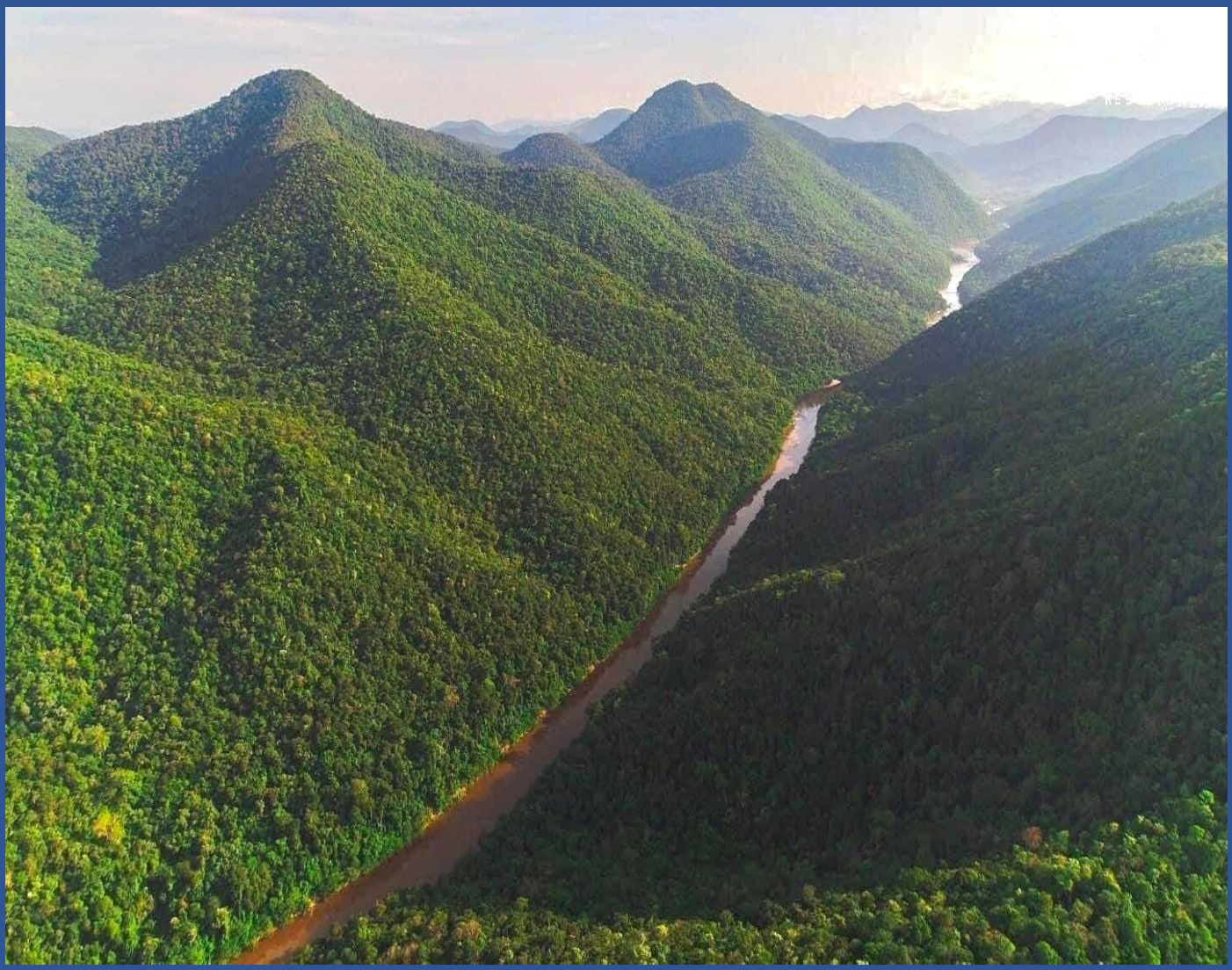
Government of Guyana

December 2024

GUYANA'S REVISED FOREST REFERENCE LEVEL

2023 - 2030



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Contents

Acronyms

AD	Activity Data
A/R	Afforestation/reforestation
AFOLU	Agriculture, forestry, and other land use
BAU	Business
CO_2	Carbon dioxide
COP	Conference of Parties
EF	Emission Factor
FCMS	Forest Carbon Monitoring System
GHG	Greenhouse Gas
GFC	Guyana Forestry Commission
GoG	Government of Guyana
GoN	Government of Norway
GPG	Good Practice Guidance
HFLD	High-forest, low deforestation
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land-use change, and forestry
MoU	Memorandum of Understanding
MRV	Monitoring, reporting, and verification
REDD+	Reducing emissions from deforestation and forest degradation, and the role of conservation of forest carbon stocks, sustainable management of forests and enhancement of carbon stocks
RL	Reference Level
REL	Reference Emissions Level
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

This document presents Guyana's submission of its forest reference level (FRL) for *"reducing emissions from deforestation and forest degradation, sustainable management of forests and the conservation of forest carbon stocks"* (REDD+) under the United Nations Framework Convention on Climate Change (UNFCCC).

Guyana submitted its initial FRL in 2014 and is now revising it based on national circumstances and international developments since then, including the Warsaw Framework on REDD+ and the Paris Agreement.

Since 2009, Guyana's Low Carbon Development Strategy (LCDS) has been the overall framing for Guyana's national REDD+ Strategy, with its latest update – LCDS 2030 - being finalised after a seven-month national consultation in 2021/2022.

As a result, the FRL takes effect from year 2023 and extends to year 2030.

Guyana's national Forest Reference Level is based on the emissions reductions and removals that result from sustainable forest management (SFM) and conservation of forest carbon stocks, as a result of the REDD+ Strategy (outlined in Guyana's LCDS 2030) and associated actions/programmes being implemented.

In Guyana, all forests, an area of approximately 18 million hectares, are under sustainable management. This comprises 12 million hectares of State Forest Estate under direct management through Codes of Practices, 3 million hectares under Site Management Plans as Protected Areas and State Lands Management, and 3 million hectares under Village Sustainability Plans within Indigenous Village management structures. In each of these categories, sustainable forest management is the underlying Cooperative Approach that conforms with Article 6 of Paris Agreement.

To ensure alignment of the country's national policies and strategy with its international commitments to the UNFCCC, this revised FRL increases accuracy and consistency, reflecting Guyana's current national circumstances. In this document, Guyana is submitting detailed information on its emissions, removals and conservation of carbon stocks that are:

- transparent, fully documented, and applying the relevant guidelines, highly sufficient for reviewers to assess the extent to which good practice requirements have been met;
- complete, whereby all relevant emissions categories are estimated and reported;
- consistent, whereby the methodologies used over the historical period are the same and use the same implementers, so the differences from year to year are real and not an artifact of change in methodology; and
- accurate and with low uncertainty so that results are neither under or over-estimated.

Like the predecessor, this FRL is developed at the National scale, includes a detailed and robust analysis of historical emissions from known drivers of deforestation and forest degradation, as well as a detailed analysis of removals as listed inTable 1 , and includes the following:

- The key drivers of deforestation include conversion to agriculture, mineral extraction, and infrastructure expansion (mining and logging roads);
- Degradation from timber production, representing a source of emissions;
- Degradation from mining and infrastructure, representing a source of emissions;
- Removals as determined by country specific information determined over a data span of 20 years from a long-term study established in 1993.

Furthermore:

- Forests are defined as having a minimum area of land of 1 ha with tree crown cover (or equivalent stocking level) of more than 30% with the potential to reach a minimum height of 5 m at maturity in situ;
- All five IPCC-recognized carbon pools are included, and the key GHG selected are CO_2, N_2O and CH_4;
- The historic period selected is from 2018 to 2022;
- The collection and analysis of activity data (AD) and field data on forest carbon stocks are consistent with good practice in that they neither over- nor under-estimated as far as can be judged; and
- All data are at Tiers 2 and 3 for the following reasons:
    - Wall-to-wall coverage of satellite imagery is used to obtain the activity data related to the conversion of forest lands to other uses, and such data are combined and co-registered with other key spatial databases in a Geographic Information System (GIS) such as roads, rivers, settlements, vegetation class, location of logging concessions, location of mining concessions, and topography.
    - A comprehensive, peer-reviewed field sampling system designed and implemented to attain a required precision target of a 95% confidence interval of <+/-15% of the mean total carbon stock of Guyana's forests.

Table 1 Comparison of the FRL 2015 and this revised submission

Parameters	FRL (2015)	Current FRL (2024)
IPCC Guidelines	2006 IPCC Guidelines	2006 IPCC Guidelines
REDD+ Activities	Reduction from deforestation and forest degradation	Reduction from deforestation and forest degradation
Forest Definition	30% canopy cover, >1ha, >5m in situ	30% canopy cover, >1ha, >5m in situ
Carbon Pools	-Aboveground -Belowground biomass -Deadwood included in degradation from timber harvest only.	-Aboveground biomass -Belowground biomass -Deadwood -Litter -Soils Carbon
Gas	CO_2	CO_2 , N_2O and CH_4
Deforestation Drivers	-Forestry infrastructure -Agriculture -Mining (medium and large scale) -Infrastructure	-Forestry infrastructure -Agriculture -Mining (medium and large scale) -Infrastructure -Settlement -Biomass Burning

Parameters	FRL (2015)	Current FRL (2024)
		-Shifting Cultivation
Degradation Drivers	-Logging volume harvested	-Logging volume harvested -Mining infrastructure
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 -Low Potential for Change More Accessible Area -Low Potential for Change Less Accessible Area	Combined Single Stratum. The methods applied across all strata remain unchanged. Additional data was collected and added to the data sets to inform the combination of strata.
Activity Data	Disaggregated by deforestation and forest degradation drivers by stratum	Disaggregated by deforestation and forest degradation drivers
Spatial Mapping	1ha minimum mapping unit	1ha minimum mapping unit
Emissions Factor	Developed by stratum (Tier 2).	Combine emissions factor (Tier 2).
Data Source	GFC Annual MRV Reports	-GFC Annual MRV Reports -Verification Reports

Establishment of FRL for 2023-2030

Guyana's revised FRLs include all five components of REDD+ as set out in the Warsaw Framework and incorporate the key contributions Guyana's forests make to REDD+ and global climate action based on increased capacity and improved data since the original FRL was determined in 2014:

- **Conservation**: The estimated forest biomass carbon stocks across all pools is 272.3 t C/ha without soil carbon and 331 t C/ha with soil carbon. At the end of 2022, Guyana's forest is estimated to be **17,840,520 hectares**, with a storage capacity of **21,652,444 tCO_2,** including soil carbon.
- **Emissions from Deforestation and forest Degradation:** Guyana's average emissions from 2018 to 2022 were estimated at 13.67 million tons of CO_2, 0.08% of total carbon stocks, with a maximum of 17.2 million t CO_2 in 2019 and a minimum of 10.69 million t CO_2 in 2022. These emissions are very low by global standards, because Guyana's approach to sustainable management of forests has resulted in the long-term historical deforestation in Guyana being very low over the whole country – and is one of the lowest in the world.
- **Removals:** Figure 1 shows that the GHG emissions are strongly influenced by Guyana's sustainable management of its extensive national forest cover and the consequent absorption of CO_2 from the atmosphere. Over the reference period of this FRL, Guyana has maintained a net carbon sink, with a negative emission level, surpassing -130 Mg of CO_2-eq per annum for the entire period from 1990 to 2022. To calculate removals from forests remaining forests, country-specific annual increments over 20 years were utilized (1993 to 2013). Country-specific growth increments were

referenced from Roopsind et al., 2018: Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity, 2017[1].

Roopsind et al., 2018, form the baseline for estimating removals in Guyana, estimated at 106,533,237 tCO_2.

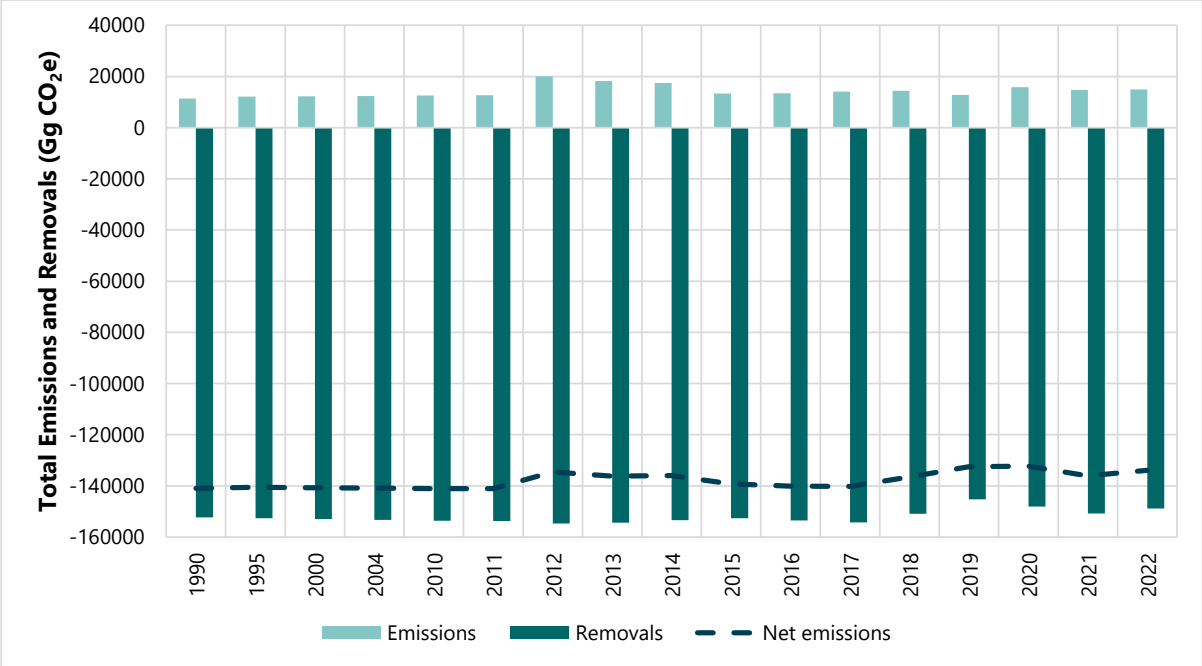

Figure 1 GHG emissions and removals of Guyana – 1990-2022.

Roopsind et al. underscore the importance of accurately accounting for these baselines to ensure fair estimation of removals and to incentivize sustainable forest management practices, by incorporating baseline data on deforestation and degradation rates as setting Guyans's reference level summarized in Table 2.

Table 2 Guyana's Reference Level

Element of REDD+	Estimations	Contribution to RL for Generation of Results
Emissions from Deforestation and Forest Degradation	Historical Emissions	13,674,678
Annual Emissions Reductions from sustainable management of forests and conservation	0.1% of Forest Carbon Stock, based on World Bank's FCPF methodology.	21,652,444
Annual Removals from sustainable management of forests and conservation	From National Specific 20-year Study	106,533,237
TOTAL (Annual)		**141,860,359**

[1] Roopsind A, Caughlin TT, van der Hout P, Arets E, Putz FE. ***Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity***. Glob Chang Biol. 2018 Jul;24(7):2862-2874. doi: 10.1111/gcb.14155. Epub 2018 May 22. PMID: 29603495. (Available at: https://pubmed.ncbi.nlm.nih.gov/29603495/)

1. Background

In accordance with decision 12/CP.17 paragraph 13,[2] Guyana submitted its first REDD+ Reference Level (RL) to the UNFCCC in 2014, which was accepted in 2015. There were two main components of the RL: (a) establishment of Guyana's historical emissions profile from the forestry sector and (b) the development of the reference level. The 2015 RL was developed as a combined reference level, averaging the rate of greenhouse gas emissions from pan-tropical forest loss with the annual rate of emissions from forest loss in Guyana between 2001 and 2012. This was consistent with UNFCCC guidance at the time, including the allowance for the use of a stepwise approach: all drivers of deforestation measured at the time were included, though the only driver of degradation included in the analysis was selective logging. Additionally, a stratified approach was used for the 2014 RL, as field data were being collected under the assumption that carbon stocks differ significantly and are, therefore, impacted by the area's potential for change and accessibility. Based on this assumption and the data available at the time, the RL was submitted for all strata (six strata, High, Medium and Low by More and Less accessible) in the country, and emission factors for incompletely sampled strata were conservatively estimated.

This revised Forest Reference Level (FRL) is a revision to the 2015 reference level, incorporating stepwise improvements and results from additional data collected. Significant revisions include the following:

- Additional data collected, representing nationwide coverage and resulting in the merging of the six strata into a single stratum; thus as a consequence, there is a convergence of biomass values and updated emission factors;
- An updated reference period – 2018 to 2022;
- The inclusion of additional drivers of both deforestation and forest degradation;
- New data on removals based on country-specific study;
- Inclusion of additional GHG;
- Inclusion of all carbon pools.

This revised FRL provides an overview of the data and methodologies used to estimate the historical emissions profile and details of how national circumstances are considered. The information presented is intended to be transparent, complete, and consistent with UNFCCC guidance, accurate, guided by the 2006 IPCC guidelines, and comparable to other Party's submissions.

1.1 Guyana Context

In global assessment reports, the Guiana Shield has been identified as one of the largest remaining blocks of primary tropical forest on earth and plays an important role in mitigating climate change. The region has both the highest percentage of primary forest cover (over 90% is intact tropical forest) and the lowest human population density of any major tropical forested area.

[2] Decision adopted by the United Nations Framework Convention on Climate Change Conference of the Parties 17th session, held in 2011, available at https://unfccc.int/resource/docs/2011/cop17/eng/09a02.pdf

In Guyana, historical deforestation has been one of the lowest rates in the world (0.02% to 0.079% yr^{-1} between 2009 and 2022[3]). Guyana is considered to be a high forest low deforestation rate (HFLD) country, with forests covering approximately 85% of the country (21.1 million hectares) and containing an estimated 5.96 gigatons (Gt) of biomass, equivalent to 21.8 Gt CO_2 with the inclusion of soil carbon.

However, in addition to being one of Guyana's most valuable natural assets, these forests are suitable for logging and agriculture, and have significant mineral deposits. Mining is the primary driver of deforestation in Guyana,[4] accounting for 85% of all deforestation between 2001 and 2012, and 74% of deforestation between 2018-2022. Agriculture, roads and mining infrastructure, forestry infrastructure, and forest fire are the remaining drivers of deforestation and forest degradation in Guyana.

There are growing demands for agriculture, livestock, timber, minerals, and human settlements on forested land. These demands have grown over many years, in particular since Guyana emerged from a period of economic stagnation after the return of democracy in the early 1990sIn order to achieve a balance between preserving Guyana's forests as a global asset in the fight against climate change and, at the same time meeting addressing poverty and other developmental challenges, Guyana has pursued a Low Carbon Development Strategy (LCDS). The latest revision of the LCDS sets out plans up to 2030 to maintain Guyana's low deforestation and high HFLD score[5] through advancing sustainable management of forests.

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[6]) 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 established to ensure sustainability. These extractions result in deforestation and forest degradation.

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 459 km long and 16km wide.

All of Guyana's forests, an area of approximately 18 million hectares, are under sustainable management illustrated in Figure 2 through the National Forest Policy, National Forest Plan and Codes of Practice, including:

[3] Guyana REDD+ Monitoring Reporting and Verification System Report – Assessment Year 2020. Available at https://forestry.gov.gy/wp-content/uploads/2021/10/Guyana-MRVS-Assessment-Year-2020-Report-Final-September-2021.pdf

[4] Decision 4, CP.15 paragraph 1(a) requests developing country Parties to identify drivers of deforestation and forest degradation resulting in emissions.

[5] https://www.artredd.org/wp-content/uploads/2021/12/ART-HFLD-Primer.pdf

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

- **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. 12 million hectares of State Forest Estate are under direct sustainable forest management through Codes of Practices as part of Guyana's REDD+ programme.
- **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. 3 million hectares ares under direct sustainable forest management by indigenous peoples and local communities through Village Plans and Indigenous Village management structures that are integrated within Guyana's REDD+ programme.
- **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 have been designated as Protected Areas (see Map 1). Three (3) million hectares are under direct sustainable forest management through Site Management Plans as Protected Areas

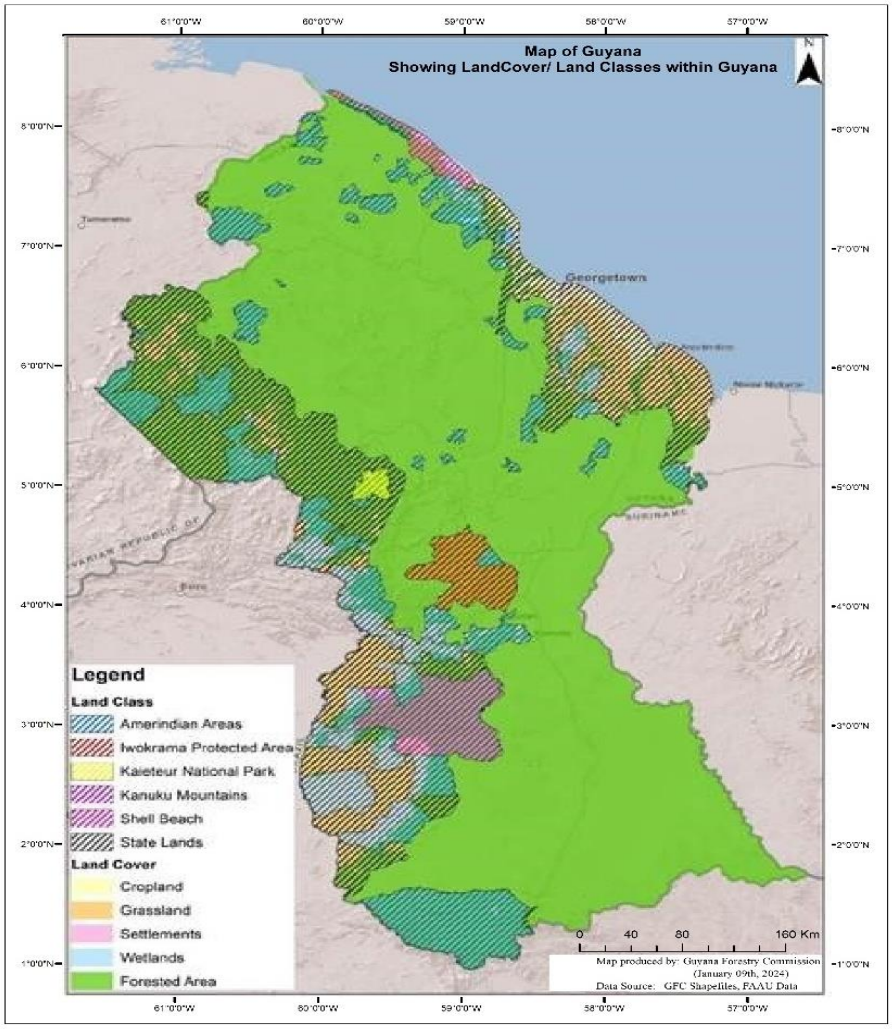

Figure 2 Map of Guyana's Land Use Classes

The remainder of Guyana's land area is categorized as:

- **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 land owned by the State, with isolated pockets of privately owned land, excluding titled Amerindian lands.

2. Application of UNFCCC Modalities

Within the context of the United Nations Framework Convention on Climate Change (UNFCCC or Convention), REDD+ Reference Emission Level/Reference Levels serve two purposes[3]. Firstly, the RLs establish a business-as-usual (BAU) baseline against which actual emissions are compared, whereby emission reductions are estimated as the difference between RLs and actual emissions. In this sense, RLs depict what the emissions scenario would be in the absence of REDD+ implementation and thus provide the basis for measuring its success. Secondly, the RLs are needed to determine the eligibility of UNFCCC Parties for international, results-based support for REDD+, and to calculate that support based on measured, reported, and verified emission reductions.

The creation of forest RLs as benchmarks for assessing performance is guided by modalities contained in UNFCCC Conference of Parties (COP) decisions, most notably decision 12/CP.17 paragraphs 7-15 and its Annex. These modalities state that when establishing forest RLs, Parties should do so transparently, taking into account historical data and adjusting for national circumstances in accordance with relevant decisions of the COP.[7] Forest RLs can be developed sub-nationally as an interim measure while transitioning to a national scale, but Guyana has chosen from the outset to develop its RL at a national scale to avoid leakage issues due to its relatively small size. A stepwise approach is allowed, which enables Parties to improve the forest RL by incorporating better data, improved methodologies and, where appropriate, additional pools. Forest RLs are expressed in units of tons of CO_2 equivalent per year and must maintain consistency with a country's greenhouse gas inventory. In response to the guidelines for submissions of information on reference levels provided in the annex to decision 12/CP.17, we present a summary of Guyana's positions in Table 3.

Table 3. UNFCCC modalities relevant for Guyana's Reference Level.

Reference to Guideline	Description	Guyana's Reference Level (2024)
Decision 12/CP.17 Annex, paragraph (d)	Definition of forest used	• Minimum tree cover: 30% • Minimum height: 5 m Minimum area: 1 ha[8]
Decision 12/CP.17 Paragraph 10	Allows for a stepwise approach	The FRL is at the national scale and includes all drivers of both deforestation and forest degradation, accounts for removals, but does not account for carbon stock enhancements.
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases included	• Pools: (activity-specific) – Aboveground biomass – Belowground biomass – Dead wood – Litter – Soil carbon • Gases:

[7] Decision 4/CP.15, paragraph 7.
[8] Based on the Marrakech Accords.

Reference to Guideline	Description	Guyana's Reference Level (2024)
		– Include CO_2 – Include N_2O and CH_4, converted to CO_2e, for biomass burning due to wildfires using IPCC default factors.
Decision 12/CP.17 Annex, paragraph (c)	Activities included	• Include deforestation (from agriculture, mining, infrastructure) • Include forest degradation (from timber harvesting, fire, small-scale mining, shifting cultivation) • Include removals
Decision 12/CP.17 Annex	IPCC guidelines and Guidelines used	• 2006 IPCC guidelines. • 2019 refinement to the 2006 IPCC guidelines
Decision 12/CP.17 II. Paragraph 9	To submit information and rationale on the development the FRL, including details of national circumstances	Guyana is an HFLD country with approximately 85% forest cover and a very low deforestation rate. This FRL proposes to make adjustments to allow for national circumstances and likely future emissions not captured in the historical ones.

2.1 Rationale and Justification of Guyana's Decisions for the Reference Level

Guyana's process of developing the initial Reference Level was based on an **agreed "Roadmap" to building a national MRV system**. The Roadmap was created in consultation with stakeholders and includes: a national implementation strategy, status of current activities and capacities, requirements for the MRV system, a capacity gap assessment, and a roadmap including an institutional framework for implementation. In March 2014, a phase 2 Roadmap was developed that assessed the achievements of the Phase 1 period and identified the next steps. Guyana developed a Phase 3 Roadmap in 2020, establishing a path for the MRVS to develop an operational forest carbon reporting approach that meets all UNFCCC recommendations and enables a market-based mechanism.

Since submission of the initial Reference Level, aspects of the original decisions have been updated, prompting this revision of the country's FRL.

2.1.1 Forest Definition

Guyana has chosen to define forest following the definition as outlined in the Marrakech Accords (UNFCCC 2001). Under this agreement forest is defined as having a minimum area of land of 0.05 – 1 ha with tree crown cover (or equivalent stocking level) of more than 10-30% with the potential to reach a minimum height of 2-5 m at maturity in situ. Guyana has elected to classify land as forest if it meets the following criteria:

- Tree cover of minimum 30%
- Minimum height of 5 m
- Minimum area of 1 ha

These thresholds were determined to be appropriate for Guyana's forests, which are largely either undisturbed primary forests or sustainably managed. This forest definition remains unchanged from the 2015 reference level and allows for appropriate monitoring at a reasonable transaction cost. Because Guyana is implementing REDD+ at the national scale, this forest definition is applicable countrywide to all REDD+ related activities and reporting.

2.1.2 Scope of Activities

Guyana's FRL includes emissions from all measured activities that result in removals, deforestation and forest degradation.

2.1.2.1 Removals

The reference level includes removals data from country-specific assessments of annual increments over 20 years.

2.1.2.2 Deforestation

The Reference Level includes all activities that result in deforestation in Guyana:

- Mining
- Infrastructure (roads, including forestry and mining roads)
- Agriculture
- Settlements
- Fire
- Shifting cultivation

2.1.2.3 Forest Degradation

Guyana defines forest degradation as any loss of carbon stocks from forests remaining forests as a result of anthropogenic activities, with an impact area exceeding 0.5 hectares.

There are multiple sources of forest degradation in Guyana, each of which has been considered separately to determine whether they result in significant emissions. Methods of accounting for each have been developed according to the extent of emissions and potential emission reductions and the cost of accounting approaches. In Guyana's initial FRL, the only degradation activity included was timber harvesting. However, with stepwise improvements, Guyana is now able to include estimates of emissions from all activities.[9] The anthropogenic activities resulting in forest degradation in Guyana that are covered in Guyana's National Forest Monitoring System and included in this revised FRL are:

- timber harvest
- anthropogenic impacts around mining sites
- anthropogenic impacts around infrastructure

[9] Using the high-resolution imagery analysis and the fieldwork of Brown *et al.* (2015), annual mining degradation emissions as a proportion of total emissions was estimated as 0.48% and the numbers for infrastructure are likely to be lower still.

Selective Logging

In accounting for emissions, forest degradation associated with timber harvesting was responsible for 23% of Guyana's annual forest emissions in 2018 and 34% in year 2022.

Forest degradation occurs through the removal of commercial timber trees from the forest (greater than 35cm dbh), collateral mortality of nearby trees as a result of harvested trees, and impacts from infrastructure such as skid trails needed to extract harvested logs from the forest.

Removals from forests remaining forests are computed utilizing country-specific annual increments over a 20-year time series. Increments were referenced from Roopsind et. al., 2018: *Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity*, 2017[10], based on country-specific grown increments. This study covers a 20-year data span (1993 to 2013), in examining the average gross periodic annual increment of logged (with different levels of Reduced Impact Logging Practices) and unlogged forest of aboveground carbon ranging between 2.11 tCO_2 and 3.54 tCO_2 per hectare, and Net Periodic Increment of aboveground carbon of unlogged and logged forests ranging between 0.13 tCO_2 and 1.69 tCO_2.

Degradation Surrounding Mining and Infrastructure

Forest degradation associated with mining is a minor source of emissions in Guyana.[11] This can be considered 'diffuse' degradation to distinguish it from clumped or condensed forms of forest degradation occurring where there are recognizable patches of cleared forest, such as those associated with roads, skid trails, and gaps in timber harvest.

The application of Guyana's forest definition requires consideration of two forms of forest degradation associated with mining. The first is clearing of a forest area that is less than the minimum1 ha to be counted as deforestation (i.e., between 0.5 and 1 ha). In this case, Guyana does not estimate emissions, as it is assumed that these areas will ultimately either return to forest cover or reach the size threshold for deforestation. The second form of degradation from mining is the damage to trees surrounding mines leading to loss of canopy and associated emissions. Forests adjacent to mines are impacted by the mining activity so carbon stocks are reduced even though the forest cover remains. Such impact occurs for several reasons, such as when trees are removed to provide wood for building mining camps or when mine tailings lead to tree mortality or when areas are subjected to pre-mining exploration. While the resulting emissions are relatively small, they are included in REDD+ accounting to ensure completeness in reporting.[12] This can be considered 'diffuse' degradation, as it is not concentrated in a specific location, since e it spreads across the forest landscape.

Forest degradation surrounding infrastructure is also a minor form of emissions in Guyana, accounting for only 0.02% of forest degradation emissions in 2016. Infrastructure here predominantly refers to roads,

[10] Roopsind A, Caughlin TT, van der Hout P, Arets E, Putz FE. ***Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity***. Glob Chang Biol. 2018 Jul;24(7):2862-2874. doi: 10.1111/gcb.14155. Epub 2018 May 22. PMID: 29603495. (Available at: https://pubmed.ncbi.nlm.nih.gov/29603495/)

[11] 0.3% of total emissions, 1.1% of forest degradation emissions according to 2016 data.

[12] Brown, Mahmood, Goslee, Pearson, Sukhdeo, Donoghue and Watt. 2020. Accounting for greenhouse gas emissions from forest edge degradation: gold mining in Guyana as a case study. *Forests*: 11(12):1307.

which provide access to the forest and result in degradation by impacting the carbon stocks immediately adjacent to roads and by allowing further human incursion. As with mining degradation, estimates from infrastructure degradation are based on an emission factors applied to a buffer zone around infrastructure deforestation.

2.1.3 Scale

Guyana has opted to retain its FRL at the national scale rather than develop subnationally due to its relatively small size and centralized government structure. This aligns well with the national REDD+ MRV system that generates annual data.

2.1.4 Pools/Gases

The carbon pools for Guyana were selected separately for each activity included in the FRL (Table 4). The selection of pools was based on the expected magnitude of the change in stock in a given pool due to deforestation and the resources required to collect accurate and precise data. For degradation caused by timber harvesting, the soil carbon pool was not included because selective logging has an insignificant impact on soil carbon.[13] Litter was also excluded from degradation because, like the soil pool, its impact is minor due to the small area impacted by timber harvesting. Harvested wood products are not included as a pool under the assumption that they are in a steady state and not changing over time, as described in Chapter 12 of the 2019 refinement to the 2006 IPCC guidelines.

Table 4. Carbon pools selected to include in the Reference Level according to activity.

Activity	AG Biomass	BG Biomass	Dead Wood	Litter	Soil Carbon
Deforestation	✓	✓	✓	✓	✓
Degradation from Timber Harvesting	✓	✓	✓		

The greenhouse gases covered in Guyana's FRL include carbon dioxide (CO_2) for all activities except biomass burning, for which nitrous oxide (N_2O) and methane (CH_4) are included based on the 2006 IPCC guidelines and reported in CO_2 e.

2.1.5 Historical Time Period

The initial Reference Level used a reference period of 2001-2012. This revised reference level will use a five-year reference period of 2018-2022.

2.1.6 IPCC Guidance

The IPCC 2003 IPCC Good Practice Guidance for Land Use, Land-use Change, and Forestry (GPG-LULUCF) and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Agriculture, Forestry and Other

[13] Johnson, D. W. and P. S. Curtis. 2001. Effects of forest management on soil C and N storage: meta-analysis. Forest Ecology and Management 140:227-238

Land Use (AFOLU),[14] along with the 2019 refinements to the 2006 IPCC Guidelines[15] were used for preparing the latest national greenhouse gas inventory in Guyana. No guidance has been made with respect to preparing and reporting on REDD+-related activities, although in 2011, the UNFCCC Conference of Parties agreed that the Biennial Update Reports for non-Annex 1 Parties (i.e., developing countries) should be based on the 2003 GPG, including the Tables in Annex 3.A.2.However, Decision 12/CP.17 Annex states that information used to develop an RL should be guided by the most recent IPCC guidance and guidelines; thus, Guyana refers to the 2003, 2006, and 2019 IPCC reports.

Key concepts that the IPCC recommends countries address with respect to estimating emissions and removals, and how Guyana applies these concepts in developing this FRL are described as follows:

- **Good Practice**: Inventories consistent with good practice are those that contain neither over- nor under-estimates as far as can be judged, and in which uncertainties are reduced as far as practicable. These requirements are intended to ensure that estimates of emissions by sources and removals by sinks, even if uncertain, are bona fide estimates, in the sense of not containing any biases that could have been identified and eliminated. Good practice entails the following five principles: 1) Transparency—that documentation is sufficient for reviewers to assess the extent to which good practice requirements have been met; 2) Completeness—all relevant emissions and removal categories are estimated and reported; 3) Consistency—differences in emissions and removals between years are real and not an artifact of changes in methodology or data; 4) Comparability—so that inventory estimates can be compared among countries; and 5) Accuracy—methods used are designed to produce neither under or overestimate.

Guyana has applied good practice to all its data collection and analysis efforts by:

  - Building local capacity in all aspects of data collection and analyses
  - Developing and implementing a QA/QC plan, including steps for checking internal consistency, checking against other independent estimates, standard operating procedures (SOPs) for field data collection, data analysis, processing remote sensing imagery, and data archiving
  - Establishing and achieving accuracy targets for interpretation of remote sensing imagery used to estimate rates of forest loss used to develop activity data (AD)
  - Establishing and achieving accuracy and precision targets for field data collection and analyses for estimating emission factors (EFs)
  - All documents and databases are available for inspection
- **Tiers**: A system of tiers has been developed by the IPCC to represent different levels of methodological complexity. Tier 1 is the basic method employing generic calculations, whereas the intermediate Tier 2 and advanced Tier 3 are more demanding in terms of complexity and specificity of data requirements.

[14] Available at http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html. And http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
[15] Available at https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

The higher order Tier 3 includes models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at a sub-national level. Such systems may include comprehensive field sampling repeated at regular time intervals and/or GIS-based systems of age, class/production data, soils data, and land-use and management activity data, integrating several types of monitoring. Parcels of land where a land-use change occurs can usually be tracked over time, at least statistically. All models should undergo quality checks, audits, and validations and be thoroughly documented.

Guyana is operating at Tier 2 to 3 levels for the following reasons:

- Wall-to-wall coverage of satellite imagery is used to obtain the AD related to the conversion of forest lands to other uses. From 1990 to 2010, Guyana used primarily Landsat imagery with a variety of other sensors. Post-2010 AD is based on practically wall-to-wall monitoring using high-resolution, including RapidEye and Sentinel imagery.
- All AD are disaggregated by the drivers used to develop EFs (e.g. mining, infrastructure, converted to cropland, converted to settlements,).[16]
- All AD data are combined and co-registered with other key spatial databases in a GIS such as roads, rivers, settlements, vegetation class, location of logging concessions, location of mining concessions, topography, etc.
- A comprehensive, peer-reviewed field sampling system was designed and implemented to attain a required precision target. The location of each sample plot was randomly selected statistically through a series of steps in a GIS.[17]
- A field sampling plan has been designed for long-term, repeated measurements of the forest carbon stocks and ongoing monitoring of forest cover change.
- The allometric model of Chave et al.[18] was validated for use in Guyana forests.

2.1.7 Adjust for National Circumstances

In accordance with Decision 12/CP.17 II. Paragraph 9, countries can submit information and rationale on the development of FRL—including details of national circumstances—and, if adjusted, include details on how the national circumstances were considered. Being a HFLD country, Guyana considers the following national circumstances:

- Guyana's sustained success in advancing sustainable management of forests has created a situation where removals capabilities of the forests are maximised to provide climate mitigation and other services.

[16] Activity data can also be disaggregated by the strata previously used for field sampling, in the event that it is determined that stratification should be employed again.

[17] Brown, S., K. Goslee, F. Casarim, N. L. Harris, and S. Petrova. 2014. Sampling Design and Implementation Plan for Guyana's REDD+ Forest Carbon Monitoring System (FCMS): Version 2. Submitted by Winrock International to the Guyana Forestry Commission.
Note that the sampling approach has been updated, with stratification eliminated as described in the 2019 Forest Stratification Report, submitted by Winrock International to the Guyana Forestry Commission.

[18] Chave, J, C. Andalo, S. Brown, M.A. Cairns, J.Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J.P. Lescure, B.W. Nelson, H. Ogawa, H. Puig, B. Riera, T. Yamakura. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87-99.

- Mining is a major driver of deforestation, and rising mineral prices could create incentives that significantly impact the rate of forest cover change caused by this driver.
- Logging is the main driver of forest degradation, and changes in timber demand and prices could create incentives that significantly impact emissions caused by this driver.
- Rapid economic growth and socio-economic development are creating pressures for infrastructure development and population centers on forested land.

Guyana's Low Carbon Development Strategy

In 2009, Guyana launched the first Low Carbon Development Strategy (LCDS) to balance legitimate development aspirations and the need to maintain its high HFLD status. The strategy has been updated on several occasions, with the latest version setting out plans up to 2030 (LCDS 2030).

In outlining an economic development strategy compatible with maintaining Guyana's high HFLD status, the LCDS 2030 sets out how Guyana has been using economic incentives (referred to as "payments for climate services") based on REDD+, through a three-phase plan. The first phase saw Guyana earn US$212 million in payments from a bilateral agreement with Norway, based on Guyana's official reference level in 2015. The second and third phases seek to access payments from voluntary and compliance markets, as well as full integration with REDD+ mechanisms as envisaged in the Paris Agreement under Articles 6.2 and 6.4.

As a result, the establishment of Guyana's FRL is guided by the objectives of aligning with methodologies that are (i) scientifically valid and conservative, (ii) consistent with Guyana's original reference level, and also being (iii) capable of integrating with market-based mechanisms that are compatible with advances within the UNFCCC since the approval of the country's first submission.

As set out in the LCDS 2030, these objectives are being met through Guyana's integration with a jurisdiction-scale, market-based mechanism, with access to markets that are aligned with the UNFCCC and recognize all aspects of REDD+ as defined by the UNFCCC. Practically, that means accessing markets that recognize all elements of REDD+ and enable Guyana to achieve the following goals set out in LCDS 2030:

- **Conservation of Standing Forests**: Guyana's forests store approximately 21.8 Gt CO_2
- **Removals**: Every year, Guyana's forests remove about 106 million tCO_2 from the atmosphere
- **Reductions in Deforestation**: Guyana aims to stay 90 percent below the global average
- **Restoration of Forests**: Guyana aims to restore about 200,000 hectares of forest as a priority

3. National Forest Monitoring System

UNFCCC decisions request developing country Parties to establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems (NFMS), and, if appropriate, sub-national systems as part of national monitoring systems that:

- Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related GHG emissions by sources and removals by sinks, forest carbon stocks and forest area changes
- Provide estimates that are transparent, consistent, and accurate, and that reduce uncertainties, taking into account national capabilities and capacities
- Are transparent, with results that are available and suitable for review as agreed by the COP

Guyana's NFMS, referred to within Guyana as the Monitoring, Reporting, and Verification System (MRVS), is comprised of the Forest Area Assessment System and the Forest Carbon Monitoring System (FCMS). The MRVS details the methods required to quantify the changes in forest cover and changes in forest carbon stocks in Guyana, establish activity data, develop driver-specific emission factors, and monitor emissions from land cover/land use changes over time based on a variety of management activities. Additionally, the MRVS ensures consistency in the data and information supporting the implementation of REDD+ activities.

The activity data and emission factors generated from the MRVS for key categories are combined to estimate total CO_2 emissions by source or driver under Guyana's REDD+ programme. Table 5 provides an overview of each key category addressed by Guyana, including the associated drivers and the pools included in each IPCC-required category.

Table 5. Overview of the IPCC categories, drivers, and pools used to estimate emission factors for each key category.

IPCC Category	Driver(s) as defined in MRVS	Pools included		
		Biomass	Dead organic matter	Soil
Forest Land Remaining Forest Land	Degradation caused by logging	Above- and belowground tree	Dead wood caused by logging	Not included
Forest Land Converted to Cropland	Agriculture	Above- and belowground tree, saplings	Standing and lying dead wood, litter	Based on conversion to permanent agriculture
Forest Land Converted to Settlements	Infrastructure including mining roads and forestry infrastructure	Above- and belowground tree, saplings	Standing and lying dead wood, litter	Based on conversion to unpaved roads
Forest Land Converted to Other Land	Mining (bare soil)	Above- and belowground tree, saplings	Standing and lying dead wood, litter	Based on conversion to mining
Biomass Burning in Forest Lands	Fire-Biomass burning	Above-ground tree, saplings	Standing and lying dead wood, litter	Not included

3.1 Estimating Activity Data

3.1.1 Deforestation

Activity data (AD) for deforestation are developed by estimating the extent of forest change measured by area. Forest area change has been estimated for forests converted to other lands (deforestation) for all drivers, based on IPCC Approach 3. The Guyana Forestry Commission assessed historical forest area change over a benchmark period of 1990 through 2009. From 2010 onwards, national assessments have been conducted to determine annual forest area change.

For each period, satellite imagery was used to quantify deforestation resulting from various drivers, including mining, agriculture, forestry infrastructure, road infrastructure, shifting cultivation, settlements, and fire. The datasets used for the change analysis have evolved, with the historical change analysis for the benchmark period conducted using Landsat imagery. In 2010, a combination of DMC and Landsat was used, and between 2011 and 2014, GFC used high-resolution images from RapidEye. For 2015 and 2016 GFC used a combination of Landsat and Sentinel data. Because high resolution imagery was cost prohibitive and not sustainable in the long term, since 2017 data from the Sentinel (2A/2B) multispectral imager (MSI) has been the primary dataset for monitoring deforestation, supplemented by Landsat and fire monitoring datasets. [19]

All remote sensing products have been assessed for accuracy (accuracy on forest area of >97%), verified independently by a third party and all steps have been certified by external auditors. It is important to note that using the Sentinel dataset has maintained the accuracy of forest monitoring.

3.1.2 Degradation

3.1.2.1 Selective logging

Activity data for logging are obtained from timber harvest records. The GFC reports on volume of timber extracted, by the primary product class (Table 6) from its concessions and the length of the skid trails planned to extract the timber to the logging decks. All timber data are converted to cubic meters over bark using a variety of factors and summed to give a total timber production for each year.

Table 6. Primary product classes tracked by GFC, along with conversion factors to obtain true volume under-bark in cubic meters. All volumes are multiplied by 1.12 to convert to over-bark (from IPCC 2006 AFOLU).

Product	Description
Logs, 1000 m^3/yr	Log is the main product produced and is not a subset of any category. This volume that is declared is the hoppus volume that discounts a part of the log to provide for the taper factor. To determine the true volume of logs, it is recommended to multiply this volume by 1.278%.
Sawnwood, 1000 m^3/yr	This category of products is a stand-alone category and is in addition to logs. That is, it is not a subset of the Logs category. This is the case since Guyana's Forest Act allows for forest concessionaires to declare harvested timber in logs as well as Primary Lumber, which is largely Chainsawn Lumber or Portable Mill produced

[19] Guyana Forestry Commission. Guyana REDD+ Monitoring Reporting & Verification System (MRVS); MRVS Report – Assessment Year 2020

Product	Description
	lumber. To derive a total harvested volume quantity, this has to be added to Logs harvested.
Roundwood (piles, poles, posts, spars), 1000 m^3/yr	This is a separate category, not a subset of Logs or Primary Lumber, and needs to be added to Logs and Primary Lumber to generate a total of harvested timber.
Splitwood (staves, shingles), 1000 m^3/yr	This is a separate category and only includes non-factory manufactured splitwood, not a subset of Logs or Primary Lumber, and needs to be added to Logs, Primary Lumber, and Roundwood to generate a total of harvested timber.

3.1.2.2 Degradation Resulting from Mining and Infrastructure

The method Guyana uses for diffuse forms of forest degradation, such as that which occurs surrounding mining sites, is to establish a buffer zone of an established width around areas of deforestation and develop an emission factor for the entirety of the buffer zone. The analysis is conducted in ArcMap using Guyana's yearly forest change dataset.

For mining, buffers with a width of 100m have been determined to be appropriate for capturing the degradation associated with mining activities. The activity data, therefore, requires calculating the total area within 100m buffers around all new areas of mining deforestation in a given year. Additionally, for mines where expansion has occurred, the buffer area is calculated both with and without the most recent expansion, with the current year's forest degradation emissions calculated only on the expanded area. Deforestation due to mining is identified in Guyana's yearly forest change driver dataset including the drivers of mining.

A specific analysis has not yet been conducted for infrastructure, so the 100m buffers used around mining are currently used and are considered highly conservative as, unlike for mining, there are no resident populations around new infrastructure. Activity data for degradation from infrastructure, therefore, requires calculating the total area within 100 m buffers around all new areas of infrastructure deforestation each year, as well as degradation emissions resulting from the current year expansion of any existing infrastructure.

3.2 Estimating emission factors

In deriving country-specific emission factors for drivers, Guyana conducted numerous field data collection exercises following the methods prescribed in the 2006 IPCC Guidelines. Field data were collected to estimate forest carbon stocks and establish emission factors for all drivers of deforestation and degradation. Carbon stocks are estimated for all pools (see Table 4 and Table 5) using country-specific data, conversion factors, and allometric model[20]. The allometric model's applicability to Guyana's environment was verified through destructive sampling, validating its applicability and resulting in developing country-specific emission factors that meet IPCC's requirements for Tier 3.

[20] Chave, J, C. Andalo, S. Brown, M.A. Cairns, J.Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J.P. Lescure, B.W. Nelson, H. Ogawa, H. Puig, B. Riera, T. Yamakura. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87-99.

3.2.1 Deforestation

The original deforestation emission factors within the REDD+ MRVS were developed in 2013 and covered only the forested area of the country that was determined to be under the highest threat of conversion. In 2016, emission factors for deforestation were developed for the entire country for all pools,[21] differentiated across six strata based on the potential for change and accessibility. In 2018 and 2019 the stratification under the FCMS was revised, with a new threat analysis conducted to reassess the potential for change and updated road maps used to revise the accessibility classification. New field data were collected based on the updated stratification, and with the addition of these data, the results suggest there was no significant difference between carbon stocks across the strata, and therefore, a single undifferentiated stratum is possible, which is currently applied for deforestation emission factors in Guyana.[22] This is also the main reason for selecting the reference period for this revised FRL.

The emission factor for deforestation in Guyana is calculated as the sum of all carbon stocks from live and dead biomass pools minus the post-deforestation carbon stocks and the change in stocks for the soil carbon pool.

The development of country-specific emissions factors for deforestation in Guyana was done through a combination of spatial data and those collected in the fields (Petrova, Goslee, Harris, & Brown, 2013). In 2010, methodologies were tested to determine the most appropriate emissions factor, applying Equation 1 that allows for a confident estimation of Guyana's carbon stock, which ultimately contributed to the development of its emissions factors.

Equation 1

$$EF_{deforestation} = \{C_{AGB} + C_{BGB} + C_{DW} + C_{\mathrm{LT}} + C_{sap} - C_{post} + [C_{soil} - (C_{soil} \times F_{LU} \times F_{MG} \times F_I)]\} \times \frac{44}{12}$$

Where:

$EF_{deforestation}$	= Emission factor for deforestation; t CO_2 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}
C_{DW}	= Carbon stock in dead wood pools (standing and lying); t C ha^{-1}
C_{LT}	= Carbon stock in the litter pool; t C ha^{-1}
C_{sap}	= Carbon stock in saplings; t C ha^{-1}
C_{post}	= Biomass carbon stocks following deforestation; t C ha^{-1}
C_{soil}	= Carbon stock in soil organic matter pool (to 30 cm); t C ha^{-1}
F_{LU}	= Stock change factor for land-use systems for a particular land-use, dimensionless
F_{MG}	= Stock change factor for management regime, dimensionless
F_I	= Stock change factor for input of organic matter, dimensionless

3.2.1.1 Change in soil carbon

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 (2006).[23] For

[21] Goslee, K. and S. Brown. 2016. Forest Carbon Monitoring System: Emission Factors and their Uncertainties, Version 3. Submitted by Winrock International to the Guyana Forestry Commission.
[22] Winrock International. 2019 Forest Stratification Report. Submitted to the Guyana Forestry Commission.
[23] IPCC (2006). Guidelines for National Greenhouse Gas Inventories. Volume 4, Agriculture, Forestry and Other Land Use.

simplicity in accounting, we assume the full emission of soil carbon in the year of clearing rather than dividing the emissions over 20 years (the default period suggested by IPCC 2006). The changes in soil carbon by each driver are given in Table 7. This equation incorporates initial carbon stock, specific land use, land management, and soil inputs. Soil carbon stocks are highly variable as shown by the high uncertainty of 18.7% of the mean at the 95% confidence level.

Table 7. Values for stock change factors for soil carbon by activity based on IPCC, 2006, and final change in soil carbon as calculated for Guyana. The 95% CI as a percent of the mean is for sampling error only.

	C stock (t C/ha)	90% CI	F_{LU}	F_{MG}	F_I	C stock at 20 yr (t C/ha)	Change in Soil C (t C/ha)
Conversion to permanent agriculture	58.7	18.7%	0.48	1.00	1.00	28.18	30.53
Mining			0.82	1.00	0.92	44.29	14.42
Infrastructure and settlements			0.82	1.00	0.92	44.29	14.42
shifting cultivation			0.65	1.00	1.00	38.16	20.55

3.2.1.2 Post-Deforestation Carbon Stocks

Most of the drivers of deforestation in Guyana – mining, agriculture, infrastructure, and settlements – are assumed to result in the complete removal of all vegetation. Shifting cultivation is the one deforestation activity that has long-term post-deforestation carbon stocks. Based on an analysis of existing literature,[24] these stocks are estimated to be 6.1 tC/ha on average across the cycle of planting and fallow on lands under shifting agriculture in Guyana. This value is subtracted from the carbon stocks to develop the emission factor for deforestation from shifting cultivation.

3.2.1.3 Fire

Emissions from fire (biomass burning) are estimated differently than other activities, as they entail both a loss of carbon in tree removal and the emission of other greenhouse gases during combustion. Thus, the emission factor for deforestation from fire is estimated using Equation 2 (equation 2.27 in Chapter 2 of Volume 4 of the 2006 IPCC Guidelines).[25]

Equation 2 Estimating Biomass Burning

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG: CO2, CH4, N2O

A = area burnt, ha

M_B = mass of fuel available for combustion, tones ha^{-1}; this includes biomass, ground litter and dead wood.

C_f = combustion factor, dimensionless; in Guyana, 0.5 is used based on IPCC defaults.

[24] See Recommendations Paper: Shifting Cultivation and REDD+ in Guyana, Winrock International for the Guyana Forestry Commission, September 2019.

[25] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf

G_{ef} = emission factor, g kg^{-1} dry matter burnt. The following IPCC default values are used in Guyana:
CO_2: 1.580 tonn per t dry matter burnt
CH_4: 0.0068 tonn per t dry matter burnt
N_2O: 0.0002 tonn per t dry matter burnt

3.2.2 Degradation

Details of the forest degradation accounting approaches are given in Winrock 2020.[26] The emission factors developed in 2013 included only factors for forest degradation associated with selective logging, updated in 2016. In 2019 and 2020, additional data collection and analyses were conducted to develop emission factors for sources of forest degradation other than logging, which include mining, infrastructure, and biomass burning.

3.2.2.1 Selective Logging

The emission factors for forest degradation associated with timber harvest in Guyana associate total biomass carbon damaged (and thus carbon emissions) with the volume of timber extracted, based on the method described in Pearson et al.[27]

Emission factors for selective logging are developed in relation to the volume of timber extracted (in m^3 over bark). Factors have been created linking extracted volume with 1) biomass of extracted boles; 2) non-merchantable biomass of felled trees (top and stump); 3) collateral damage; and 4) damage from skid trails left as dead wood in the forest.[28]This method allows for the estimation of the total emissions generated by selective across Guyana, implemented by:

1. Measuring, within a sample of logging gaps, the extracted volume and carbon in the timber tree and the incidental damage to surrounding trees.
2. Estimating the carbon impact caused by the construction of skid trails. (Note that emissions from log roads and decks are estimated as deforestation.)

Estimating the total impact of selective logging on carbon stocks involves quantifying the following components:

- Emissions from volume removed in the commercial tree felled
- Emissions from dead wood created as a result of tree felling
- Emissions from damage by logging infrastructure

Carbon loss or change in live and dead biomass between the "before-logging" and "after-logging" scenario is a result of the felling of the timber tree, extraction of timber volume, the damage caused to residual trees from the logging activities, and the extraction of trees due to construction of skid trails, estimated using Equation 3.

[26] Winrock. October 2020. Accounting for GHG Emissions from Forest Degradation in Guyana. Developed for Guyana Forestry Commission.
[27] Pearson, TRH, S Brown, and FM Casarim. 2014. Carbon emissions from tropical forest degradation caused by logging. Environ, Res. Lett 9 034017 (11 pp) doi:10.1088/1748-9326/9/3/034017
[28] Goslee, K., S. Brown, and F. Casarim, 2016. Forest Carbon Monitoring System: Emission Factors and their Uncertainties, Version 3. Submitted by Winrock International to the Guyana Forestry Commission.

Equation 3 Emissions from Logging

$$Emissions, t\ C/yr = [Vol \times WD \times CF] + [Vol \times LDF] + [Len \times LIF]$$

(1) (2) (3)

Where:
Vol = total volume timber over bark extracted ($m^3\ yr^{-1}$)
WD = wood density ($t\ m^{-3}$)
CF = carbon fraction, the proportion of biomass that is carbon (dimensionless)
LDF = logging damage factor—dead biomass left behind in gap from felled tree and collateral damage ($t\ C\ m^{-3}$)
Len = total length of skid trails ($km\ yr^{-1}$)
LIF = logging infrastructure factor—dead biomass caused by construction of skid trails ($t\ C\ km^{-1}$)

Field measurements are collected from logging plots to quantify components (1) and (2) in Equation 3, to quantify the biomass carbon that is damaged and dead as a result of constructing the skid trails (component 3), measurements of the average width of skid trails and the forest carbon stocks damaged during the construction of trails are made.

Because of the need to collect data at plots located exactly where a tree has been felled, it is impossible to establish completely random plots across Guyana. Rather, plots are located at sites of recently felled trees in concessions, and the volume and biomass removed in commercial logs are determined. In addition, for the measurement of damage that results from tree felling, it is not possible to establish a set plot size. Instead, one or more felled trees that create one gap define a "logging plot," and it is necessary to identify and measure all of the surrounding trees damaged during the felling in a given gap. In this way, it is possible to calculate carbon emissions per unit of volume extracted from commercial trees.[29]

3.2.2.2 Degradation resulting from mining and infrastructure

Forest degradation around mines and infrastructure are forms of "forest edge degradation."[30] Brown et al[31] assessed 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 commensurate 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 an emission factor that is applied to the buffer zone around mining deforestation.

No analysis has been conducted to date, specifically on forest degradation surrounding infrastructure. However, the emission factor for mining is applied and is considered to be conservative, as, unlike mining, there are no resident populations around new infrastructure.

[29] Further details of all field measurements and analyses are given in are given in Guyana Forestry Commission. 2021. Standard Operating Procedures for the Forest Carbon Monitoring System of Guyana. Winrock International; and Casarim F., K. Goslee, and S. Brown, 2014. User Manual for Calculating Emission Factors with Guyana's Selective Logging Tool. Submitted by Winrock International to the Guyana Forestry Commission.
[30] Goslee, K.M.; Pearson, T.R.H.; Bernal, B.; Simon, S.L.; Sukhdeo, H. Comprehensive Accounting for REDD+ Programs: A Pragmatic Approach as Exemplified in Guyana. Forests 2020, 11, 1265.
[31] Brown, S.; Mahmood, A.R.J.; Goslee, K.M.; Pearson, T.R.H.; Sukhdeo, H.; Donoghue, D.N.M.; Watt, P. Accounting for Greenhouse Gas Emissions from Forest Edge Degradation: Gold Mining in Guyana as a Case Study. Forests 2020, 11, 1307.

4. Historical Emissions and Removals

This section includes the new historical data used to derive the revised FRL.

4.0 Deforestation

4.0.1 Activity Data

The activity data for all drivers of deforestation from 2018 to 2022 are provided in Table 8. This includes the addition of Settlements, Fire-Biomass burning, and Shifting Cultivation, which will be included in the FRL going forward. Figure 3 Illustrate the annual deforestation per year while Figure 4 depicts the application of area change over time.

Table 8. Deforestation activity data by driver

Driver	2018	2019	2020	2021	2022
	hectares				
Forestry infrastructure	356	226	195	228	155.6
Agriculture	512	246	489	216	281.6
Mining	7,624	5,821	6,452	6,825	5,264.3
Infrastructure	67	52	102	117	110.6
Settlements	7	22	60	105	169.4
Fire-Biomass burning	661	6,371	2,933	139	332.9
Shifting Cultivation	436	431	554	393	155.5
Deforestation	**9,227**	**13,169**	**10,786**	**8,023**	**6,470**

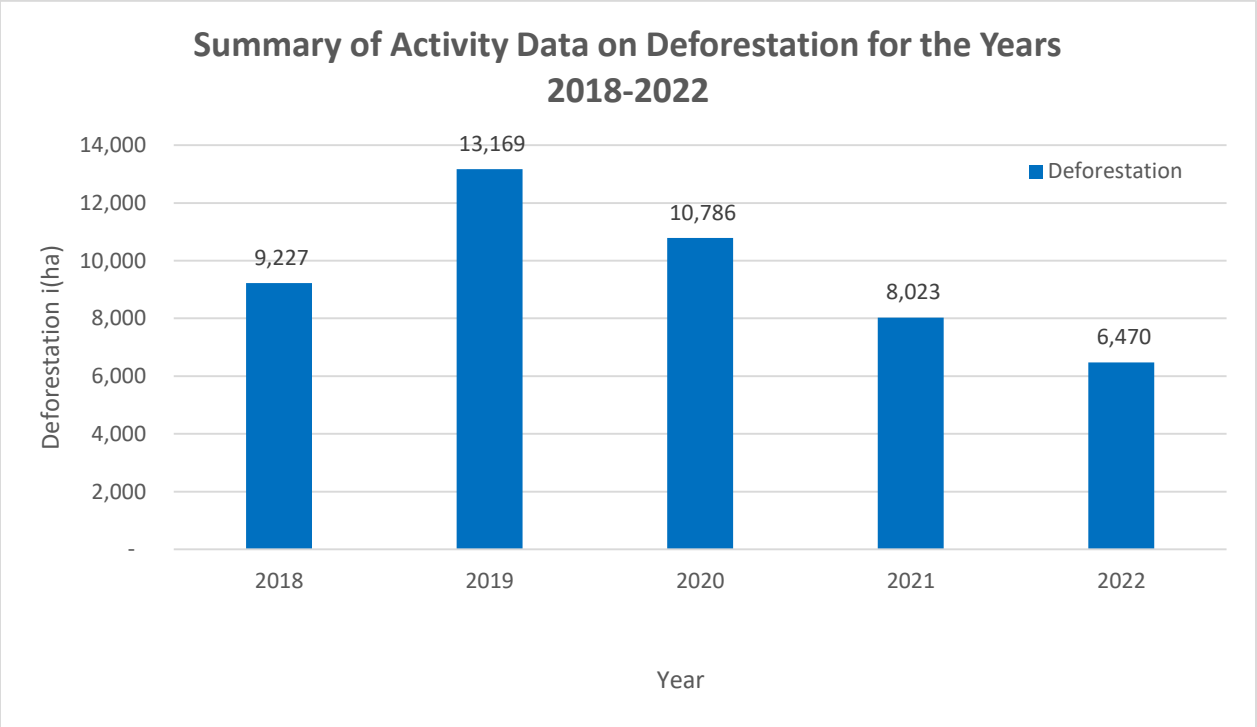

Figure 3 Graph Showing Summary of Activity Data on Deforestation for 2018-2022

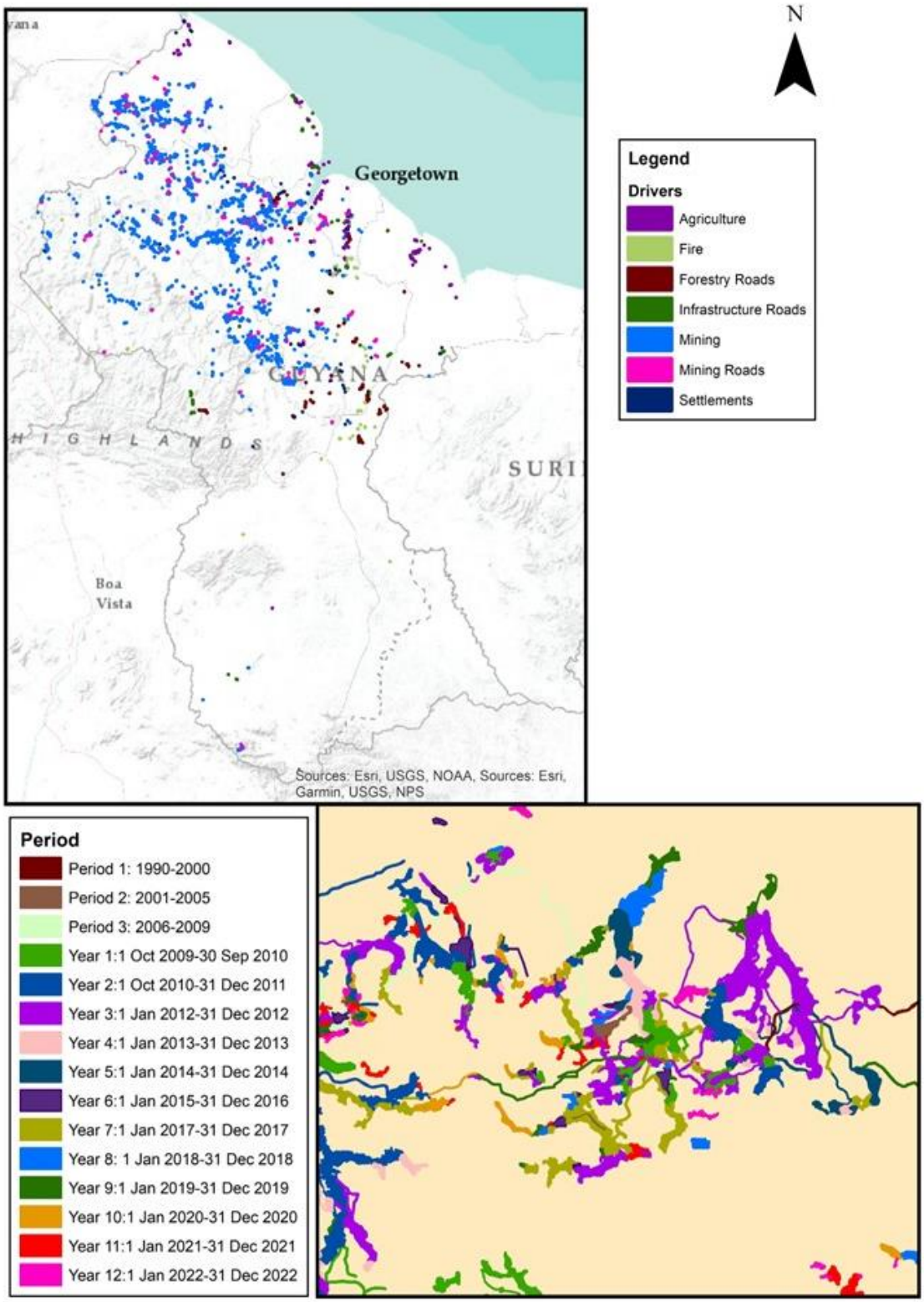

Figure 4 Area Change Map

4.0.2 Emission Factors

Because the country has only one stratum, there is now a single biomass carbon stock. The final country-wide forest biomass carbon stocks across all pools are 272.3 t C/ha without soil carbon and 331 t C/ha with soil carbon (Table 9).

Using the total forest area at the end of 2022 of **17,840,520** hectares and applying the forest carbon biomass of all carbon pools, Guyana's forest carbon stocks, including soil are **21,652,444 tCO_2**[32]

The emission factors for Guyana are net of post-deforestation carbon stocks where such stocks differ significantly from zero (true only where shifting cultivation is the post-deforestation land use). Table 10 lists Gyana's final emission factors and their associated combined uncertainties at 95% confidence interval (CI) and is based on simple error propagation and represents the sampling error only.

Table 9. Country-wide Forest carbon stocks by pool for all forests in Guyana.

AG Tree (t C/ha)	BG Tree (t C/ha)	Saplings (t C/ha)	Standing Dead Wood (t C/ha)	Lying Dead Wood (t C/ha)	Litter (t C/ha)	**Sum Carbon Pools without Soil (t C/ha)**	Soil Carbon (t C/ha)	**Sum Carbon Pools with Soil (t C/ha)**	Number of plots	90% CI as a % of mean
205.8	48.3	3.7	2.6	8.6	3.3	272.3	58.7	331	118	4.3%
						Total CO_2: 998.46		**Total CO_2:** 1,213.7		

Table 10. Deforestation emission factors by activity, with uncertainty based on simple error propagation and representing sampling error only

Drivers	**EF (t CO_2e ha^{-1})**	**Uncertainty (90% confidence interval as % of the mean value)**
Forestry infrastructure	1,051.3	4.8%
Agriculture	1,110.4	4.8%
Mining	1,051.3	4.8%
Infrastructure	1,051.3	4.8%
Settlements	1,051.3	4.8%
Fires	1,053.0	4.8%
Pioneer shifting cultivation	1,106.0	4.8%

[32] Computed by total hectares of forest at end of 2022 multiplied by total carbon stock taken to CO2 equivalent by 0.1 percent: (17,840,520 * 331*(44/12)*0.001)

4.0.3 Historical Emissions

The activity data and deforestation emission factors were combined to estimate the historical emissions for 2018-2022 as provided in Table 11.

Table 11. Total emissions for deforestation by driver from 2018 to 2022

Driver	2018	2019	2020	2021	2022
	tCO_2				
Forestry infrastructure	374,273	237,600	205,521	239,703	163,551
Agriculture	568,523	273,158	542,943	239,846	312,712
Mining	8,015,329	6,119,784	6,783,276	7,175,318	5,534,470
Infrastructure	70,439	54,669	107,744	123,005	116,233
Settlements	7,359	23,129	62,971	110,390	178,107
Fire-Biomass burning	696,018	6,708,516	3,088,387	146,364	350,543
Shifting Cultivation	482,266	476,920	613,138	434,639	171,976
Deforestation	**10,214,207**	**13,893,776**	**11,403,980**	**8,469,264**	**6,827,592**

4.2 Degradation

4.2.1 Activity Data

Annual activity data for degradation by driver for the period 2018-2022 are provided in Table 12

Table 12. Degradation activity data by driver

Driver	2018	2019	2020	2021	2022
	hectares				
Logging - volume harvested (m^3)	546,242	521,172	545,355	547,516	622,643
Logging - skid trail length (km)	2,065	1,971	2,062	2,070	2,354
Mining and Infrastructure (ha)	28,185	23,028	22,795	26,651	18,417

4.2.2 Emission Factors

Emission factors for selective logging and forest edge degradation are provided in Table 13.

Table 13. Degradation emission factors by activity

Drivers	EF
Selective logging	
Wood density (t m^{-3})	1.47
Carbon fraction (dimensionless)	0.5
Logging damage factor, LDF (t CO_2 m^{-3})	3.85
Logging infrastructure factor, LIF (t CO_2 m^{-3})	171.8
Forest edge degradation	
Mining and infrastructure (t CO_2 ha^{-1})	8.1

4.2.3 Historical Emissions

The activity data and degradation emission factors were combined to provide estimates of the historical emissions for the period 2018 to 2022, as provided in Table 14.

Table 14. Total emissions for degradation from 2018 to 2022, by driver

Driver	2018	2019	2020	2021	2022
	tCO_2				
Logging (includes both legal and illegal volume and skid trails)	3,259,093	3,109,512	3,253,797	3,266,693	3,714,932
Mining and Infrastructure	227,362	185,756	183,877	214,982	148,565

4.3 Total Emissions

Table 15 and Figure 5, show the total emissions from both deforestation and forest degradation from 2018 to 2022.

Table 15 Total emissions for deforestation and degradation

	2018	2019	2020	2021	2022
	Million tCO_2				
Deforestation	10.20	13.89	11.40	8.47	6.83
Degradation	3.49	3.30	3.44	3.48	3.86
Total	**13.70**	**17.19**	**14.84**	**11.95**	**10.69**
AVERAGE	**13.67**				

Emissions include both aboveground and belowground emissions (soil carbon emissions).

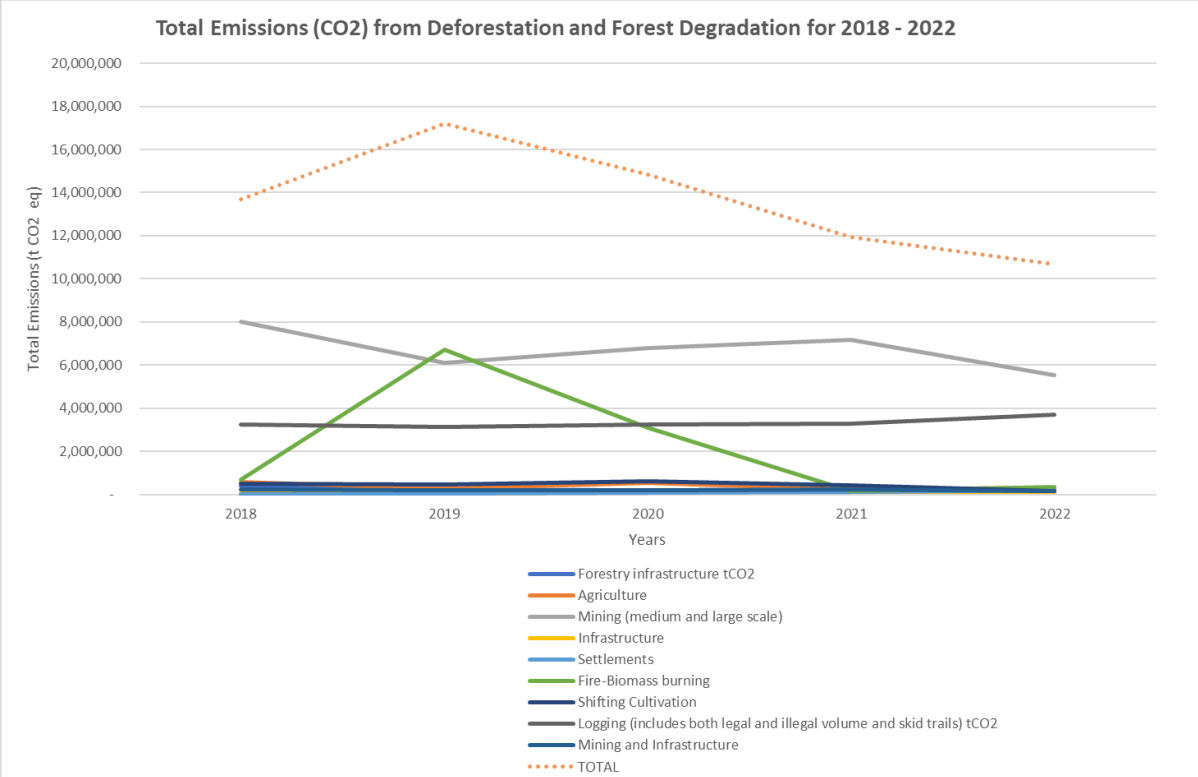

Figure 5 Total annual emissions for deforestation and degradation for Year 2018 to 2022

4.4 Removals

As shown in Figure 6, GHG emissions are strongly influenced by Guyana's management of its extensive national forest cover and the consequent absorption of CO_2 from the atmosphere. Over the reference period of this FRL, Guyana has maintained a vast net carbon sink, with a negative emission level, surpassing -130 Mg of CO_2-eq per annum from 1990 to 2022. To include removals from forests remaining forests, country-specific annual increments over 20 years were utilized (1993 to 2013). Country-specific growth increments were referenced from Roopsind et al., 2018:

Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity, 2017[33].

[33] Roopsind A, Caughlin TT, van der Hout P, Arets E, Putz FE. ***Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity***. Glob Chang Biol. 2018 Jul;24(7):2862-2874. doi: 10.1111/gcb.14155. Epub 2018 May 22. PMID: 29603495. (Available at: https://pubmed.ncbi.nlm.nih.gov/29603495/)

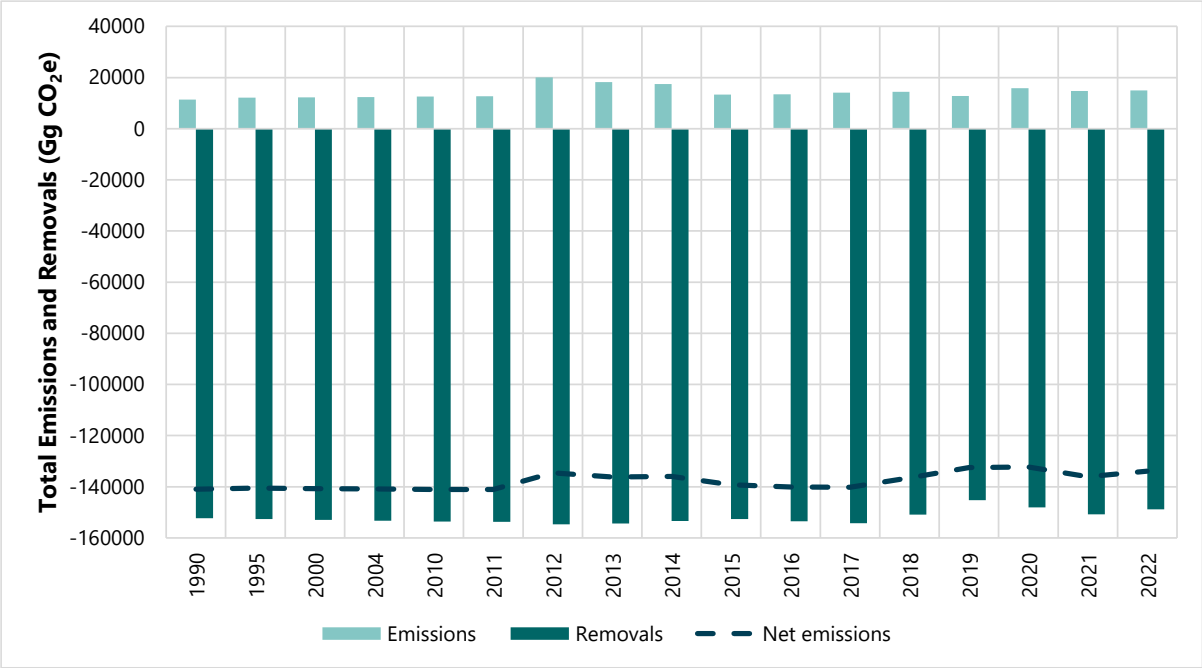

Figure 6 GHG emissions and removals of Guyana – 1990-2022.

Removals data are country-specific information as set out in Roopsind A, Caughlin TT, van der Hout P, Arets E, Putz FE (2018). The ***Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity. Glob Change Biol. 2018;24:2862–2874***.[34] This Study examines data over a data span of 20 years from a long-term study in Central Guyana (5_020N,58_370W) established in 1993 by Van der Hout (1999) under the Tropenbos-International Sustainable Forest Management and Conservation Research Program (http://www.tropenbos.org/). All plots were first censused in 1993 (pre-logging) and then the 12 experimental harvest units were logged in 1994. Plots were re-censused approximately 1 (1995), 3 (1997), 6 (2000), and 20 years (2013) after logging in 1994; and 1 (1997), 4 (2000), and 17 years later (2013).

Roopsind *(2018) measures the average gross periodic annual increment of unlogged forest and records this as 2.34 t CO per hectare, while logged forests record a higher rate of carbon sequestration of up to 2.88 t CO* per hectare as seen in Figure 7. The removal area only includes aboveground carbon.

[34] See full article at: https://doi.org/10.1111/gcb.14155

Silvicultural treatment	Gross PAI of aboveground carbon (Mg C ha^{-1} $year^{-1}$; *SE*)	Net PAI of aboveground carbon (Mg C ha^{-1} $year^{-1}$; *SE*)
RIL—Low	2.11 (±0.32)	0.13 (±0.42)
RIL—Moderate	2.78 (±0.78)	1.09 (±1.02)
RIL—High	2.88 (±0.55)	1.04 (±0.65)
RIL—Moderate + liberation	3.54 (±0.63)	1.69 (±0.88)
Control (unlogged)	2.34 (±0.57)	1.02 (±0.87)

Figure 7 Removal Factors

Published in Wiley's Global Change Biology: Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity, 2017 Journal Article, the average gross periodic annual increment (Table 16) of unlogged forest is 2.34tCO per hectare, with logged forests recording a higher rate of carbon sequestration of up to 2.88tCO per hectare.

Table 16 Unlogged Forest

Land Management Category	**Description of Activity in Area**	**Size (in Hectares)**	**Area Included in Removals Calculations (in Hectares)**	**Factor (tCO/ha)**
State Forest	Timber Harvesting Area	6,257,000	Included - factor from Roopsind 2017.	2.34
	Mining Area	1,113,000	Included using IPCC factor	0.47
	Unallocated forest area/conservation area	4,780,000	Included using IPCC Factor	0.47
State Lands	Agriculture activities	2,442,000	Included - factor from Roopsind 2017.	2.34
Protected Areas	Limited to no extraction/use	1,091,000	Included using IPCC factor	0.47
Amerindian Lands	Subsistence forestry activities	2,300,000	Included - factor from Roopsind 2017.	2.34

Source: Land Cover classes informed from Guyana's MRVS Year 2022 report (Table 2-1)

To reflect a conservative approach, Guyana applies a tiered approach based on disturbed and undisturbed forests, informed by the land management categories below

This enables the calculation of the annual carbon sequestration of Guyana's forest, computed by the size of the forest in the year 2022, multiplied by the rate of carbon sequestration per hectare converted to CO_2 as:

10,999,000 hectares X (2.34tCO X 3.67[35]) = 94,457,212tCO2 per year
Plus
7,001,000 hectares X (0.47tCO X 3.67) = 12,076,024.9tCO2 per year

TOTAL = 106,533,237tCO2 per year

[35] Conversion factor of carbon to carbon dioxide equivalent.

5. Guyana's Revised Reference Level

Development is ongoing in Guyana, and like all countries, Guyana needs to sustain its economy and safeguard the livelihoods of its citizens. To date, Guyana has not experienced an increase in deforestation and degradation due in large part to its ability to continually advance the sustainable management of its forests, building on results-based payments under Guyana's bilateral agreement with Norway, a robust national forest monitoring system and a national FRL that has included both deforestation and degradation. However, as a developing country largely dependent on extractive activities for its economy, emissions from land use in Guyana stand to increase without continued efforts to maintain current low levels of deforestation and forest degradation, and high levels of removals.

The country continues to experience economic pressure to realize value from forest resources including timber, sub-surface minerals, and agricultural development. Mining is a critical component of Guyana's economy, contributing 15.0% to the nation's annual GDP in 2019.[36] In addition to its well-known deposits of gold, bauxite, and diamonds, Guyana's mineral heritage includes deposits of semi-precious stones, kaolin, silica sand, soap stone, kyanite, feldspar, mica, ilmenite, laterite, manganese, copper, molybdenum, tungsten, iron, and nickel, among others. In the last five (5) years, discoveries of lithium, manganese, and coltan have led companies to consider investing in mining operations. A detailed mineral mapping exercise is planned for national scale assessment of all deposits. In addition to the national significance of these resources, the importance of several aspects of Guyana's mineral deposits, such as lithium to the global energy transition towards clean and renewable energy is highlighted. Meanwhile, agriculture contributed 17.6% to the country's GDP, which includes forestry (1.3%). In 2019, gold represented 56% of the country's total export revenue, while bauxite represented 8%, and timber represented 2.1%.

For Guyana to maintain its low level of deforestation, it is necessary for continueal investment in the sustainable management of forests as well as the creation of broader incentives to alleviate the need for future development activities that will increase forest degradation and conversion of forest lands.

Guyana's specific approach to creating these incentives is set out in Guyana's Low Carbon Development Strategy 2030.[37]

5.1 Background to Guyana's Revised Reference Level

Guyana's original submission dated September 2015, utilized the Combined Reference Level. The Combined Reference is developed by averaging the rate of pan-tropical forest loss with the annual rate of Guyana's forest loss. This average rate is then applied to the total current carbon stocks to develop the combined reference level in CO_2. While there are multiple options for an estimate of pan-tropical forest loss, Hansen *et al.* is the most up-to-date source and is based on high-resolution data from 151 countries located between 30 degrees north and 30 degrees south. This model was applied under the Guyana-Norway Bilateral Cooperation on Climate and Forests.

[36] Guyana bureau of statistics; Note that this is expected to shift significantly as Guyana begins to realize oil revenues from offshore drilling that began in 2020. These revenues are anticipated to increase Guyana's overall GDP and reduce the percent of the GDP taken by gold and bauxite.
[37] https://lcds.gov.gy/wp-content/uploads/2022/08/Guyanas-Low-Carbon-Development-Strategy-2030.pdf

Like the predecessor, this FRL is developed at the National scale, includes a detailed and robust analysis of historical emissions from known drivers of deforestation and forest degradation, as well as a detailed analysis of removals, and includes the following:

- The key drivers of deforestation include conversion to agriculture, mineral extraction, and infrastructure expansion (mining and logging roads);
- Degradation from timber production, representing a source of emissions;
- Degradation from mining and infrastructure, representing a source of emissions;
- Removals as determined by country-specific information determined over a data span of 20 years from a long-term study established in 1993.

Furthermore:

- Forests are defined as having a minimum area of land of 1 ha with tree crown cover (or equivalent stocking level) of more than 30% with the potential to reach a minimum height of 5 m at maturity in situ;
- All five IPCC-recognized carbon pools are included, and the key GHG selected is CO_2; N_2O and CH_4;
- The historic period selected is from 2018 to 2022;
- The collection and analysis of activity data (AD) and field data on forest carbon stocks are consistent with good practice in that they neither over- nor under-estimated as far as can be judged, and
- All data are at Tiers 2 and 3 for the following reasons:
    - Wall-to-wall coverage of satellite imagery is used to obtain the activity data related to the conversion of forest lands to other uses, and such data are combined and co-registered with other key spatial databases in a Geographic Information System (GIS) such as roads, rivers, settlements, vegetation class, location of logging concessions, location of mining concessions, and topography.
    - A comprehensive, peer-reviewed field sampling system was designed and implemented to attain a required precision target of a 95% confidence interval of <+/-15% of the mean total carbon stock of Guyana's forests.

Parameters	FRL (2015)	Current FRL (2024)
IPCC Guidelines	2006 IPCC Guidelines	2006 IPCC Guidelines
REDD+ Activities	Reduction from deforestation and forest degradation	Reduction from deforestation and forest degradation
Forest Definition	30% canopy cover, >1ha, >5m in situ	30% canopy cover, >1ha, >5m in situ
Carbon Pools	-Aboveground -Belowground biomass -Deadwood included in degradation from timber harvest only.	-Aboveground biomass -Belowground biomass -Deadwood -Litter -Soils Carbon
Gas	CO_2	CO_2 , N_2O and CH_4
Deforestation Drivers	-Forestry infrastructure -Agriculture -Mining (medium and large scale) -Infrastructure	-Forestry infrastructure -Agriculture -Mining (medium and large scale) -Settlement -Infrastructure

		-Biomass Burning -Shifting Cultivation
Degradation Drivers	-Logging volume harvested	-Logging volume harvested -Mining infrastructure
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 -Low Potential for Change More Accessible Area -Low Potential for Change Less Accessible Area	Combined Single Stratum. The methods applied across all strata remain unchanged. Additional data was collected and added to the data sets.
Activity Data	Disaggregated by deforestation and forest degradation drivers by stratum	Disaggregated by deforestation and forest degradation drivers
Spatial Mapping	1ha minimum mapping unit	1ha minimum mapping unit
Emissions Factor	Developed by stratum (Tier 2).	Combine emissions factor (Tier 2).
Data Source	GFC Annual MRV Reports	-GFC Annual MRV Reports -Verification Reports

Establishment of FRL for 2023-2030

Guyana's FRLs are inclusive of all five components of REDD+ as set out in the Warsaw Framework, and therefore, Guyana's FRL incorporates the key contributions Guyana's forests make to REDD+ and global climate action based on increased capacity and improved data since the original FRL wad determined in 2014:

Conservation: The estimated forest biomass carbon stocks across all pools is 272.3 t C/ha without soil carbon and 331 t C/ha with soil carbon. At the end of 2022, Guyana's forest is estimated to be **17,840,520 hectares**, with a storage capacity of **21,652,444 tCO_2,** including soil carbon.

Emissions from Deforestation and Degradation: Guyana's average emissions from 2018 to 2022 were estimated at 13.67 million tons of CO_2, 0.08% of total carbon stocks, with a maximum of 17.2 million tons CO_2 in 2019 and a minimum of 10.69 million tons CO_2 in 2022. These emissions are very low by global standards, because Guyana's approach to sustainable management of forests has resulted the long-term historical deforestation in Guyana being very low over the whole country – and is one of the lowest in the world.

Removals: As shown in **Error! Reference source not found.** , GHG emissions are strongly influenced b y Guyana's sustainable management of its extensive national forest cover, and the consequent absorption of CO_2 from the atmosphere. Over the reference period of this FRL, Guyana has maintained a vast net carbon sink, with a negative emission level, surpassing -130 Mg of CO2-eq per annum for

the entire period from 1990 to 2022. To calculate removals from forests remaining forests, country-specific annual increments over 20 years were utilized (1993 to 2013). Country-specific growth increments were referenced from Roopsind et al., 2018: Trade-offs between carbon stocks and timber recovery in tropical forests are mediated by logging intensity.

Roopsind et al., 2018, form the baseline for estimating removals in Guyana, estimated at 106,533,237 tCO_2.

Therefore Guyana's Reference Level is as summarised in the following table:

Element of REDD+	**Calculation (Annual)**	**Contribution to RL for Generation of Results (Annual)**
Emissions from Deforestation and Forest Degradation	Historical Emissions	13,674,678 tCO2e
Annual Emissions Reductions from sustainable management of forests and conservation	0.1% of Forest Carbon Stock, based on World Bank's FCPF methodology.	**21,652,444** tCO2e
Annual Removals from sustainable management of forests and conservation	From National Specific 20-year Study 106,533,237	106,533,237 tCO2e
TOTAL (Annual)		**141,860,359** tCO2e

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