluated against historical deforestation for the periods 2000-2005 and 2005-2009, using the statistic of Relative Operating Characteristic (ROC). ROC is a method that assesses how well a factor map portrays the location of forest change for both periods without estimating the exact quantity of the change. Factor maps that show high ROC statistics were combined in different combinations to create a Potential for Change (PC) map. The Potential for Future Change (PFC) map was created following the combination of identified factors from the historical analysis.

The idea is that areas close to factor features (roads, settlements, rivers, etc.) have a higher potential for future deforestation or forest degradation due to accessibility than areas further away from these factor features. This resulted in the second stratification of more accessible and less accessible, as illustrated in **Error! Reference source not found.**. A large portion of Guyana's forestland is less accessible, and the sampling stratification aims to overcome this operational constraint while maintaining robust sampling results. As such, the accessibility factor was introduced in the sampling stratification methodology to provide a forest carbon sampling framework that efficiently collects carbon sampling data. The more accessible stratum is defined as a 5 km straight distance from roads, a distance which will enable a field team to travel to the sampling point, establish the plots and return to the road within one day. The less accessible stratum is defined as all forestland outside the 5 km road buffer and will require additional travel that may entail camping or air travel for drop-off.

The more accessible stratum is defined as a 5 km straight distance from roads, a distance which will enable a field team to travel to the sampling point, establish the plots, and return to the road within one day. The less accessible stratum is defined as all forestland outside the 5 km road buffer and will require additional travel that may entail camping or air travel for drop-off.

[9] Spatial Analysis for Forest Carbon Stratification and Sample Design for Guyana's FCMS: Phase II

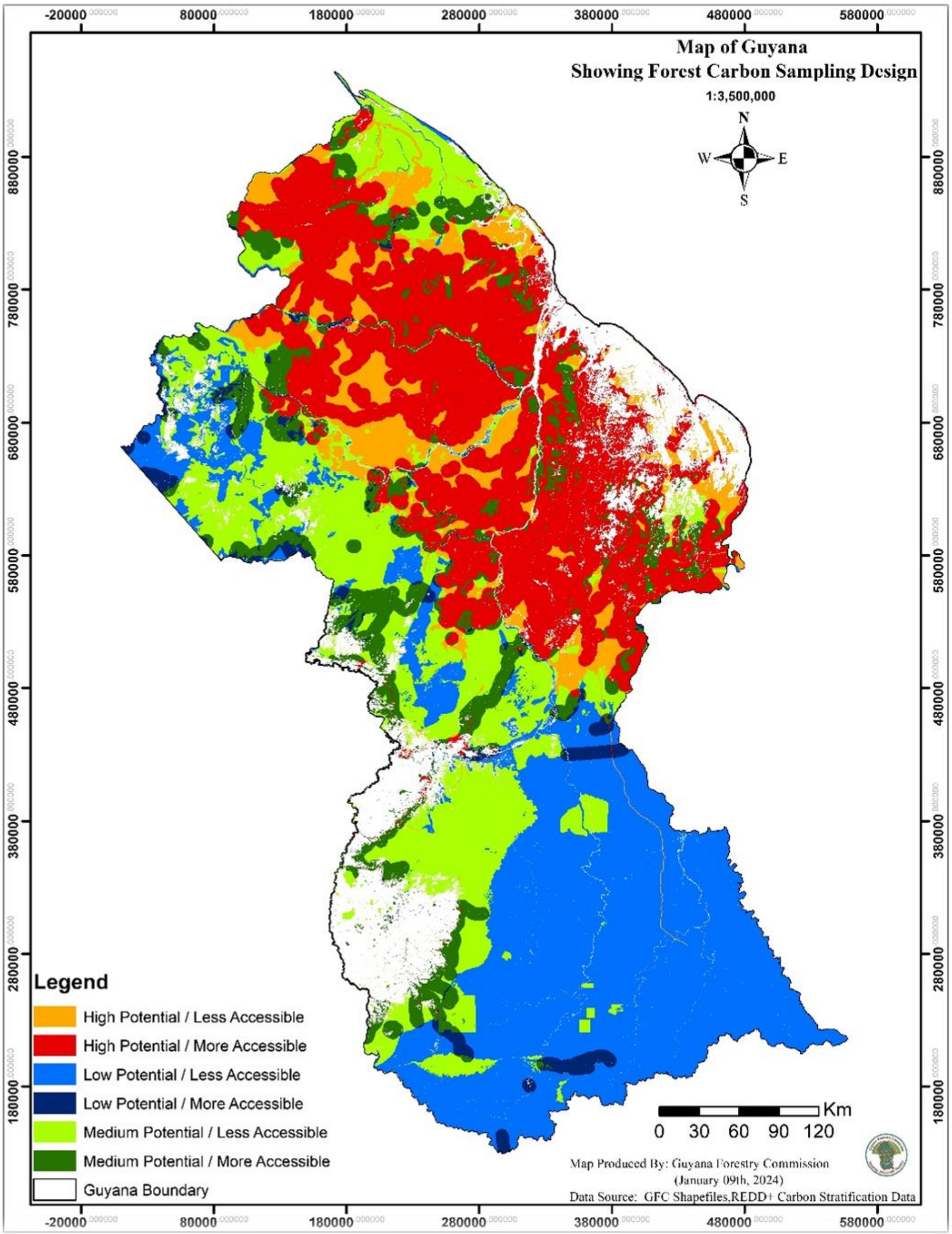


Figure 10 Guyana Forest Stratification Map

Designing the Sampling Approach Within the Stratum

Guyana's FCMS uses a stratified two-stage list sampling design with clustered plots for carbon stock assessment. Having established the six strata across the forested areas, subsets of primary sampling units (PSUs) are designed in which clustered plots of secondary sampling units (SSUs) are established. This allows field teams to achieve higher sample sizes at a relatively low cost. The number of PSUs to be sampled varies by stratum, with a greater sampling intensity (two-thirds) implemented in the more accessible strata and a lower sampling intensity (one-third) implemented in the less accessible strata. This follows the rational that areas with high accessibility have a higher chance of changing and should be sampled first.

The PSUs are determined by laying a 10x10km grid across a map of Guyana, as illustrated in Figure 11 and identifying those grid cells which fall on the stratum of interest (for example, if data is being collected in the medium potential for change, then only those cells in orange and red will be targeted). Grid cells allow for the clustering of plots to aid in access and efficiency of data collection while focusing on the area of interest. The PSUs to be sampled are randomly selected with probability proportional to the area of a stratum of interest. The grid design of PSUs allows for systematic distribution of SSUs.

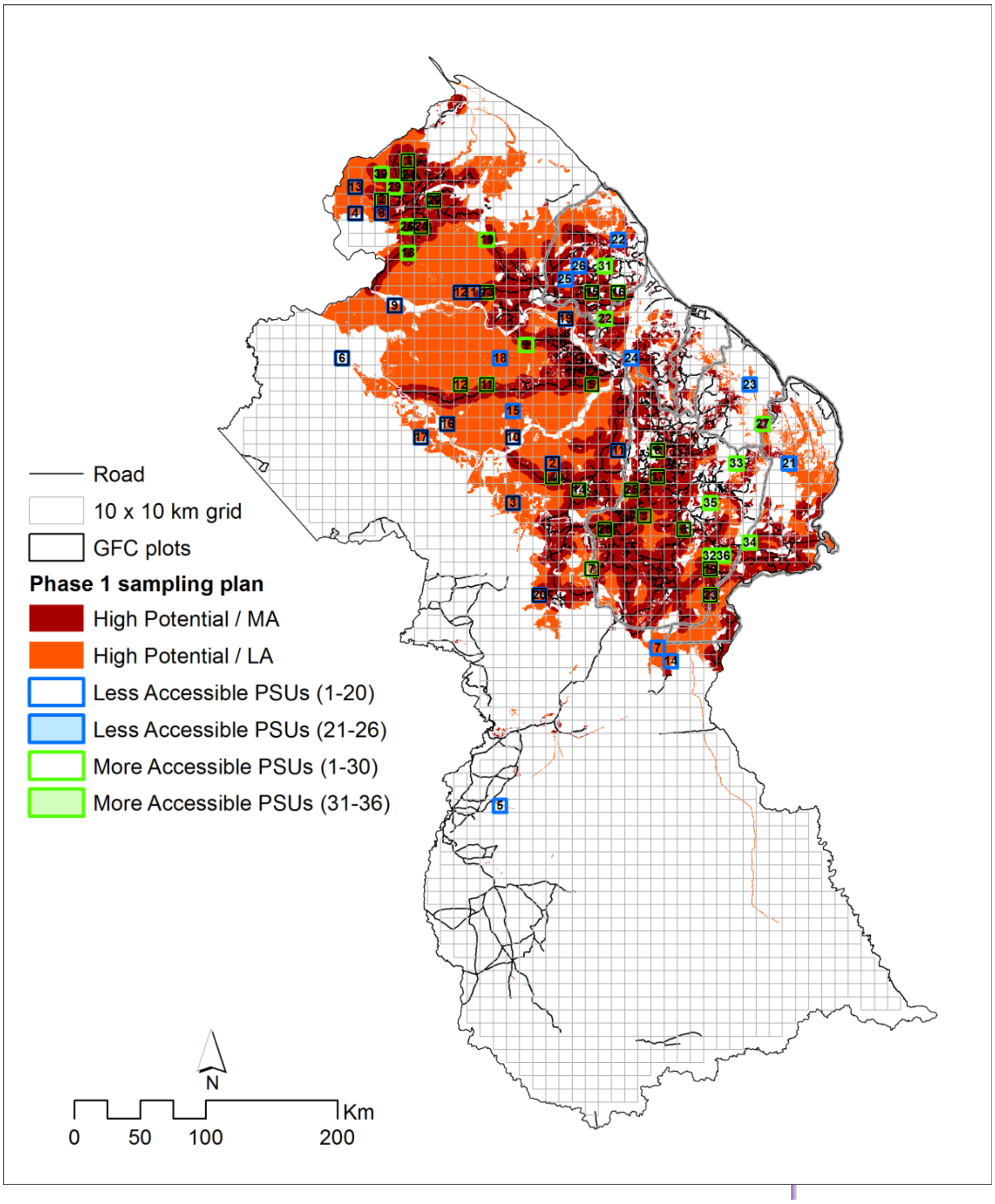


Figure 11 Guyana PSUs and SSUs by Two-tier Stratification

Secondary Sampling Units (SSU) are

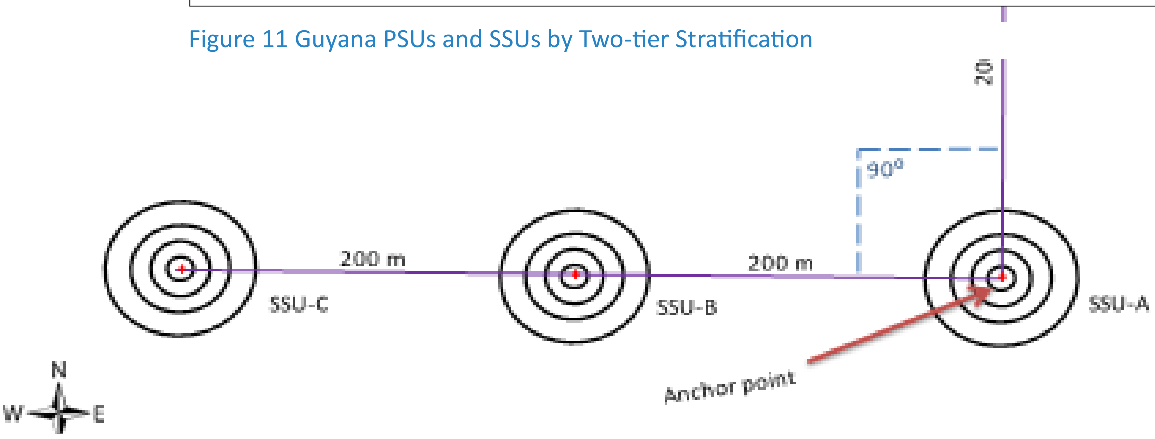


Figure 12 A Single SSU for Field Data Collection

randomly located within each selected PSU with a minimum distance of 1 km from each other. By establishing three locations per SSU, the likelihood is increased that one of the SSU locations can be reached and data can be collected. The three SSU points are randomly numbered 1-3, and the field team collects data at point 1 first, failing that, point 2, and finally, point 3 if the other two are not reachable. SSU consists of a cluster of four (4) subplots established in an "L" shape intended to capture landscape variability, as shown in Figure 12. In cases of safety concerns, SSUs can be composed of fewer than four subplots, or the subplot center is located in a different stratum than other subplots within SSU, in which case the subplot in the different stratum shall also be sampled. Still, data from SSU will be disaggregated during the analysis. Each subplot of this SSU is further divided into nested plots from which different tree diameters are measured. This approach provides an efficient inventory distributed across the landscape.

Estimating the Biomass Carbon Stocks

Guyana estimated its forest carbon stocks to inform its national emissions factors for all five carbon pools (aboveground, belowground, deadwood, litter, and soils). Some of these estimates were done using field-tested allometric models (Chave, et al., 2005), others using IPCC-approved methods (Mokany, Raison, & Prokushkin, 2006), and field-collected data.

Aboveground Biomass Carbon Stock

When calculations are done, data and analyses at the plot level are extrapolated to the area of a whole hectare to produce carbon stock estimates. Extrapolation is done by the use of scaling factors that are calculated as the proportion of a hectare (10,000 m^2) that is occupied by a given nested plot by applying Equation 2. Under the methodology developed, Guyana collected information for all five carbon pools (ABG, BGB, Litter, Deadwood, and Soils).

Equation 2 Scaling factor to extrapolate to a hectare

$$Scaling\_factor = \frac{10{,}000m^2}{Area\_of\_nest\_(m^2)}$$

Chave et al. 2005 for tropical moist forest stands, Equation 3, using diameter at breast height and wood density was used to estimate the aboveground carbon pool in Guyana (Chave, et al., 2005), as such, data required to apply this equation was collected, compiled, and generated.

Equation 3 Chave et al. 2005 tropical moist forest

$$AGB_{est} = \rho \text{ x } \exp(-1.499 + 2.1481 \ln(D) + 0.207(\ln(D))2 – 0.0281(\ln(D))3)$$

Where:

AGB_{est} = aboveground biomass

ρ= species-specific wood density (when not available, an average value of 0.65 g/cm3 is used)

D = diameter at breast height

Belowground Biomass Carbon Stock

Belowground is one of the most challenging carbon pools to measure. It is even more complex and impractical to measure belowground biomass in tropical forests on a routine basis, making it complicated to develop country-specific allometric equations for root biomass. Instead, belowground biomass is estimated from a well-accepted ratio, an approach Guyana has taken to determine its belowground biomass for tropical moist forests, developed by Mokany (Mokany, Raison, & Prokushkin, 2006) and accepted by the 2006 IPCC Guidelines, which reliably estimates root biomass based on live aboveground biomass Equation 4.

Equation 4 Belowground Biomass Estimation

$$BGB = 0.235 * AGB \text{ if } AGB > 62.5 \text{ t C/ha}$$

$$BGB = 0.205 * AGB \text{ if } AGB \leq 62.5 \text{ t C/ha}$$

Where:

BGB = belowground biomass carbon
AGB = aboveground biomass carbon

The methods described for estimating the carbon stock per carbon pools that inform the country-specific emissions factors are the same methods used for calculating the emissions by drivers in the FRL, including only aboveground and belowground carbon pools and deadwood carbon pools for logging.

The information presented was derived from 66 sample plots, each consisting of 4 subplots across the high and medium potential for change stratum. The data analysis for deriving the estimates can be found in the GFC Carbon stocks Calculator tool (GFC, 2015a; GFC, 2015b; GFC, 2015c). The emission factors presented in this REDD+ TA align with those of the FRL and only include the aboveground and belowground biomass. Table 7 lists the country-specific emissions factors developed by stratum. For consistency purposes, the combined emissions factors used in the medium potential for change area are also applied to the low potential for change areas.

Table 7 Emission factors for deforestation

Stratum	AG Tree (t C/ha)	BG Tree (t C/ha)	Sum Carbon Pools (t C/ha)	# Plots	95% CI as a % of mean
HPfCMA	193.6	45.5	**239.1**	26	10.3%
HPfCLA	267.6	62.9	**330.5**	16	13.1%
MPfC	229.7	54.0	**283.7**	24	10.1%

Source: FRL Tabel 7(a).

Emissions Factors for Degradation

Guyana developed country-specific emissions factors for degradation resulting from logging. Forest degradation in Guyana is primarily attributed to timber harvest, which was the only degrading activity accounted for in Guyana's FRL; however, since the submission of the FRL, Guyana has developed emissions factors for its infrastructure drivers that are also contributing to forest degradation.

To estimate emissions from logging, Guyana uses the approach that is based on estimating emissions per volume of timber harvested, including the timber tree, incidental tree damage, and development of skid trails needed for harvesting. The emission factors were developed to correlate the total biomass damaged (collateral damage and extraction infrastructure-skid trails) to the volume of timber extracted (GFC, 2015d). This relationship allows for the estimation of the total emissions generated by selective logging for different concession sizes across Guyana. Selective logging clears forest for roads and decks, which are primarily large areas that can be identified spatially; hence, they are captured spatially, and their emissions are calculated through the stock-change method based on estimates of area deforested by logging infrastructure determined in the land cover change monitoring, provided that the area is more than 1ha. The emissions factor includes accounting for the impact of selective logging on carbon stocks, including the estimation of both emissions and removal components associated as following:

- Biomass removed in the commercial tree felled – emission.
- Incidental dead wood created as a result of tree felling – emission.
- Damage from logging skid trails – emission.
- Carbon stored in wood products from extracted timber by product class – removal.
- Regrowth resulting from gaps created by tree felling - removal.

The total emissions from selective logging are estimated using Equation 5, which incorporates the various emissions sources associated with log extraction.

Equation 5 Total Emissions from Selective Logging

$$Emissions = \{[Vol * WD * CF * (1 - LTP)] + [Vol * LDF] + [Lng * LIF]\} * 3.67$$

Where:

Emissions =Total emissions from Selective logging (t CO_2 Yr^{-1})
Vol = volume of timber over bark extracted (m^3)
WD = wood density (t/m^3)
CF = carbon fraction
LTP = proportion of extracted wood in long-term products still in use after 100 years (dimensionless)
LDF = logging damage factor—dead biomass left behind in the gap from the felled tree and incidental damage (t C/m^3 extracted)
Lng = total length of skid trails constructed to extract Vol (km)
LIF = logging infrastructure factor—dead biomass caused by construction of infrastructure (t C/km of skid trail to remove the Vol)
3.67 = conversion factor for t carbon to t carbon dioxide Wood in long-term products

Not all carbon is released at once since logs are converted into various items and put to different uses. Therefore, not all the carbon in harvested timber gets emitted into the atmosphere because a proportion of the wood removed may be stored in long-term wood products and must be accounted for. Total carbon stored in long-term wood products is estimated using Equation 6.

Equation 6 Carbon Stores in Long-term Wood Products

$$LTP = C * (1 - WW) * (1 - SLF) * (1 - OF)$$

Where:

LTP: = Carbon stock in long-term wood products pool (stock remaining in wood products after 100 years and assumed to be permanent); t C ha^{-1}
C = Mean stock of extracted biomass carbon by class of wood product; t C ha^{-1}
WW= Wood waste. The fraction immediately emitted through mill inefficiency by class of wood product.
SLF = Fraction of wood products with a short life that will be emitted to the atmosphere within 5 years of timber harvest by class of wood product.
OF = Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest by class of wood product.

A total of 183 logging plots were installed across four large-scale commercial forest concessions operating on a 25-year cutting cycle from which data was used to derive the emissions factors for degradation resulting from logging in Guyana (GFC, 2015d) as listed in Table 8.

Table 8 Extracted volume and estimated emission factors from selective logging

	Extracted Volume	Average wood density	Top & stump of Felled Tree	Collateral Damage per Vol. Extracted	LDF Total Carbon Damage per Vol. Extracted	LIF Carbon Damage from Skid Trail
	(m3 gap-1)	(t C m-3)	(t C m-3)	(t C m-3)	(t C m-3)	(t C/km)
Mean	3.47	0.4	0.57	0.48	1.05	46.87
Std.Dev	2.19	0.03	0.03	0.56	0.68	8.08
95% CI	0.32	0	0.04	0.08	0.1	1.91
Uncertainty (CI as % of mean	9.20	1.00	7.50	16.90	9.40	4.10

Source: FRL Table 11, source data, GFC Logging_plots_ALL_TREES_V1.1

Table 9 Lists the emissions factors for forest degradation resulting from selective logging where LDF=logging damage factor and the LIF=logging infrastructure damage from skid trails.

Table 9 Emission factors for selective logging

Driver	Emission Factors		
	Unit	t C	t CO_2
LDF	per m^3	1.05	3.85
Wood Density of timber harvested	per m^3	0.40	1.47
LIF (Skid Trails)	per km	46.87	171.86

Source: FRL Table 12, source data, RL File - Guyana - Historic Emissions Tool - September 2015

3.4 Uncertainties Estimation

Guyana's approach to calculating uncertainties reported in the FRL was the application of the error propagation method. The methods used follow the recommendations set out in the GOFC-GOLD guidelines to help identify and quantify uncertainty in the level and rate of deforestation and the amount of degraded forest area in Guyana. This uncertainty estimate reported in the FRL is based on the application of the error propagation equation in Ch.5 of the IPCC GPG (2003), which was applied to each stratum.

Activity Data Uncertainties

The uncertainties associated with the spatially generated activity data are catered to in the QA/QC mapping procedures outlined in the SOP (GFC, 2021), which provides strict mapping rules and is still guided by the IPCC Guidelines. The wall-to-wall mapping by GFC generates a polygon-based area for land cover change but does not include any information on mapping uncertainty. The independent accuracy assessment generates data on uncertainties in the forest loss statistics, and confidence intervals are reported for AD (forest loss by driver) for the whole Guyana "result" period. Note that the accuracy assessment is conducted independently of the GFC wall-to-wall mapping using a two-stage change sample design with stratification of the primary units. Sample means and variances are calculated for each stratum, and a weighted average of the within-stratum estimates is derived, where weights are proportional to stratum size. This method aims to improve the precision of the forest (or deforestation) area using a stratum-based estimate of variance that will be more precise than simple random sampling.

For instance, in 2022, the Change Assessment involved the collection of 1030 equally sized primary sample units (each with 100 ha) with a direct correspondence with the same sample areas in 2021. Within each PSU, a systematic grid of 100 hectares is generated. A total of 103,000 one-hectare samples (Secondary sampling units – SSUs) are used for change assessment. For each secondary sampling unit (SSU), the land cover class (e.g. Forest or Non-Forest, Degradation or Non-Degradation) is determined for the year deforestation and degradation map. The assessment follows a systematic procedure where the GIS table for the samples is populated using a GIS toolbar. The reference data selected for the change assessment in 2022 was a combination of SkySat, PlanetScope, Maxar, and Sentinel-2 imagery for the High-Risk stratum, and Sentinel-2 and PlanetScope imagery for the Low-Risk stratum. The assessment generates independent deforestation and degradation numbers using a stratified random sampling approach reported in the country's annual MRV reports.

The independent accuracy assessment data allows the deforestation statistics to be broken down by changing the driver for the assessment sample. For example, for 2022, this shows that 82% of deforestation is associated with mining and mining infrastructure, 14% with agriculture, and 3.5% with road infrastructure. Change associated with settlements, fire and shifting agriculture are recorded as degradation as these changes did not meet the definition of area change threshold for deforestation.

The uncertainty data is taken from the independent change sample analysis that also provides an estimate of forest loss, broken down by driver where possible, based on a large sample of immaculate reference data. The MRVS report always comments on the correspondence of the GFC mapping and the accuracy assessment. For most of the reference and results periods, the GFC mapping values have been within the standard error of the sample-based estimate. The accuracy assessment uses an independent sample-based approach, reporting the change data in tables by stratum. Table 10 reproduces the uncertainty data from 2013 to 2022 in summary form. The full tables for the accuracy assessment are available in the MRVS Appendices.

Table 10 Activity data accuracy assessment results matrix

Year	Accuracy Assessment Result	Confidence Interval	
	Area (ha)	Lower Estimate (ha)	Upper Estimate (ha)
2013	13,695	11,876	15,514
2014	12,218.6	10,712	13,725
2015	8,119.3	7,149.1	9,089.4
2016	8,119.3	7,149.1	9,089.4
2017	7,722	6,319	9,125
2018	6,983	5,707	8,259
2019	8,202	6,789	9,615
2020	10,667	9,070	12,264
2021	8,096	6,925	9,267
2022	4,625	3,751	5,499

The uncertainty of the total emissions for deforestation has a 95% confidence interval. This is based on applying the error propagation equation in Ch.5 of the IPCC GPG (2003) to each stratum. Activity data from the accuracy assessment are reported in hectares for the reporting period. Table 10, and a standard error is provided. The confidence interval reported for this period is 2.5% compared to the 3% reported in the FRL. This decrease is due to the larger data sets being available over more time and the mapping of the changes across the same.

Emissions Factors Uncertainties

Uncertainty in degradation emissions

The degradation reported results from logging, and the estimation is based on production data. The GFC tracks and monitors all concessions, and as such, the uncertainty in the timber production data is assumed to be zero. The uncertainty is based on the application of error propagation, 7 (equation 4 in Ch.5 of the IPCC GPG, 2003).

Equation 7 Simple error propagation for degradation

$$U_{total} = \sqrt{U_1^2 + U_2^2 + U_n^2}$$

Where

U_{total}= percentage uncertainty in the production of the quantities (half the 95% confidence interval divided by the total and expressed as a percentage)

U_i = percentage uncertainty associated with each of the quantities, i=1,…,n

The same method was applied to the estimates reported in the FRL, where the uncertainty of the total emissions for logging a 95% confidence interval of is ±6.6% of the mean. The uncertainty of the total emissions for logging is a 95% confidence interval, which has increased to ± 6.7% of the mean. This includes the uncertainty of the LDF (95% CI of ±9.4% of the mean), the uncertainty in mean volume * wood density of species logged (95% CI of ±10.1% of the mean), and the uncertainty in the measurements of the width and C stock of damaged trees for skid trails (95% CI of ±14.6% of the mean). The detailed calculations can be found in the REDD+ TA Analysis Estimation Tool 2024, as presented in Table 11.

Table 11 Degradation uncertainty

Degradation	Uncertainty	Average Annual Total Emissions (t CO_2 e)
Uncertainty in AD	10%	
LDF	9.4%	2,254,651
Wood Density	1.0%	858,915
Skid trails		
Width	4.0%	
C stock	14.0%	
Skid trails uncertainty	14.6%	380,532
Total degradation uncertainty	**6.7%**	

Source: REDD+ TA Analysis Estimation Tool 2024

Uncertainty in deforestation emissions

Guyana developed a comprehensive accounting of uncertainty, represented by 95% uncertainty limits. The results represent the following: if the entire stratum was destructively sampled and the actual carbon in each pool measured, including the separate effects from conversion to agriculture, mining, and roads, there is a 95% chance that the value measured would fall between the upper and lower limits if the assumptions about component level uncertainty are realistic. The methods followed for developing the uncertainties are included in (Hagen, Goslee, Pearson, & Brown, 2017), and the results compiled and presented in Emission Factors reports (GFC, 2021). The total deforestation uncertainty per strata is presented in Table 12.

Table 12 Total deforestation uncertainty

	HPfC MA	HPfC LA	MPfC	LPfC
Uncertainty in AD	2.5%	2.5%	2.5%	2.5%
Uncertainty in C stocks	10.3%	13.1%	10.1%	10.1%
Total deforestation uncertainty	10.7%	13.4%	10.5%	10.5%

Source: REDD+ TA Analysis Estimation Tool 2024

Combined Uncertainties

The combined uncertainties for the REDD+ results are calculated using the same method applied in the FRL where equation 5 in Ch.5 of the IPCC GPG (2003) was applied. The overall uncertainty for deforestation and combining deforestation and forest degradation was estimated using. Equation 8.

Equation 8 Combined Uncertainty

$$U_E = \frac{\left\{\sqrt{(U_1 * E_1)^2} + (U_2 * E_2)^2 + \cdots . (U_n * E_n)^2\right\}}{(E_1 + E_2 \dots . E_n)}$$

Where
U_E= percentage uncertainty of the sum
U_n = percentage uncertainty associated with each source i
E_n = emission estimate for source i

4 DESCRIPTION OF THE NATIONAL FOREST MONITORING SYSTEM AND INSTITUTIONAL ROLES AND RESPONSIBILITIES FOR MRV RESULTS

The national forest monitoring system is being implemented by the Guyana Forestry Commission (GFC). In 2009, Guyana and Norway collaborated on emission reduction goals under UNFCCC-REDD+, leading to the development of a Measurement Reporting Verification (REDD+ MRV) system for assessing forest area change. The system used satellite data, which at the time was slowed owing to capacity and technological constraints. Since then, GFC has made incremental gains by including new sources of satellite data and refining mapping and reporting processes while building its capacity to manage and monitor its forest, boosting its reporting capability and enhancing accuracy. Simultaneously, field data was being collected to establish verified emissions factors.

4.1 National Forest Monitoring System (NFMS)

The building block of Guyana's national forest monitoring system (NFMS) used for REDD+ is built on spatial and temporal change, including satellite imagery and a way to process the satellite imagery to provide layers of change over time. Additionally, data collected from the field allows for the verification of spatial information as well as monitoring of forest activities. A combination of spatial information and field-based monitoring data provides the annual snapshot of forest change and production data.

Central to the system are satellite data and the datasets provided by Guyana's agencies. GFC's Forest Area Assessment Unit interprets and analyses these data and generates maps and associated spatial layers required to meet annual reporting requirements. Two external audits are included in the process, as illustrated in Figure 13, which provides an overview of Guyana's REDD+ MRV system. The first is the accuracy assessment; since inception, this analysis has been conducted externally by a team from Durham University and external auditors who review and verify methods and analytical processes that meet specified reporting requirements.

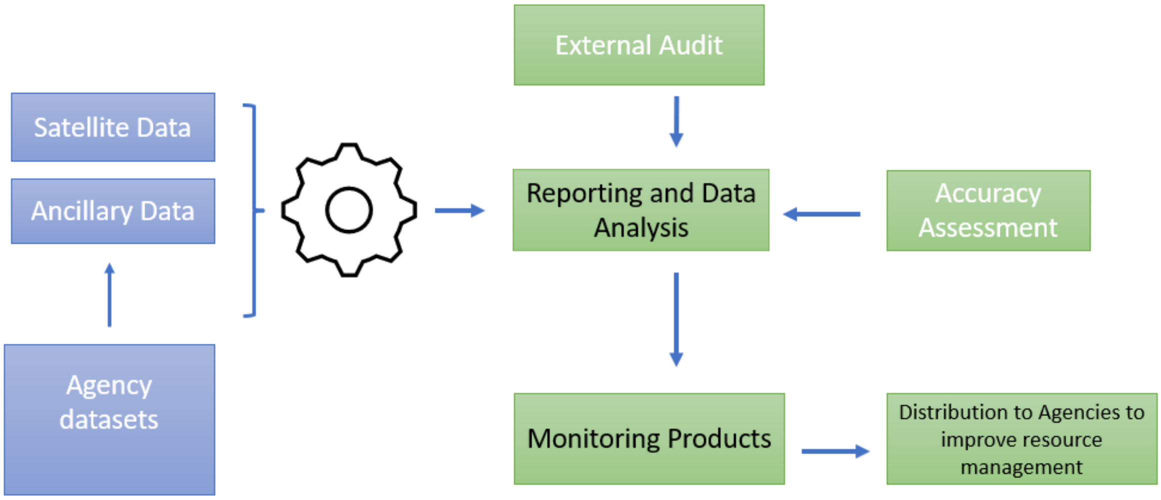


Figure 13 Overview of Guyana REDD+ MRV System within the GFC. Source, (GFC, 2023)

The schematic in Figure 14 shows the various departments/units within the Government of Guyana that provide the data used in measuring, estimating, and reporting for various purposes and the reporting flow. The data generated are used to inform national policies and strategies, access carbon finance, and for international reporting purposes such as to the UNFCCC. As such, information flows from the GFC to other government departments, depending on their use upon request.

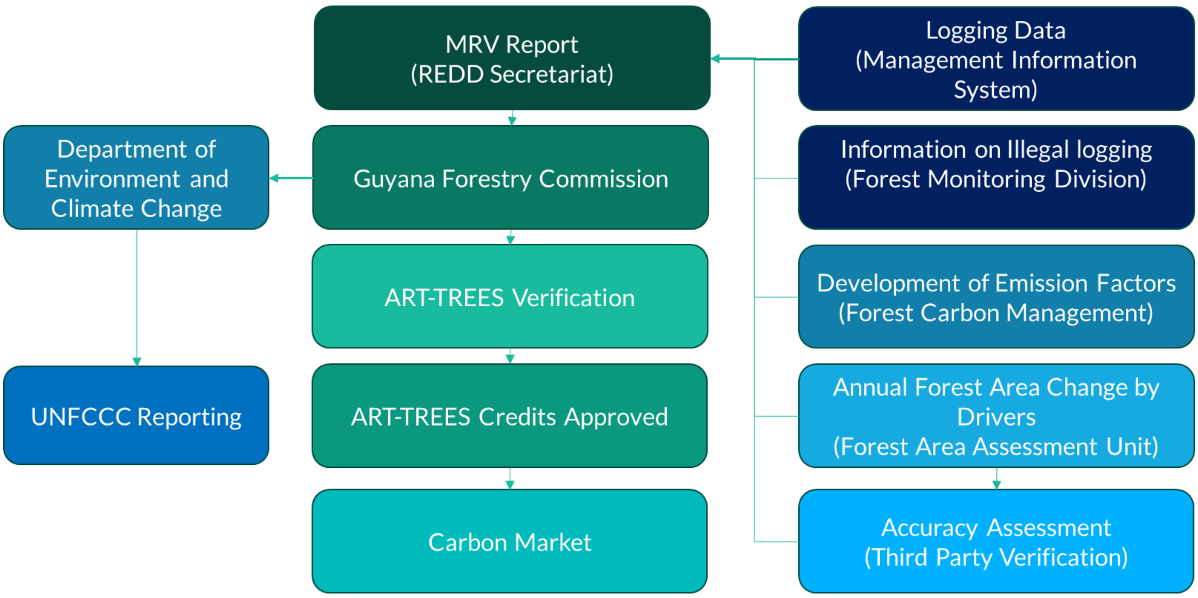


Figure 14 Guyana National REDD+ MRV System

Data storage is an integral part of the national MRV system. All data generated is stored on the Network Attached Storage (NAS) at GFC and is managed by the IT team, who routinely backed it up and stored it off-site. The relevant datasets that are used during the analyses are documented and archived. This includes metadata on the dataset, its location on the network and anticipated/or update frequency. Several datasets are actively used and reside on the GFC's Forest Resource Information Unit (FRIU) network drives. The FAAU (Forest Area Assessment Unit) undertakes the mapping and has access to these drives as well. Additionally, the GFC gathered and analyzed data from various government agencies with different roles and responsibilities, as illustrated in Figure 14.

In 2018, the GFC facilitated consultations with several agencies to identify options for further use of MRVS data beyond the use for forest monitoring and management, thereby establishing the Continuous Resource Monitoring System (CRMS), a prototype system designed to allow more frequent monitoring of Guyana's natural resources and reducing reliance on commercial satellite imagery and software. The system aims to streamline existing image processing workflows by recording them for use within the Google Earth Engine (GEE) platform, which provides access to cloud processing capability, satellite images, and other open-source datasets. The CRMS design incorporates low-cost satellite data and generates monitoring products that support compliance processes, awareness promotion, improved information flows between agencies, enforcement policies, and regulations (GFC, 2020).

4.2 Role and responsibilities

In Guyana, several government agencies are involved in managing and allocating land resources that also contribute data to the national REDD+ MRV systems and national forest management system. The Protected Areas Commission (PAC) holds spatial representations of all protected areas. Each of the agencies has its data management systems and provides relevant requested information to the GFC for the compilation of annual reports.

Guyana Forestry Commission (GFC)

The GFC[10] is responsible for advising the subject Minister on issues relating to forest policy, forestry laws and regulations, guided by the Forests Act 2009 and the Guyana Forestry Commission Act 2007. Under these Acts, the GFC is responsible for administrating and managing all State Forest land, and the work is guided by Guyana's National Forest Plan and the National Forest Policy of 2018, among various other regulations put in place by the Commission. The Commission develops and monitors standards for forest sector operations, implements forest protection and conservation strategies, oversees forest research and provides support and guidance to forest education and training. The agency is currently responsible for implementing the National REDD+ MRV System through the REDD Secretariat.

The REDD+ Secretariat was formed in 2009 and, housed within the GFC, is responsible for developing the national REDD+ MRV systems to generate the results and report on the country's REDD+ performance. This secretariat produces the annual MRV reports, which comprise the data for the FOLU sector in Guyana, generated by the spatial mapping developed by the Forest Area Assessment Unit and field data collected by the Forest Carbon Monitoring Unit. Additionally, the secretariat and the GFC are responsible for contracting independent verifiers to verify the results reported by the country independently, enhancing reporting transparency.

The Forest Monitoring Division of the GFC is responsible for the enforcement of forest laws and regulations, monitoring and controlling the environmental and social impact of operations within the state forest, and collecting revenue in accordance with the various actions and regulations in place. This division is also responsible for processing export documents (with forest produce), quality control and promoting forest products, reviewing and assisting in inquiries in relation to lumber and logs, and therefore recording the annual forest productions by product types. Additionally, this department reports on illegal logging and provides this information to the REDD Secretariat to generate the results for the yearly MRV report.

The Management Information Systems Division [?] of the GFC is responsible for improved data communication between both internal and external stakeholders and ensuring that technological advancements are captured.

[10] GFC: Guyana Forestry Commission – Ensuring Sustainable Forestry

The main function of this unit is to maintain reliability, security and availability of information that is accessed throughout GFC. It also overlooks the data accuracy, productivity and processing speed/capabilities as it is responsible for developing end-user reporting on the GFC activities data, which are shared with the REDD Secretariat to generate the results for the annual MRV report.

The Forest Resource Management Division of the GFC is responsible for data collection on national forest resources, conducting surveys and inventories, researching and making recommendations on forest dynamics and silviculture, planning and recommending the allocation of concession areas, preparing operational guidelines for forest management planning, evaluating management and operational plans, prescribing standards for forest management and providing support for forestry extensions. This division is also responsible for building a GIS capacity, developing a database of digital geographical data and providing a service to both external & internal stakeholders.

Guyana Geology and Mines Commission (GGMC)

The Guyana Geology and Mines Commission (GGMC[11]) was created in 1979. It was previously the Department of Geological Surveys and Mines and is guided by the Mining Act 1989. It has in place various regulations that guide the work of the commission, including its own MRV system for its operation. The GGMC's mission is to promote, facilitate, monitor, and regulate the sustainable utilization of Guyana's mineral resources (including petroleum) and to provide effective stewardship of Guyana's mineral resources through deploying competent human resources employing innovative tools and methods, research, and analysis. The GGMC collaborates with the GFC in providing information affecting the forests, which it monitors on the ground and spatially. Together, the GGMC and the GFC provide enhanced ground verification for the various drivers of deforestation and forest degradation in Guyana. Additionally, the GGMC is responsible for piloting the reforestation of mined-out areas in collaboration with the GFC.

Guyana Lands and Survey Commission (GL&SC)

The Guyana Lands and Surveys Commission (GL&SC[12]), which falls under the Office of the President, is responsible for the overall management of the national territory. The work of the GL&SC is guided by the Guyana Lands and Survey Commission Act 1999, Lands Department Act 1903, State Lands Act 1903, Land and Surveyors Act 1891, and various other regulations. The GL&SC's mandate includes providing land policy recommendations and drafting land use plans to ensure orderly and efficient utilization of public land resources, advice on land surveying matters, and effective and efficient land administration. This is the agency that provides land-use zoning and allocations of titles and lease lands. Most of the information collected by this agency is reported under land use, for example, the area allocated for mining, agriculture, settlement, infrastructure development such as Hydroelectric projects, and titled Amerindian areas. This agency provides the various land use changes to the GFC used to generate and report data for the FOLU sector.

Protected Areas Commission

The Protected Area Commission (PAC[13]) is a government agency under the Office of the President mandated to manage Guyana's National Protected Areas, guided by the Protected Area Act 2011. This Act provided for the establishment, management, maintenance, promotion and expansion of the protected area system in Guyana. The main objectives of the PA Act are to assist in combating climate change, assist the state in meeting international obligations, recognize the value of biological diversity, conserve biodiversity, and conserve ecosystem services and ecosystems representative of Guyana's natural land and seascapes. Additionally, guiding

[11] GGMC: Who We Are | Guyana Geology and Mines Commission (ggmc.gov.gy)
[12] GL&SC: GLSC – Administer Land. Promoting Development
[13] PAC: https://www.pac.gov.gy/

the work of the PAC are the Iwokrama Act 1996, the Kaieteur National Park Act 1929 and amended Act 2002, and other regulations put in place by the PAC.

Prior to becoming a commission, there was a national Protected Area System that was in existence for over 90 years and under which the Kaieteur National Park (KNP) was established in 1929, the first national park created in the Amazon region and only one of three countries in South America to have a protected area. Guyana has taken a measured approach to the development of protected areas, with the country's second protected area, the Iwokrama Rainforest Reserve, being formally established in 1996. Two new protected areas, the Kanuku Mountains Protected Area (KMPA) and Shell Beach Protected Area (SBPA), were declared following decades of preparatory work with local communities and other stakeholders in 2011. The largest and first-ever indigenous-owned PA, Kanashen Amerindian Protected Area (KAPA), was added to the NPAS in 2017. Also included in the system are four urban parks: the Botanical Gardens, Zoological Park, National Park, and Joe Vieira Park. The PAs, together with the urban parks, account for approximately 8.4% of the country's land area. The PAC provides this information to the GFC to be included in the annual MRV reports as these land use types impact the forest uses and, consequently, the emissions.

Department of Environment and Climate Change

The Department of Environment and Climate Change (DECC) was formed by merging the Office of Climate Change and the Department of Environment in 2020. This department is the National Focal Point of the UNFCCC on climate change issues and is responsible for coordinating Guyana's reporting requirements and other international agreements. The role of the DECC continues to evolve as it advises government partners to participate in international climate negotiations representing Guyana's best interests and leads on national climate actions and policies. It also leads dialogues with multilateral agencies on behalf of the Government of Guyana (GoG) to establish partnerships and facilitate access to technical and financial support for low-carbon initiatives and national development. The DECC activities span policy-level intervention and advisory as well as program and project management and execution, with engagements directly with sectoral GoG partners to provide advice and recommendations to sector-level planning and strategies where they intersect with climate change adaptation and mitigation. Additionally, the DECC is responsible for leading and coordinating national adaptation and mitigation efforts in collaboration with multiple GoG sector agencies and other stakeholders.

Together, these agencies are responsible for the development and testing of methodologies, conducting the data analysis, and reporting under the various conventions and national agencies that require this information for the fulfilment of multiple purposes.

5 INFORMATION NECESSARY FOR THE RECONSTRUCTION OF THE RESULTS.

For the reconstructions of the results presented in this REDD+ Technical Annex, information extracted from Guyana's national REDD+ MRV System is presented disaggregated by activity data and emission factors as reported in the FRL.

5.1 Activity Data for Deforestation and Forest Degradation by Drivers

The average of the various activity data generated and used in deriving the results presented by Guyana in establishing its REDD+ results are listed in Table 13. The results cover the period 2013-2022 and exclude natural events that are considered non-anthropogenic change.

Table 13 Annual Average of Forest and Forest Loss by Deforestation Drivers

Variable	Description	
Coverage	National	
Period	2013-2022	
Satellite Image Resolution (m)	Variations of 5m, 10, and 15 m	
Average Deforestation by Driver (ha)	Forestry Infrastructure	223
	Agriculture	375
	Mining	6,832
	Mining Infrastructure	663
	Infrastructure	142
Average Logging extraction (m^{-3})		585,624
Average Logging - skid trail (km yr^{-1}		2,214

Source: REDD+ TA Analysis Estimation Tool 2024

While the system initially measured and reported on forest area change in its inception, over the years, it has evolved as more data are collected, and the system's data uses changes to satisfy multiple purposes, including reporting to the UNFCCC. As such, while methods remain largely the same, many improvements occurred to improve estimates' accuracy and reporting transparency. However, the carbon pools, as per the FRL, remain consistent for this reporting period. The area deforested by drivers is listed in Table 14. A detailed breakdown of areas deforested by drivers within each stratum of potential for change can be found in the REDD+ TA Analysis Estimation Tool 2024.

Table 14 Area deforested by drivers per annum

Drivers	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Area (ha)									
Forestry infrastructure	330	204	261	366	102	158	226	195	228	156
Agriculture	424	817	304	454	237	282	246	489	216	282
Mining (medium and large scale)	10,600	9,512	6,518	6,185	6,495	6,937	5,248	5,895	6,086	4,842
Mining infrastructure	917	922	264	597	947	688	573	557	739	423
Infrastructure	342	141	344	89	65	59	52	102	117	111
Total	**12,614**	**11,596**	**7,691**	**7,691**	**7,847**	**8,123**	**6,345**	**7,239**	**7,386**	**5,812**

Source: REDD+ TA Analysis Estimation Tool 2024

For the reconstruction of the results presented in Chapter 2, **Error! Reference source not found.** lists the areas deforested per annum by the various drivers while Table 15, further disaggregated by stratum and sub-stratum.

Table 15 Area of forest change by deforestation drivers by stratum

			Area of forest change (ha)									
Stratum		**Drivers**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
High Potential for Change (HPfC)	HPFC-MA	Forestry infrastructure	297.69	173	205	203	61	101	172	144	122	88
		Agriculture	320.28	592	189	210	72	152	74	216	136	160
		Mining (medium and large scale)	8657.23	7719	4343	4761	4588	4956	3891	4314	4555	3440
		Mining infrastructure	765.62	785	210	452	554	497	435	435	591	334
		Infrastructure	207.63	88	86	14	15	20	39	65	85	68
	HPFC-LA	Forestry infrastructure	0.00	20	13	118	11	4	10	7	13	14
		Agriculture	99.06	181	28	113	150	84	45	135	15	26
		Mining (medium and large scale)	187.51	365	346	561	671	664	291	355	346	236
		Mining infrastructure	0.00	27	10	55	171	77	12	35	26	18
		Infrastructure	0.00	5	216	0	17	18	4	24	15	18
	Total	**Forestry infrastructure**	**98**	**194**	**219**	**321**	**72**	**105**	**182**	**151**	**135**	**103**
		Agriculture	**419**	**773**	**216**	**323**	**223**	**236**	**119**	**352**	**151**	**186**
		Mining (medium and large scale)	**8,845**	**8084**	**4689**	**5323**	**5259**	**5620**	**4182**	**4670**	**4901**	**3676**
		Mining infrastructure	**766**	**812**	**220**	**508**	**725**	**573**	**447**	**470**	**618**	**352**
		Infrastructure	**208**	**93**	**303**	**14**	**32**	**38**	**43**	**89**	**100**	**86**
	Total across drivers		10,535	9955	5647	6488	6311	6572	4974	5731	5906	4403
	Total Annual Average		10,535	9955	5647	6488	6311	6572	4974	5731	5906	4403
Medium Potential for Change (MPfC)	MPFC-MA	Forestry infrastructure	28.34	5	38	10	23	30	33	27	24	36
		Agriculture	3.03	13	0	31	8	6	0	17	2	3
		Mining (medium and large scale)	1429.52	996	1238	337	675	688	505	686	575	647
		Mining infrastructure	140.11	74	15	44	73	39	36	51	42	24
		Infrastructure	106.62	18	0	60	18	7	4	6	3	17
	MPFC-LA	Forestry infrastructure	3.14	3	4	35	4	10	8	8	61	15
		Agriculture	1.93	31	85	99	5	34	78	71	5	62
		Mining (medium and large scale)	123.88	238	279	287	200	163	180	209	326	199
		Mining infrastructure	0.00	14	18	22	58	17	23	33	53	12

		Infrastructure	0.00	0	40	1	13	6	0	0	8	5
	Total	**Forestry infrastructure**	**31**	**8**	**42**	**45**	**28**	**40**	**41**	**35**	**85**	**51**
		Agriculture	**5**	**44**	**85**	**131**	**13**	**41**	**78**	**88**	**7**	**64**
		Mining (medium and large scale)	**1,553**	**1233**	**1517**	**625**	**874**	**851**	**686**	**895**	**901**	**846**
		Mining infrastructure	**140**	**88**	**33**	**66**	**131**	**56**	**59**	**84**	**96**	**36**
		Infrastructure	**107**	**18**	**40**	**60**	**31**	**13**	**4**	**6**	**10**	**21**
	Total across drivers		1,837	1391	1718	927	1077	1000	868	1108	1099	1019
	Annual Average		1,837	1391	1718	927	1077	1000	868	1108	1099	1019
Low Potential for Change (LPfC)	LPFC-MA	Forestry infrastructure	1.27	0	0	0	0	6	0	8	0	0
		Agriculture	0.00	0	2	0	0	0	0	2	3	1
		Mining (medium and large scale)	157.44	118	165	138	151	178	193	137	114	130
		Mining infrastructure	10.85	13	7	5	46	8	0	1	8	11
		Infrastructure	27.73	30	1	15	0	2	0	1	1	0
	LPFC-LA	Forestry infrastructure	0.00	3	0	0	3	6	2	2	8	2
		Agriculture	0.00	0	0	0	2	5	49	48	54	30
		Mining (medium and large scale)	44.84	77	146	99	211	287	187	194	170	189
		Mining infrastructure	0.00	9	4	17	45	51	67	2	18	23
		Infrastructure	0.00	0	0	1	2	6	5	7	6	3
	Total	**Forestry infrastructure**	**1**	**3**	**0**	**0**	**3**	**13**	**2**	**9**	**8**	**2**
		Agriculture	**-**	**0**	**2**	**0**	**2**	**5**	**49**	**50**	**57**	**31**
		Mining (medium and large scale)	**202**	**195**	**311**	**238**	**362**	**466**	**380**	**331**	**284**	**319**
		Mining infrastructure	**11**	**22**	**11**	**23**	**90**	**59**	**67**	**3**	**25**	**34**
		Infrastructure	**28**	**30**	**1**	**16**	**2**	**8**	**5**	**8**	**6**	**3**
	Total across drivers		242	250	325	276	459	551	504	400	381	389
	Annual Average		242	250	325	276	459	551	504	400	381	389

Source: REDD+ TA Analysis Estimation Tool 2024

5.2 Emission from Deforestation and Forest Degradation

Guyana applied the emission factors for deforestation listed in Table 7 and forest degradation listed in Table 9. These country-specific emission factors used here in this REDD+ Technical Annex will not align with those reported in the GHG inventory in the country's first Biennial Transparency Report (BTR). This is because, to maintain consistency with the FRL, only two carbon pools are included in the estimates, along with the drivers listed in the FRL, which are also different than those used in the BTR. Additionally, emission factors were generated for degradation attributed to mining and infrastructure and logging activities linked to the volume extracted. These are captured in the GHG inventory estimates but are excluded from this report, along with emissions from degradation resulting from settlements, biomass burning, and shifting cultivation for consistency with the FRL. Table 16 list the annual emissions by driver of deforestation and forest degradation.

Table 16 Annual emissions by drivers of deforestation and forest degradation

	Forestry infrastructure	Agriculture	Mining (medium & large)	Mining infrastructure	Infrastructure	Logging
	Emissions (t CO2/yr)					
2013	295,088	406,013	9,644,190	828,326	321,807	3,724,779
2014	187,408	784,576	8,695,384	835,650	132,836	4,532,621
2015	239,814	290,018	6,129,361	242,241	381,213	3,910,449
2016	367,634	457,538	5,751,917	556,378	90,781	2,987,930
2017	98,212	260,364	6,122,054	923,706	68,454	3,180,504
2018	148,436	282,606	6,519,532	647,215	61,437	3,259,568
2019	208,299	251,914	4,873,298	526,579	48,773	3,108,671
2020	181,049	496,445	5,488,281	514,097	100,161	3,254,751
2021	219,667	204,936	5,645,825	676,417	110,122	3,266,728
2022	149,799	271,209	4,514,730	388,229	107,025	3,714,974

Source: REDD+ TA Analysis Estimation Tool 2024

5.3 Calculation of Emission Reductions Resulting from REDD+

Guyana's annual emissions and reduction from REDD+ are estimated using the systems outlined in the methodology section of this report, which is guided by the country's national REDD+ MRV system that is compliant with the 2006 IPCC Guidelines (IPCC, 2006). Since this REDD+ technical annex covers the period from 2013- 2022, Table 17 lists the country's annual emissions and reduction performance, only accounting for the drivers and carbon pools covered in the FRL.

Table 17 Annual REDD+ Performance in relation to FRL

	Total Emissions from Deforestation (tCO2)	Total Emissions from Degradation (tCO2)	Total Emissions (tCO2)	Total Reduction as per FRL (tCO2)
2013	11,495,423	3724779	15,220,202	31,081,049
2014	10,635,854	4532621	15,168,475	31,132,776
2015	7,282,648	3910449	11,193,097	35,108,154
2016	7,224,248	2987930	10,212,178	36,089,073

	Total Emissions from Deforestation (tCO2)	Total Emissions from Degradation (tCO2)	Total Emissions (tCO2)	Total Reduction as per FRL (tCO2)
2017	7,472,790	3180504	10,653,294	35,647,957
2018	7,659,225	3259568	10,918,794	35,382,457
2019	5,908,863	3108671	9,017,534	37,283,717
2020	6,780,034	3254751	10,034,785	36,266,466
2021	6,856,968	3266728	10,123,695	36,177,556
2022	5,430,992	3714974	9,145,966	37,155,285

Source: REDD+ TA Analysis Estimation Tool 2024

6 DESCRIPTION OF HOW THE ELEMENTS IN 4/CP.15 PARA. 1(C) AND (D) HAVE BEEN TAKEN INTO ACCOUNT

6.1 Use of the most recent IPCC Guidance and Guidelines

In developing this REDD+ Technical Annex, Guyana utilised the 2006 IPCC Guidelines, as encouraged by the Conference of the Parties, for estimating its anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes. The same guidelines were used to develop the national GHG inventory reported in the BTR and the FRL, submitted to the UNFCCC.

To calculate the net change in carbon stocks resulting from deforestation, Guyana used the Stock-Difference method, which estimates the difference in total carbon stock between two time periods following Equation 2.5, Chapter 2, Volume 4, 2006 IPCC Guidelines. Additionally, the emissions resulting from fire, which is also a driver of deforestation, are estimated using Equation 2.27, Chapter 2, Volume 4, 2006 IPCC Guidelines.

To estimate the emissions from forest degradation attributed to logging activities, the Gain-Loss Method based on estimates of annual change in biomass was used by applying Equation 2.4, Chapter 2, Volume 4, 2006 IPCC Guidelines.

Following the Good Practice Guidance and uncertainty, Guyana applied the Monte Carlo uncertainty simulation. The Monte Carlo estimation of uncertainties was done by source as well as using the techniques to estimate overall uncertainty annually as well as trends.

6.2 Establish, According to National Circumstances and Capabilities, Robust and Transparent National Forest Monitoring System

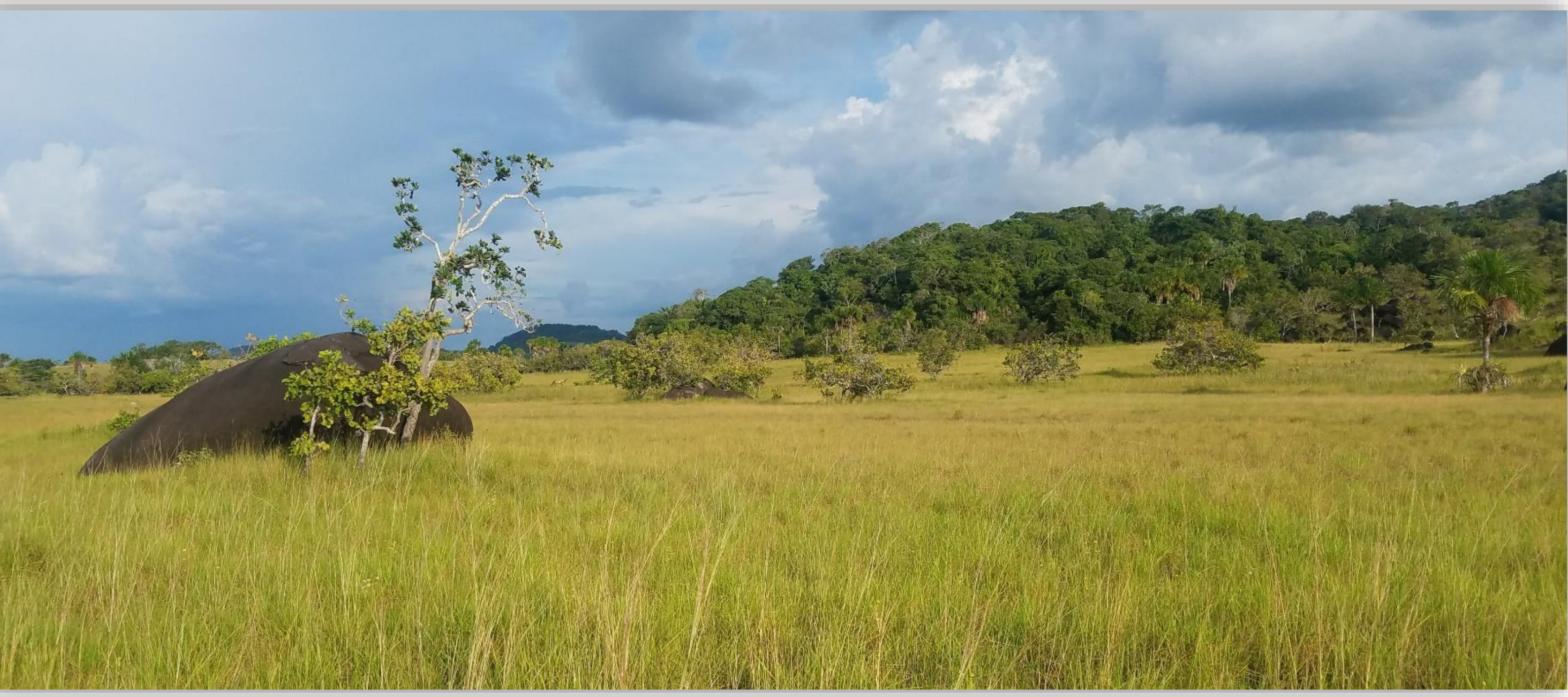
As stated in Guyana FRL, the forest MRV system in place is at a national scale and will remain as such (described in Chapter 4). As mentioned in Chapter 3, Guyana employed the use of a combination of remote sensing and ground-based forest carbon inventory approaches for estimating its anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes. The spatial estimates include the use of high-resolution imagery of various types, tested to determine the appropriateness and applicability for the country's needs. The field data used were also tested to ensure its suitability and applicability, including the uncertainty associated with the data collected and analysis.

Guyana's reporting on its methods and uncertainties demonstrates the openness to transparently reporting on its emissions and removals as far as practical, utilizing its national capacity and capabilities. The rigorous accuracy assessment built into the REDD+ MRV system illustrates the confidence in the accuracy of the estimates generated by the country, which is proven by the various international verifications. Additionally, the generating and publishing of the annual MRV System reports indicates Guyana's openness and confidence in its transparent system, which is no different from this report being submitted to the UNFCCC, which is also subjected to review, which Guyana welcomes.

Additionally, data collected from Guyana's national REDD+ MRV systems has been used to inform many international journal publications[14] over time, providing another layer of accuracy testing and utility. These include but are not limited to accounting for GHG from degradation resulting from mining, using data to guide national forest management and decision making, interoperability of various data streams, comprehensive accounting for REDD+ programs, etc.

While Guyana reports in this REDD+ Technical Annex information consistent with its FRL, many improvements have been made, which are presented in Chapter 7 of this report. Guyana intends to revise its FRL to reflect and incorporate the many changes and improvements in data collection, analysis, and reporting resulting over the years to increase transparency in reporting accurate and consistent information and to bring alignment to its GHG inventory in subsequent reports.

[14] Journal Publication using data generated from Guyana's REDD+ MRVS



7 Improvements

Since submitting the FRL, Guyana has made significant improvements in capacity building, data collection and analysis, revised country-specific emission factors, and revised emissions accounting to improve its reporting accuracy. Some of these changes include the revision of the stratification of the country's forest; the addition of three new deforestation drivers: settlement, biomass burning, and shifting cultivation to its monitoring; the addition of a new driver for degradation: mining and infrastructure, the development of additional country-specific emission factors, and the move to a higher form of uncertainty assessments. The emission factors presented in this section of the REDD+ TA align with that of the latest GHG inventory, which applies the same emissions factors, ensuring consistency in reporting.Figure 15Figure 15 Illustrates the key milestones achieved by Guyana over the years.

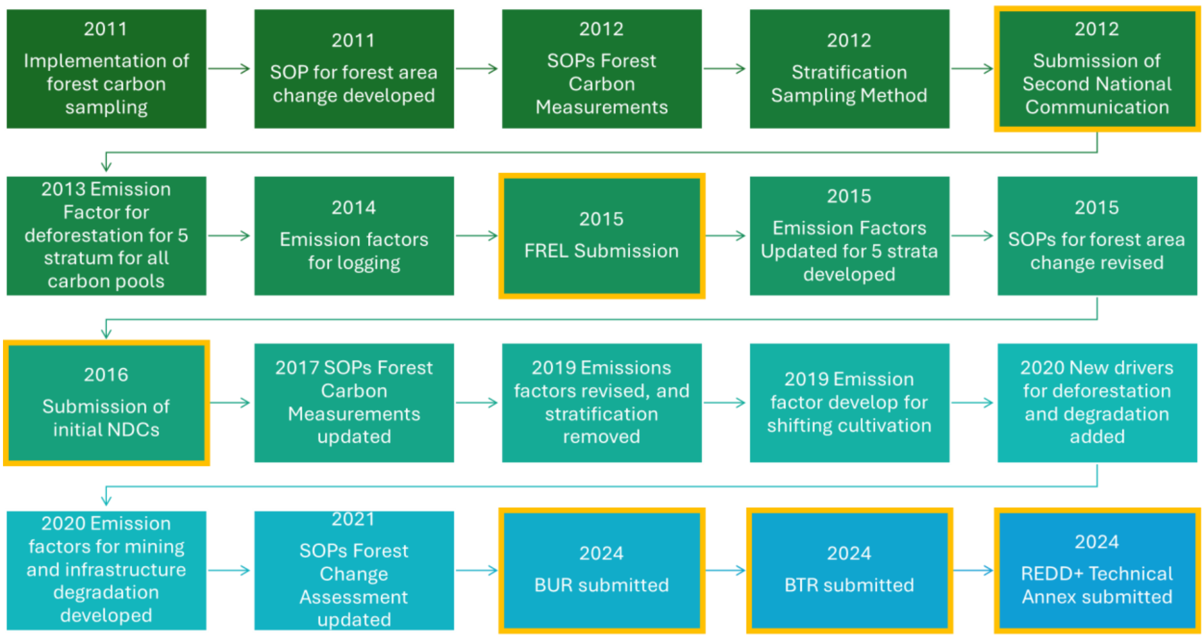


Figure 15 MRVS milestones achieved

7.1 Improved Results

The results in this report section include all the improvements for activity data and emissions factors. The annual emissions from deforestation and forest degradation, including estimated using updated activity data and emissions, are presented in Figure 16, while Figure 17, presents the information disaggregated by drivers.

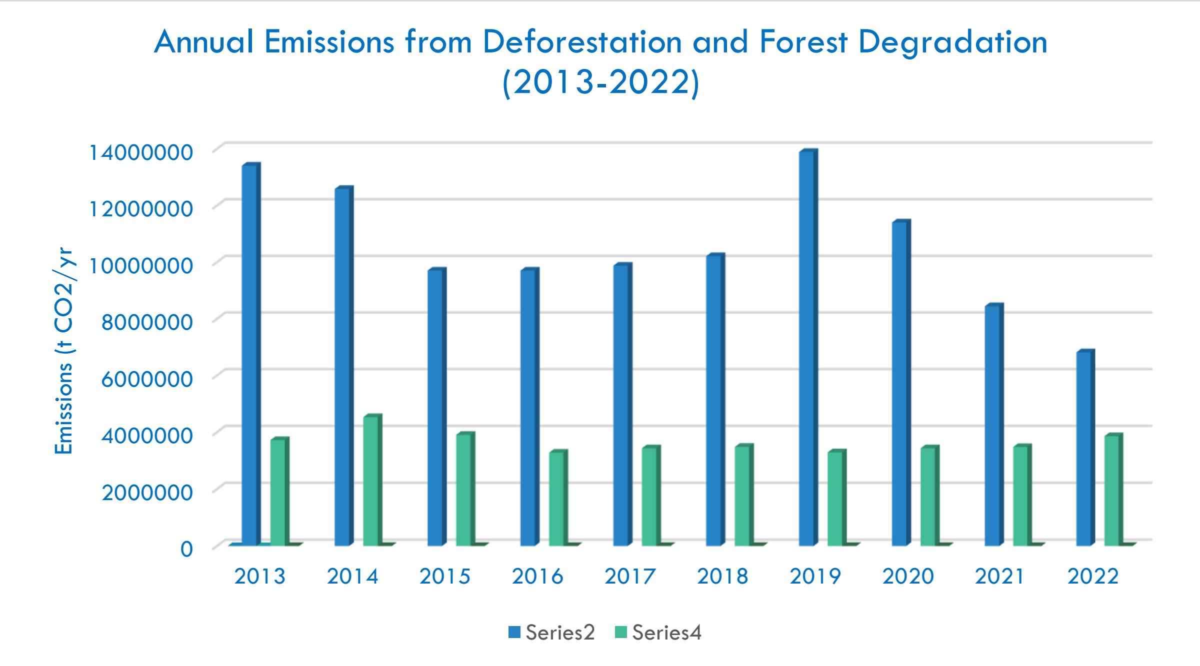


Figure 16 Annual Emissions from Deforestation and Forest Degradation updated

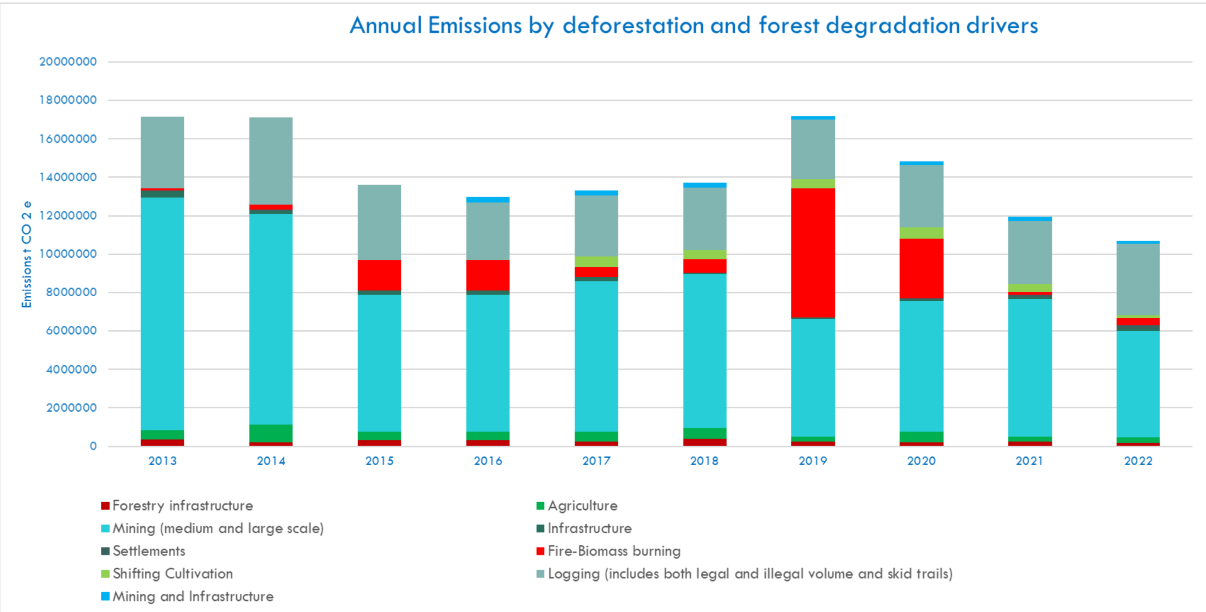


Figure 17 Annual emissions by deforestation and forest degradation drivers updated

7.2 Improved Methodologies

Since its inception, the MRV System has seen considerable methodological improvements and has evolved with advanced techniques, better data integration, and increased transparency. Initially, the MRV System focused on foundational satellite imagery and forest area change assessment. However, with technological advancements, it now incorporates high-resolution satellite data, which allows for better detection of forest degradation and deforestation, even in cloudy conditions. Over the years, Guyana's MRV System has adopted a model where local stakeholders, including Indigenous communities, actively participate in data collection and reporting, enhancing data accuracy and fostering community engagement. Additionally, the MRVS now uses the Collect Earth tool in partnership with Google Earth Engine, allowing real-time analysis and comprehensive reporting. These improvements enable more accurate carbon stock assessments and timely identification of illegal activities, which is critical for REDD+ reporting. Guyana's MRV System stands as a robust model in forest conservation, demonstrating the power of adaptive methodologies in environmental management.

7.3 Emissions Factors

Guyana has developed detailed emissions factors for deforestation and forest degradation as part of its MRV System to estimate carbon emissions associated with forest loss accurately. This development included extensive field data collection to determine biomass levels across various forest types by identifying species during sampling, enabling precise carbon stock assessments. The emissions factors are calculated based on these localized data specific to Guyana's forests, which reflect the unique flora composition of the country forest. Regular updates and recalibrations are now part of the methodology to ensure emissions factors remain accurate, supporting Guyana's REDD+ commitments and contributing to more reliable carbon accounting and climate strategy.

Deforestation

Guyana has been collecting information covering all carbon pools; however, owing to the method used in the FRL, only two pools were included and accounted for in the emissions reported. In addition to the methods used in determining aboveground and belowground carbon, which are included in Chapter 3 of this report, Guyana also collected information on deadwood, sapling, and soil carbon pools following the 2006 IPCC Guidelines.

Carbon Pools

Deadwood Biomass Carbon Stock

Estimating the carbon stocks in dead wood, both lying and standing, is detailed in the Standard Operating Procedures (SOPs) for Guyana's forest carbon monitoring system (FCMS). The primary methods are:

(1) **For standing dead wood** - the volume of the main stem is estimated from measurements of base diameter and height, which is then multiplied by the density of the species.

(2) **For lying dead wood** - measurements are taken to estimate the volume and its density class (sound, intermediate, and rotten) according to the FCMS SOPs.

Biomass Carbon Stock from Sapling

Sapling data is also collected under Guyana's REDD+ MRV system in a 2 m radius plot in the centre of the nested plots. Saplings are defined as trees <5 cm DBH and >1.3 m tall. The number of samplings is multiplied by the average dry weight per sapling to derive the carbon stock.

Biomass Carbon Stock from Litter

Guyana defines the litter layer as all dead organic surface material on top of the mineral soil, including recognizable dead leaves, twigs, dead grasses, small branches and some unidentifiable decomposed fragments of organic material (fruits, flowers, and seeds). The dead wood with a diameter of less than 10 cm is included in the litter layer. Complete samples are weighed in "clip" plots of $1m^2$, from which samples are taken to determine the dry weight, which is then extrapolated to estimate this carbon pool

In 2019, Guyana revised the emission factors generated by the stratum and, after combining all data for a total of 118 plot biomass plots, established across all potential for change and accessibility stratum concluded that there is no significant statistical difference between the emission factors. Consequently, a single emissions factor for all forests in Guyana was determined. The findings of this study and the contribution of carbon pools are summarised in Table 18 , which shows the single forest carbon stocks for the five carbon pools at a 95% confidence interval and the resulting sampling errors. The final country-wide forest carbon stocks across all pools except for soils is now estimated at 272.3 t C ha^{-1}. These values are used to estimate the various emissions across the drivers of deforestation. (GFC, 2019a).

Table 18 Single emissions factor by pools for the country

AG Tree (t C/ha)	BG Tree (t C/ha)	Saplings (t C/ha)	Standin g Dead Wood (t C/ha)	Lying Dead Wood (t C/ha)	Litter (t C/ha)	Sum Carbon Pools (t C/ha)	Number of plots	95% CI as a % of mean
205.8	48.3	3.7	2.6	8.6	3.3	**272.3**	118	4.3%

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

Biomass Carbon Stock from Soil

To account for changes to soil carbon, Guyana applied the stock change methods prescribed by the 2006 IPCC Guidelines (IPCC, 2006). The change in carbon stocks in the top 30 cm of soil is calculated as the difference between the soil carbon stocks before conversion and the soil carbon stocks after conversion. Soil carbon stocks after conversion were estimated based on land use, management, and input factors as derived from IPCC Guidelines. For simplicity in accounting, Guyana assumes the total emission of soil carbon in the year of clearing rather than spreading the emissions over 20 years (the default period suggested by IPCC 2006). Guyana adopted this conservative approach because the high uncertainty shows that carbon stocks are highly variable. Soil carbon pool is not impacted equally or at all across all drivers of deforestation and degradation; as such, only those drivers in which this pool is affected include emissions from soils.

The emissions from soils estimated from 87 plots are 58.7 t C ha-1, with an 18.7% confidence interval as a percentage of the mean. Soil carbon is affected to varying degrees depending on the deforestation driver. Table 19 lists the Soil carbon stock and its percentage impacted by drivers of deforestation as per the 2006 IPCC Guidelines approach 1.

Table 19 Soil carbon emission factor applied to deforestation drivers

Stratum	C stock (t C/ha)	FLU	FMG	FI	C stock at 20 yr (t C/ha)	Change in Soil C (t C/ha)
Combined - all forest	58.71					
Conversion to permanent agriculture		0.48	1.00	1.00	28.18	30.53
Mining		0.82	1.00	0.92	44.29	14.42
Conversion to unpaved roads		0.82	1.00	0.92	44.29	14.42
Shifting cultivation-short cycle		0.65	1.00	1.00	38.16	20.55
Shifting cultivation-long cycle		0.80	1.00	1.00	46.97	11.74

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

Drivers

Mining

In the improvements, mining resulting from medium and large scale as well as the previously classified mining infrastructure in the FRL, has been merged into a single driver – Mining (medium and large scale).

Shifting Agriculture

Over the years, Guyana has been tracking shifting cultivation and collecting field data to understand this driver better. In 2018, the GFC conducted a field mission to collect data across a range of ages of cropping and fallow stages in shifting cultivation areas. This was used to develop a time-average stock across the full cycle. These data, however, were highly variable, and considering the minimal contribution to deforestation, the literature was consulted to supplement the data to derive an emission factor, as such an effort was not warranted at this time.

The Monte Carlo simulation combined the uncertainties of the factors, assuming Gaussian distributions and truncating them at zero so that simulations did not include negative values (10,000 simulations). The resulting uncertainty of the shifting cultivation long-term average carbon stocks was **6.1 ± 0.1 t C/ha**. As such, the emission factor for shifting cultivation is 6.1 t C/ha (GFC W. I., 2019b).

Fire/ Biomass Burning

Burning of biomass emits methane (CH_4) and nitrous oxide (N_2O). However, it should be noted that fire affects the aboveground carbon, and belowground carbon is assumed to be unaffected. To account for emissions from biomass burning, the factors in Table 20 are applied.

Table 20 Emission factors for biomass burning

Stratum	Total biomass minus BG (t C/ha)	Fire EF CO2 (g/kg dry mass)	Global Warming Potential	Combustion factor (dimension-less)	Fire Emissions (t CO2e/ha)
Combined - all forest	223.98				
CO_2		1,580.00	1	0.50	353.9
CH_4		6.80	28	0.50	42.6
N_2O		0.20	265	0.50	11.9

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

Having established these new emission factors as the most updated driver of deforestation, Guyana has revised its emission factor and applied it to estimate the country's total deforestation emissions. The emission factor listed in Table 21 is now being used to estimate the emissions and will be used to inform the updated FRL.

Table 21 Current emission factors by deforestation drivers

Stratum	Drivers	Emission Factors		
		tC/ha	t CO2/ha	Uncertainty (IPCC approach 1)
Combined - all forest	Forestry infrastructure	286.7	1,051.3	4.8%
	Agriculture	302.8	1,110.4	4.8%
	Mining (medium and large scale)	286.7	1,051.3	4.8%
	Mining infrastructure	286.7	1,051.3	4.8%
	Infrastructure	286.7	1,051.3	4.8%
	Settlements	286.7	1,051.3	4.8%
	Fire-Biomass burning		1,053.0	4.8%
	Shifting Cultivation		1,106.0	

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

Degradation

In addition to logging, Guyana has done extensive work on degradation resulting from mining and infrastructure. This was done by assessing the loss of trees in the forests surrounding mines by establishing 100 m transect plots originating in mines. Tree mortality was identified along the transects, and the proportional carbon loss was estimated. All carbon loss that was not a result of natural tree mortality was considered an emission from mining and was used to develop the emission factor. (Brown, et al., 2020).

The emission factor applied to degradation resulting from mining and infrastructure is 8.1 t CO_2 ha^{-1}.

7.4 Activity Data

The development of activity data mapping deforestation and forest degradation in Guyana has been pivotal for accurate monitoring under the MRVS. Initially reliant on low-resolution satellite imagery, mainly Landsat, the system now uses high-resolution remote sensing technology capitalizing on advanced technology, enabling more precise and frequent tracking of forest changes. Detailed mapping of deforestation and degradation drivers, location, and frequency allows for the creation of comprehensive activity data calibrated with ground-truthing efforts. This enhances the reliability of data, which is essential for accurate emissions reporting and compliance with REDD+ requirements.

Deforestation

One of the most significant changes in reporting emissions is combining the stratum into a single stratum. This was done after the data collection and analysis were completed, resulting in a single emission factor. For data collection efficiency purposes, the stratified sampling approach will be maintained. The changes to drivers compared to the FRL include shifting cultivation, fire/biomass burning, settlement, and the merging of the mining drivers.

Mining

In 2013, Mining and mining infrastructure were merged as a single driver (Mining) on medium and large scales, and the same mapping methodology was applied to derive the activity data.

Shifting Agriculture

Dedicated studies were conducted on shifting agriculture, which occurred in Guyana's hinterland areas and was separated from agriculture. Based on remote sensing analyses over the last 20 years, zones of shifting cultivation were identified, and shifting cultivation parcels were categorized as non-forest and subsequently not included in the forest lands. In 2017, a shifting cultivation driver was added, and in 2018, owing to a better understanding resulting from data, 363,653 ha of forest lands within which this driver occurs was moved from forest to non-forest areas within which this driver is monitored and reported. This change was made based on a study that concluded that these areas should be considered non-forest, which aligns with Guyana's forest definition, (GFC W. I., 2019b).

Settlement

While the settlement has historically been an insignificant driver, with Guyana's rapid expansion and economic development, this driver has become important enough to warrant tracking and including in the annual report.

Fire/ Biomass Burning

Forest fires have become increasingly prevalent as Guyana experiences prolonged dry seasons and increases in temperature. In fact, in some years since the submission of the FRL, this driver has been responsible for clearing larger areas of land compared to the traditional drivers in areas such as agriculture and infrastructure. As such, Guyana has included this driver in its emission estimates, and there are monitors and maps of areas deforested owing to fire. Table 22 list the annual areas deforested by drivers for the reporting period of this Report.

Table 22 Annual area change by drivers of deforestation

Drivers	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Area (ha)									
Forestry infrastructure	330	204	313	313	227	356	226	195	228	155.6
Agriculture	424	817	379	379	477	512	246	489	216	281.6
Mining (medium and large scale)	11,518	10,434	6,782	6,782	7,442	7,624	5,821	6,452	6,825	5,264.3
Infrastructure	342	141	217	217	195	67	52	102	117	110.6
Settlements	23	71	8	8	7	7	22	60	105	169.4
Fire-Biomass burning	96	259	1,509	1,509	502	661	6,371	2,933	139	332.9
Shifting Cultivation					494	436	431	554	393	155.5

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

Degradation

Apart from degradation resulting from logging, as reported in the FRL, the driver mining and infrastructure (buffer area) have been added. The degradation buffer method involves creating 100-meter buffers around areas impacted by mining and road construction between specific years. To avoid double-counting, overlapping buffer regions from different years were erased, ensuring only new degradation for each year was counted. This method involves the use of the "Select By Attribute," "Buffer analysis," and "Erase tool" in ArcGIS Pro and is applied to the mining and infrastructure degradation driver. The methods used to produce degradation buffers around deforestation are included in the dataset “All Change Layer.”

The final degradation areas are calculated for each year, showing the total area of degradation and the contributions from each deforestation driver. The results indicate that over time, degradation areas varied, with mining consistently being the most significant contributor to land degradation. The methods and GIS tools used ensured that areas impacted by different deforestation drivers were clearly defined and accurately measured.

The method used to derive the activity data for estimating emissions from logging remains unchanged.

Table 23 list the activity data used to estimate the emissions from degradation in Guyana currently being tracked and accounted for.

Table 23 Activity data for degradation by driver

	Logging - volume harvested	Mining and Infrastructure (buffer area)
	m3	ha
2013	624,287	
2014	759,684	
2015	655,406	
2016	500,788	36,647
2018	546,242	28,185

	Logging - volume harvested	Mining and Infrastructure (buffer area)
2019	521,172	23,028
2020	545,355	22,795
2021	547,516	26,651
2022	622,643	18,417

Source: Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

7.5 Uncertainty

Guyana has transitioned from using the error propagation method of the IPCC GPG (2003) to using the more advanced Monte Carlo simulation to estimate its uncertainty across all its data. This area of improvement was advanced since the commencement of the implementation of the REDD+ MRV system, and this advancement enhances the assessment of all factors affecting the reported results' uncertainty level.

A variant of the residual bootstrap sampling algorithm was used to estimate uncertainty in the model parameters. With this algorithm, uncertainty in model coefficients is estimated by a) sampling the residuals generated from the model fit (e.g. Chave et al. 2005), with replacement, b) adding these "bootstrapped" residuals to the model estimates to generate a pseudosample, c) fitting the model to the pseudosample, d) saving these fit parameters to a file, and e) repeating steps (a) through (d) 10,000 times. The file with saved parameters is ingested into the primary Monte Carlo uncertainty simulation, and each iteration relies on a separate set of stochastically generated Chave model parameters.

The sources of uncertainty include a) measurement, b) allometric model parameterization, c) allometric model structure, d) factor, and e) sampling. The simulation is designed so that sources of uncertainty can be turned off or on as needed, enabling estimates of the contribution to total uncertainty from each source. Multiple simulations were run within each stratum, each time turning off or on a source of uncertainty, thereby isolating the contribution of each source of uncertainty. The full method with step-by-step application is available in (Hagen, Goslee, Pearson, & Brown, 2017). From the simulations, a comprehensive accounting of uncertainty, represented by 95% uncertainty limits, was developed. The results represent the assumption that if the entire stratum was destructively sampled, and the actual carbon in each pool measured, including the separate effects from conversion to agriculture, mining, and roads, there is a 95% chance that the value measured would fall between the upper and lower limits.

The Monte Carlos method is now used to estimate uncertainty for both activity data and emission factors data and is calculated within the ART Workbook, which Guyana currently uses for estimating its emissions across the various drivers of deforestation and forest degradation (Copy of Guyana ART Workbook MC—thru2022_IAP_UoD).

CONCLUSIONS

Guyana intends to continue improving its national REDD+ MRV systems as more information and data become available. The country will continue to build on the existing systems and adopt changes as necessary to ensure its sustainability. One of the key improvements is the planned implementation of the Continuous Resource Monitoring System (CRMS), which is currently being tested and aims to reduce the reliance on commercial satellite imagery and software. Guyana will continue to put systems in place to implement the modalities and procedures required for the Enhanced Transparency Framework (ETF) implementation with an effort to implement Article 6 of the Paris Agreement. In the interim, Guyana intends to pursue the voluntary carbon markets to continue accessing carbon financing for national development and putting the necessary systems and institutional arrangements in place, including capacity-building to fulfill its commitment to the Paris Agreement.

Since Guyana's FRL was submitted in 2015, many improvements have been made owing to data availability and changing national circumstances, as presented in Chapter 7 of this report. Guyana will submit a revised FRL, which will then align with the improved MRV system.

In the future, Guyana will continue to participate in the jurisdiction approach to REDD+ accessing voluntary and compliance markets (and once operational, full UNFCCC mechanisms for REDD+) and has outlined a benefit-sharing mechanism to ensure that the climate finance benefits will be shared in a way that is fair and equitable, recognizing the contribution of stakeholders.

REFERENCE

Baccini, A., Goetz, S., Walker, W., Laporte, N., Sun, M., Sulla-Menashe, D., . . . Houghton, R. (2012). Estimated Carbon Dioxide Emissions from Tropical Deforestation Improved by Carbon-density Maps. *Nature Climate Change, 2*, 182-185. doi:10.1038/nclimate1354

Brown, S., Magmood, A. R., Goslee, K. M., Pearson, T. R., Sukhdeo, H., Donoghue, D. N., & Watt, P. (2020). Accounting for Greenhouse Gas Emissions from Forest Edge Degradation: Gold Mining in Guyana as a Case Study. *Forests, 11*(12). doi:https://doi.org/10.3390/f11121307

Casarim, F., Goslee, K., Petrova, S., Brown, S., Sukhdeo, H., & Bhojedat, C. (2017). *Standard Operating Procedures for the Forest Carbon Monitoring System of Guyana.*

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., . . . Riera, B. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, 87-99. doi:10.1007/s00442-005-0100-x

Decision 14/CP.19. (2013). Modalities for measuring, reporting and verifying. In U. Secretariat (Ed.), *Warsaw Climate Change Conference.* Warsaw.

Decision 18/CMA.1 . (2018). Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement. Retrieved from https://ledslac.org/wp-content/uploads/2020/09/e.-Decision-18-cma.1.pdf

EPA. (2014). *Guyana's National Biodiversity Strategy and Action Plan (2012-2020).* Retrieved from https://faolex.fao.org/docs/pdf/guy156992.pdf

FCCC/TAR. (2015). *Report on the technical assessment of the proposed forest reference emission level of Guyana submitted in 2014.* FCCC. Retrieved from https://unfccc.int/resource/docs/2015/tar/guy.pdf

GFC. (2010). *Definition Paper: Definition of Forest for Guyana.*

GFC. (2015a). Carbon Stock Calculation HPC_LA_V6_11.

GFC. (2015b). Carbon Stock Calculation HPC_MA_V6_14.

GFC. (2015c). Carbon Stock Calculation_MPC_MA_LA combined.

GFC. (2015d). Logging_plots_ALL TREES_V 1.1.

GFC. (2017). *Definition Paper: Definition of Forest Degradation in Guyana.*

GFC. (2019a). *Forest Carbon Monitoring System Revised Emission Factors for Deforestation in Guyana.*

GFC. (2020). *Development and Implementation of Parallel Reporting System: Guyana’s Continuous Resource Monitoring System.*

GFC. (2021). *Guyana MRVS for REDD+ Standard Operating Procedures for Forest Change Assessment.*

GFC. (2021). *Emission Factors for Guyana’s REDD+ Monitoring Reporting and Verification System.*

GFC. (2022). Guyana ART Workbook MC - thru2022_IAP_UoD. 340. Government of Guyana.

GFC. (2023). *Guyana REDD+Monitoring Reporting & Verification System (MRVS) MRVS Report – Assessment Year 2022.* Georgetown: Guyana Forestry Commission (GFC). Retrieved from https://forestry.gov.gy/wp-content/uploads/2023/08/Guyanas-Monitoring-Reporting-and-Verification-System-Report-Year-2022.pdf

GFC, W. I. (2019a). *Revised Emission Factors for Deforestation in Guyana.*

GFC, W. I. (2019b). *Shifting Cultivation and REDD+ in Guyana.*

GFC, Copy of Guyana ART Workbook MC - thru2022_IAP_UoD

GFC, REDD+ TA Analysis Estimation Tool 2024

GoG. (2015). *The Reference Level for Guyana's REDD+ Program.* Technical. Retrieved from https://redd.unfccc.int/media/guyanas_proposal_for_reference_level_for_redd__-_final_sept_2015.pdf

Hagen, S., Goslee, K., Pearson, T., & Brown, S. (2017). *A Comprehensive Uncertainty Assessment of the Emission Factors in Guyana's Forest Carbon Monitoring System.*

IPCC. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Retrieved from https://www.ipcc-nggip.iges.or.jp/public/2006gl/

LCDS. (2022). *Guyana's low Carbon development Stratagy 2030.* Naitonal Stratagy, Georgetown. Retrieved from https://lcds.gov.gy/wp-content/uploads/2022/08/Guyanas-Low-Carbon-Development-Strategy-2030.pdf

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. doi:https://doi.org/10.1111/j.1365-2486.2005.001043.x

PA. (2015). The Paris Agreement. *COP 21* (p. 27). Paris: UNFCCC. Retrieved from https://unfccc.int/sites/default/files/english_paris_agreement.pdf

Petrova, S., Goslee, K., Harris, N., & Brown, S. (2013). *Spatial Analysis for Forest Carbon Stratification and Sample Design for Guyana's FCMS: Phase II.* Winrock Internaitonal to the Guyana Forestry Commissions.

Roopsind, A., Caughlin, T. T., van der Hout, P., Arets, E., & Putz, F. E. (2018, July). Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity. *Global Chnage Biology, 24*(7), 2862-2874. doi: https://doi.org/10.1111/gcb.14155

WI, G. s. (2019). Recommendations Paper: Shifting Cultivation and REDD+ in Guyana.