The Republic of Suriname

2nd REDD+ TECHNICAL ANNEX

to first Biennial Update Report of Results achieved by Suriname from Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation for REDD+ Results-based Payments 2020 and 2021

Author:

Foundation for Forest Management and Production Control

In Dutch: Stichting voor Bosbeheer en Bostoezicht (SBB)

Martin Luther Kingweg perc. 283

Paramaribo, Suriname

http://sbbsur.com/

Citation:

Government of Suriname (2022). *REDD+ TECHNICAL ANNEX to first Biennial Update Report of Suriname. Results achieved by Suriname from Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation for REDD+ Results-based Payments 2020 and 2020.* Paramaribo, Suriname.

[1] Cover photo: https://planetofhotels.com/guide/es/surinam

CONTENTS

REDD+ TECHNICAL ANNEX

Contents

List of Figures

List of Tables

CONTRIBUTORS

REDD+ Technical Annex development team (SBB Department for Research and Development):

- Cindyrella Kasanpawiro, Measurement Reporting and Verification (MRV) coordinator
- Consuela Paloeng, NFMS Technical Assistant
- Valentien Moe Soe Let, Remote Sensing and GIS team leader
- Sarah Crabbe, National Forest Monitoring System (NFMS) Coordinator
- Rene Somopawiro, Director of Research and Development

Supporting group for the REDD+ Technical Annex:

- Coalition for Rainforest Nations

[2] https://twitter.com/CopaAirlines/status/1478432200789999620/photo/1

LIST OF ABBREVIATIONS AND ACRONYMS

AAC	Annual Allowable Cut
AAE	Asesoramiento Ambiental Estratégico / Strategic Environmental Advice
ACT	Amazon Conservation Team
ACTO	Amazon Cooperation Treaty Organization
AD	Activity data
AdeKUS	Anton de Kom University of Suriname
AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above-Ground Biomass
ASGM	Artisanal Small Scale Gold Mining
BFAST	Break detection For Additive Seasonal Trends
BGB	Below-Ground Biomass
C	Carbon
CATIE	Tropical Agricultural Research and Higher Education Center
CBD	Convention on Biological Diversity
CBM	Community-based monitoring
CELOS	Centre for Agricultural Research in Suriname
CH4	Methane
CHS	CELOS Harvesting System
CI	Confidence Interval
CI	Conservation International
cm	Centimeter
CMRV	Community Measurement, Reporting and Verification

[3] Photo: https://pixabay.com/photos/lotus-flower-flora-pink-botany-484497/

CO_2	Carbon dioxide
COP	Conference of the Parties (UNFCCC)
CSNR	Central Suriname Nature Reserve
D	Diameter (lianas)
dbh	Diameter in breast height
DDFDB+	Drivers of Deforestation, Forest Degradation and Barriers to REDD+ activities
DOM	Dead Organic Matter
DW	Dead Wood
E	Emission
EF	Emission Factors
EITI	Extractive Industries Transparency Initiative
ELE	Extracted Log Emissions
eq	Equivalent
et al.	And others (et alia)
FAO	Food and Agriculture Organization of the United Nations
FCMU	Forest Cover Monitoring Unit
FCPF	Forest Carbon Partnership Facility
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
FSC	Forest Stewardship Council
g	Gram
GCCA+	Global Climate Change Alliance
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFOI	Global Forest Observation Initiative
GHG	Greenhouse gas
GIS	Geographic Information System
GMD	Geological Mining Department
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GOS	Government of Suriname
GPG	Good Practice Guidance

ha	Hectare
HFLD	High Forest Low Deforestation
ibid	In the same source as above
ICL	Incidental Cutting License
IDB	Inter-American Development Bank
INDC	Intended Nationally Determined Contribution
INPE	National Institute for Space Research in Brazil
IPCC	Intergovernmental Panel for Climate Change
km	Kilometre
LBB	Lands Bos Beheer / State Forest Service
LDF	Logging Damage Factor
LDW	Lying Dead Wood
LIF	Logging Infrastructure Factor
LULC	Land Use Land Cover
LULUCF	Land Use, Land Use Change and Forestry
m	Metre
Mg	Megagram (= ton)
MI-GLIS	Management Institute for Land Registration and Land Information System
MMU	Minimum Mapping Unit
MRV	Measurement, Reporting and Verification
MTP	Minor Timber Products
MW	MegaWatt
N	North (latitude)
N2O	Nitrous oxide
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NH (Min)	Ministry of Natural Resources
NIMOS	National Institute for Environment and Development in Suriname
NRTM	Near Real Time Monitoring
NSC	Norwegian Space Centre
NTFP	Non-Timber Forest Products
NZCS	National Zoological Collection Suriname

ONF	French Governmental Forestry Service
ONFI	ONF International
PMU	Project Management Unit
QA/QC	Quality Assurance/Quality Control
QGIS	A free and open source GIS software
R2	R square (statistics)
RAC	REDD+ Assistants Collective
REDD+	Reduced Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
RIL	Reduced Impact Logging
RIL-C	Reduced Impact Logging Certification
RO (Min)	Ministry of Regional Development
R-PP	Readiness Preparation Proposal
SBB	Foundation for Forest Management and Production Control
SDW	Standing Dead Wood
SEPAL	System for Earth observations, data access, Processing & Analysis for Land monitoring
SF	Skidtrail Factor
SFM	Sustainable Forest Management
SIS	Safeguards Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SPS	Stichting Planbureau Suriname / National Planning Office
SRD	Surinamese Dollar
SU	Sampling Unit
TBI	Tropenbos International
TEF	Total Emission Factor for forest degradation
TNC	The Nature Conservancy
TNRS	Taxonomic Name Resolution Service
t	Tonnes
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations REDD Programme

US$	United States Dollar
WHRC	Woods Hole Research Center
yr	Year


[4]

Chapter 1. Introduction

1.1 Background

The Conference of the Parties has encouraged developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following 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).

These activities are known as REDD-plus activities and should contribute to the achievement of the objective set out in Article 2 of the Convention, which aims to strengthen the global response to climate change, in the context of sustainable development, which should also contribute to the fulfillment of the commitments set out in Article 4, paragraph 3, of the Convention in relation to the National Determined Contributions proposed by the Party.

Suriname, as a member of the group of the Small Island Developing States (SIDS), is granted full flexibility in the fulfillment of the Paris Agreement and consequently also in the fulfillment of all its rules including transparency. However, Suriname, in its interest to fulfill these commitments, has be focusing efforts aiming at achieving consistency with the objective of environmental integrity, considering the multiple functions of the forests and other ecosystems, and promoting sustainable management in accordance with national development priorities, objectives and sustainable development needs and goals.

Considering all these Decisions and Considerations of the process agreed under the Paris Agreement, Suriname has the honor to present its second REDD+ Technical Annex to the First Biennial Update Report, where the results achieved in 2020 and 2021, after the successful implementation of REDD+ activities at the national level, are reported.

Suriname welcomes the occasion to submit its second Technical Annex to its first Biennial Update Report (BUR) in the context of results-based payments for reducing emissions from deforestation and forest degradation under the United Nations Framework Convention on Climate Change (UNFCCC).

This submission was developed by the Suriname's government with technical support from the Coalition for Rainforest Nations. This document presents the results achieved in reducing emissions and enhancing removals in the context of REDD+ in the country of Suriname during the 2020 and 2021 period, and the progress made in capacity building and generation of more robust data and information to continuously improve Suriname's submission. The country has made its best effort to present all its data and information used in the estimation of anthropogenic forest-related emissions by sources and removals by sinks, forest carbon stocks, and forest carbon stock and forest-area changes, in a transparent, accurate, complete, comparable, and consistent manner,

[4] Photo: https://www.gettyimages.com.mx/

following the basic principles in the 2006 Intergovernmental Panel on Climate Change (IPCC) for the preparation of national greenhouse gas inventories.

1.2 National Circumstances

The forests of Suriname are part of the Amazon and the Guiana Shield region, included in one of the largest blocks of primary tropical rainforest worldwide and marked by high biodiversity levels. These forests provide ecosystem services important on global and local levels, including climate change mitigation, biodiversity preservation, cultural values, livelihoods and food security for communities, while they also contribute to national incomes of countries in the region (Loftus et al., 2013; de Dijn, B., 2018). The country is rather small with an official reported land surface of 163,800 km2. Suriname is located on the north-eastern coast of South America, between 2° and 6° North latitude and 54° and 58° West longitude. It borders French Guiana to the east with the Marowijne River and the Lawa River, Brazil to the south, Guyana to the west with the Corantijn River, and the Atlantic Ocean to the north with a very dynamic coastline resulting in land accretion and decrease. Figure 1 shows the map of Suriname, with the borders used for monitoring purposes and the area of the Forestry belt. Suriname's 15.2 million hectares of forest (SBB, 2021) represent around 0.83% of the total tropical forest (1.8 billion hectare) in the world (FRA/FAO, 2020).

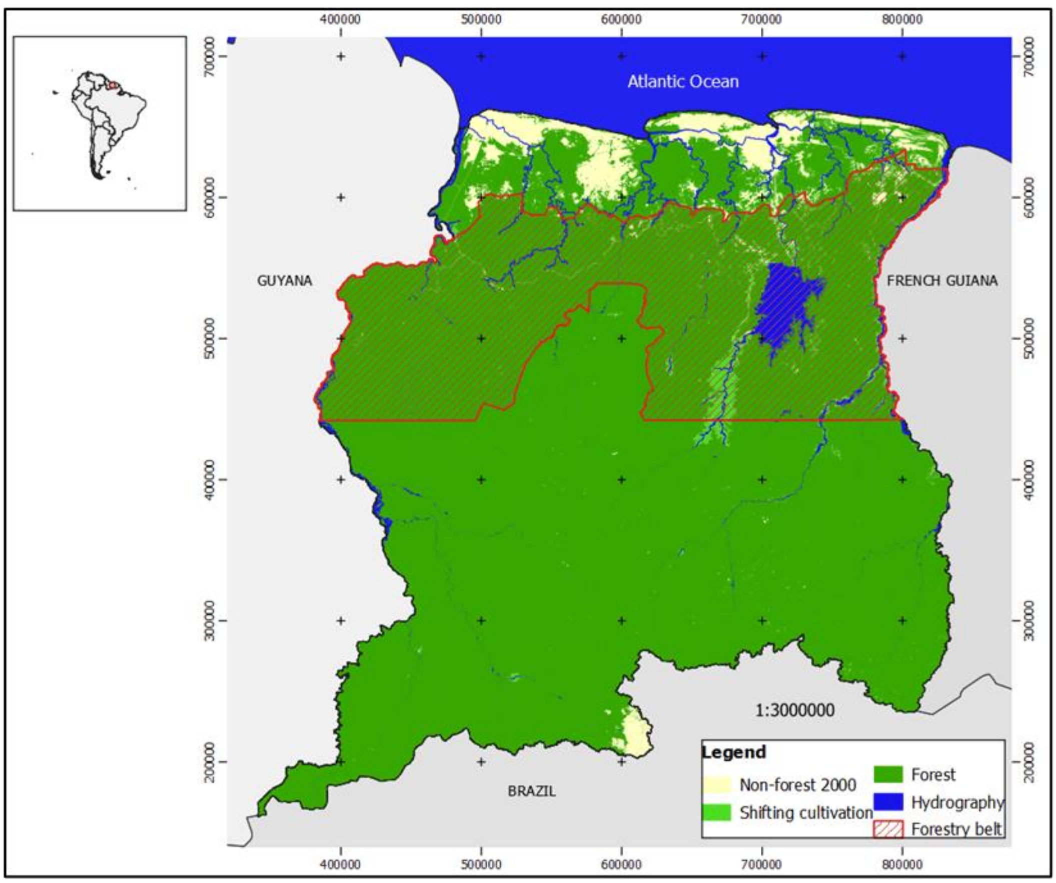

Figure 1. Monitoring area of Suriname with the Forestry belt (Source:SBB)

In terms of conservation, 13.5% of the country's surface is within protected areas (GOS, 2009). Suriname has drafted a new Nature Conservation Law in a participatory process, to enable improved management of its protected areas. This has already been submitted to the parliament with the intention of placing this proposed act on the agenda for the process of approval. This law will replace the Nature Conservation Act of 1954. In line with the UN Convention on Biological Diversity (CBD) Aichi targets It is expected that the area with a protective status will expand to at least 17% of the terrestrial land by 2030 (GOS, 2020a). This will lead to the expansion of the national network of legally protected areas to accomplish 100% representation of all ecosystems and biological species, according to the National Biodiversity Action Plan (Ministry of Labor, Technological Development and Environment, 2013), the National Forest Policy (GOS, 2005) and the Suriname National REDD+ Strategy.

The annual deforestation rate in Suriname was 0.07% for the period 2000-2019. In 2014 a peak in deforestation was observed, with a rate of 0.11%, which decreased after 2014 and remained at a rate between 0.06% and 0.08%. In the period 2020-2021.

The current main driver of deforestation is mining (mainly for gold), especially Artisanal Small-scale Gold Mining (ASGM) which was ca. 98% of all mining activities in 2017 (SBB, 2021). In addition, for the future, several proposed infrastructure projects could cause some unavoidable planned deforestation in the interest of the country's development. The Nassau mining project and the Grankriki hydropower lake are examples of projects with infrastructure activities (GOS, 2017b). However, these plans have not been implemented yet and there seems to be no interest in them at the moment. Suriname intends to keep the status as a HFLD country, but with the ongoing development and plans for the future this seems very challenging. The intention to conditionally remain a HFLD country is reflected by the first HFLD Conference on Climate Finance Mobilization which was hosted by Suriname in February 2019, where the Krutu of Paramaribo Joint Declaration on HFLD Climate Finance Mobilization was established. Furthermore, this is also mentioned in the Nationally Determined Contribution report of 2020 (GOS, 2020a) and is in line with the Suriname National REDD+ Strategy. For this to be possible without hampering national development, adequate compensation for the global climate mitigation service is necessary.

Commercial timber logging in Suriname is considered a contributor to forest degradation but not to deforestation, since only selective logging takes place due to among others the limited number of commercial tree species, the minimum allowed diameter at breast height to be cut and the promotion of sustainable forest management (SFM), including the enforcement of law by the government.

Shifting cultivation is another degradation activity that is considered in this REDD+ Technical Annex. Contrary to the emissions caused by deforestation activities, this activity does not reduce the carbon stock of the area to zero and the emissions are calculated based on the carbon stock before and after the activity has taken place.

Commercial logging activities are taking place only north of the 4° N latitude within the Forestry belt, covering an area of 4.5 million hectares, of which ca. 2.7 million ha are currently issued under timber cutting licenses (www.gonini.org). Logging impacts could be reduced by following Sustainable Forest Management (SFM) guidelines, including the enforcement of the Code of Practice for sustainable logging (including Reduced Impact Logging or Climate Smart Forestry). This national Code of Practice is currently a draft document that needs to be reviewed, updated and finalized, but many SFM requirements are already integrated in official logging requirements. Applying these guidelines enables maintenance of other forest functions such as protection of water and soil, maintenance of biodiversity, carbon sequestration and soil erosion control (Werger et al., 2011).

In the context of preparing the NC3, the SBB as technical working arm of the Ministry of Land Policy and Forest Management (Ministry of GBB) is responsible for the calculation of the emissions from the FOLU sector. The emissions regarding the agriculture sector are being estimated by the Ministry of Agriculture, Livestock and Fishery (Ministry of LVV) through a close collaboration between the two ministries. To ensure that there is consistency among the reporting of emissions from the Forestry and Other Land Uses (FOLU) sector, the definitions used within this REDD+ Technical Annex report have been streamlined with the categories that will be incorporated in the GHG inventory The NC3 is now being finalized and will be submitted by the end of 2022. Furthermore, a national database called Suriname Environmental Statistics Information Network (SMIN), is being created to ensure centralization and availability of old and updated environmental data for policymakers and reporting purposes. As a result of the SMIN a climate change knowledge database has been launched called DONDRU and can be visited on www.dondru.sr.

1.3 Objectives for submitting the REDD+ results

Suriname notes that the submission of its second Technical Annex presenting REDD+ results is voluntary and exclusively for the purpose of obtaining and receiving results-based payments for its REDD+ actions, pursuant to Decision 14.CP.19, paragraphs 7 and 8. This submission therefore does not modify in any way the Nationally Appropriate Mitigation Actions (NAMAs) voluntarily submitted by Suriname, nor does it modify its Nationally Determined Contributions (NDCs) submitted under the Paris Agreement.

This technical annex presents the REDD+ results achieved by Suriname between 2020 and 2021, measured against Second Suriname's technically assessed Forest Reference Level, which was9,237,767 $tCO2_e$. The REDD+ activities that were accounted for in the period 2020 to 2021 include reducing deforestation and reducing forest degradation. The results are derived mainly from actions to enforce forest protection regulations to halt unplanned logging, illegal deforestation, the protection of forest through the identification of new protected areas, monitoring the forest fires and formulating a regional strategy to monitor forest fires, and protection and maintenance of natural regeneration processes in degraded areas.

1.4 Progress with REDD+ Strategy and Actions

The REDD+ Strategy was published in 2019. This consists of four strategic lines, which is further divided in policy lines and measures. The REDD+ Strategy can be viewed at https://redd.unfccc.int/files/national_redd__strategy_of_suriname_en_web.pdf.

Table 1. Table of Strategic lines and progress

Strategic line	Progress
1. Continue being a High Forest cover and Low Deforestation country (HFLD) and receive compensation to invest in economic transition	- Suriname was involved in preparing a joint feedback submission to the ART Secretariat regarding the draft TREES v2., specifically on the HFLD module, together with Guyana and Gabon. - 3 documents have been released in November 2022 to reiterate the importance of the HFLD countries and to get international support to maintain the status of HFLD countries: 1. Whitepaper - Project Preservation (compressed).pdf 2. Project Preservation - Campaign communications toolkit 3. Media release - Scaling of financial incentives urgently needed to preserve last intact forests - FINAL.pdf
2. Forest governance	- The Land Use Land Cover data that is being generated by SBB undergoes a validation process, where all the relevant stakeholders are being involved. Through a working session their feedback and input is gathered to finalize the

	LULC data and increase its accuracy. This process has created an informal platform between SBB and the relevant stakeholders to strengthen the collaboration and trust. - The National Forest Monitoring System (NFMS) is continuously being strengthened and has fully executed the NFMS Roadmap. - Trainings have been given to forest-based communities in sustainable forest management - Currently in the starting phase of reviewing and updating the Code of Practice and further enforce it. - Suriname has drafted a new Nature Conservation Law. This has already been submitted to the parliament with the intention of placing this proposed act on the agenda for the process of approval. - SFISS is being implemented and continuously being improved to monitore logging activities and to trace the origin and legality of all logs - Discussions ongoing to ban export roundwood - The Climate Smart Forestry pilot project is ongoing, which promotes Sustainable Forest Management (SFM)
3. Land use planning	- Continuous update on Gonini geoportal and KOPI statistical portal - Development of a climate change knowledge database called DONDRU - Execution of a Mining project EMSAGS to apply environmental-friendly mining methods - The Min ROM is currently preparing a Spatial Planning Act.
4. Conservation of forests and reforestation as well as research and education to support sustainable development	- Forest guards training has been conducted - Mangrove forest inventory executed - Applying Near Real Time Monitoring to improve promptly monitoring of illegal activities in the protected areas to enable quick response /actions - Formulate and or update management plans for the protected areas - Drafting of a Nature Conservation Law

Chapter 2. Summary Information from the Technically Assessed Forest Reference Level

2.1 The assessed forest reference level

Being the most forested tropical country in the world, Suriname has a history of relatively low emissions related to deforestation and forest degradation. Nevertheless, these emissions have increased over the last few years. Most notable are the increased emissions of forest degradation, which have become similar to those of deforestation since 2018. There are several reasons for this, such as the exponential increase of the roundwood logging production, which now also considers fuel wood production. Degradation emissions are now also including the emissions of shifting cultivation and related non-CO_2 emissions from biomass burning, which was not included in the first FREL. Deforestation emissions have remained relatively constant in the period 2016-2019 which would most likely partially be explained by the stable gold price. Compared to the previous FREL, the yearly historical deforestation emissions decreased due to the implementation of the Chave et al. (2014) allometric equation, following the study of Wortel & Sewdien (2020) showing that the previous carbon stock equation (Chave et al., 2005) overestimated the aboveground carbon stock. The results of the predictive scenario modelling project which considered a national development scenario, indicated that the future deforestation in Suriname would follow a linear trend. This was the basis for using a linear projection for both deforestation and degradation emissions in the first FREL. The first FREL scenario modelling outputs are still relevant as the deforestation rate has remained constant in the last year and the same National Development Plan (2017-2021) is still being implemented, with no concrete details available regarding the next development plan.

For the second FREL, each category of emissions is projected separately in the “FREL Calculation Tool", due to the varying circumstances, resulting in separate emission projections for deforestation, roundwood, fuelwood and shifting cultivation. This gives better insights into the expected emission trends for each activity. The 2024 projection is based on the combined sum of the emission from all activities. All the projections are made using a linear projection method based on the 2000-2019 historical data.

Deforestation emissions

Deforestation emissions have been stable in the period 2016-2019 following the trend of the stable gold price for this period, but the emissions have had an overall rising trend when taking into account the whole 2000-2019 period.

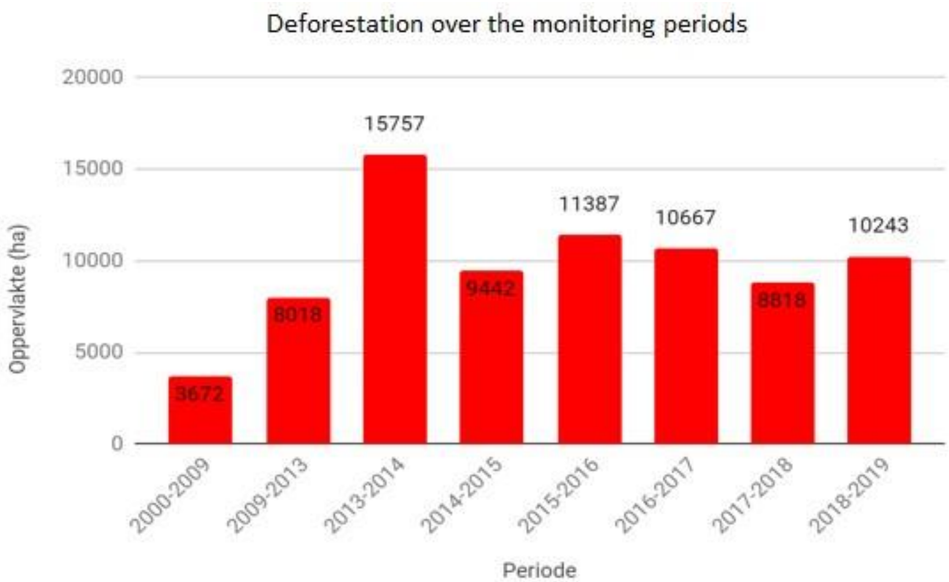

Figure 2. Deforestation over the period 2000-2019

The deforestation rate for the period 2000-2009 was 0.02%, which increased to 0.07% for the period 2009-2019. For 2019 the forest cover was 92.77% (SBB, https://kopi.sbb.sr/).

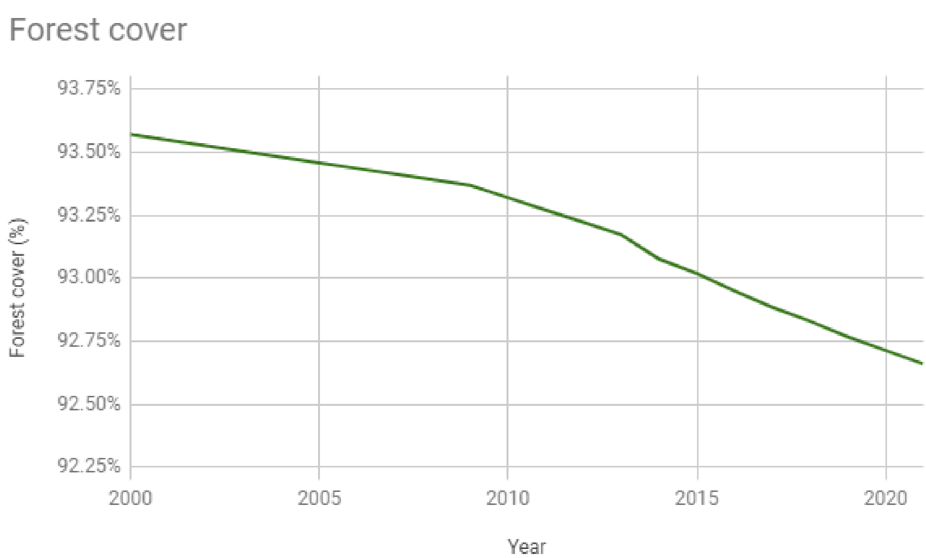

Figure 3. Forest cover trend over the period 2000-2020 (SBB, Kopi)

The main driver of deforestation is mining due to gold mining followed by infrastructure construction in logging areas. The historical data shows a period where the gold price reached its peak (2014) and deforestation showed a sudden rise that year due to the increased mining activities. It was expected that the rise in the gold price since 2019 (reaching its highest peak yet) would likely result in an increase in annual deforestation after 2019.

The 2020 COVID-19 crisis also impacted the economy with many people looking for new sources of income, and it was expected that more people would turn to the mining sector. The gold price also had an overall rising trend for the period 2000-2019, with the deforestation emissions following this trend.

We expected that this trend would continue, which is why a linear projection was used that results in a projected increase of annual deforestation emissions for the years 2020 to 2024 (See equation 5.1).

Equation 1 Linear trend equation for FREL deforestation emissions based on 2000 - 2019 historical data

t CO_2 emissions y-1 = (354,658.94 *year) - 707,990,461.56

Roundwood production emissions

Roundwood production showed a steady increasing trend due to the increased demand of wood on the international market. The increased production has a large impact on the total degradation emissions, especially if no measures are taken to reduce the emissions per produced m³ of timber. Even with the strong increasing trend, the impact of the COVID-19 crisis in 2020 was not expected to go unnoticed in the following years, resulting in a downtrend of the production in the year 2020. After that, it was expected that the production will increase again. The ban on roundwood export in other countries might increase the demand for roundwood on the international timber market, with a possibility that more log traders will purchase roundwood from Suriname.

The production data for 2009 was 206,975.00 m3, which gradually increased to 1,228,700.00 m3 for the year 2019.

Figure 4. Trend industrial roundwood production for the period 2009-2019 (SBB, Kopi)

Even with the expected production decrease due to the COVID-19 crisis, it is not expected that the long term increasing trend will change for the roundwood logging sector, which is why a linear projection is used based on the historical logging data.

Equation 2 Linear trend for FREL roundwood logging emissions

$$t\ CO_2\ \text{emissions y-1} = 251{,}028.52 \quad \text{*year} - 502{,}470{,}907.72$$

Fuelwood emissions

Fuelwood emissions have always been low and have not increased over the years such as is the case with roundwood. Over the years there has even been a steady decrease due to the overall development of the country resulting in less people applying traditional cooking methods using fuelwood. The historical data showed a slight decreasing trend for 2000-2019. A linear projection was used based on the historical fuelwood logging data since there was no method to determine if there would be a change in the fuel wood production trend. However, the economic crisis raised the price of living in the city, including cooking gas prices, which would likely result in the use of fuelwood staying stable in the coming years.

Equation 3 Linear trend for FREL fuelwood logging emissions

$$t\ CO_2\ \text{emissions y-1} = -7{,}098.9 \quad \text{*year} + 14{,}537{,}100.59$$

Shifting cultivation emissions

Shifting cultivation is similar to fuelwood emissions mostly used by local traditional communities. The historical data showed stable average annual shifting cultivation emissions regarding conversion of forest to shifting cultivation. The historical trend showed a slight overall increase of shifting cultivation expansion over the years. Based on the overall trend of the emissions, a linear projection was used.

Equation 4 Linear trend for FREL shifting cultivation emissions

$$t\ CO_2\ \text{emissions y-1} = 4{,}743.82\text{*year} - 8{,}816{,}426.47$$

Total emissions

The projected FREL emissions were based on the complete 2000-2019 activity data, applying the linear projection method. The projected total emissions for the coming years have a rising trend, as the largest sources of emissions which are deforestation and roundwood logging have seen increased annual emissions since 2000.

Table 2 FREL for Suriname, expressed in yearly CO2 emissions

FREL projected annual emissions (t CO_2e yr^{-1})						
Year	**Deforestation**	**Degradation**				**Total**
	Total deforestation	**Roundwood**	**Fuelwood**	**Shifting cultivation**	**Total degradation**	**Total projected emissions**
2020	8,420,597	4,606,703	215,503	766,090	5,588,292	14,008,889
2021	8,775,256	4,857,731	208,413	770,834	5,836,974	14,612,231

2022	9,129,915	5,108,760	201,323	775,578	6,085,657	15,215,572
2023	9,484,574	5,359,788	194,233	780,321	6,334,339	15,818,913
2024	9,839,233	5,610,817	187,143	785,065	6,583,022	16,422,255

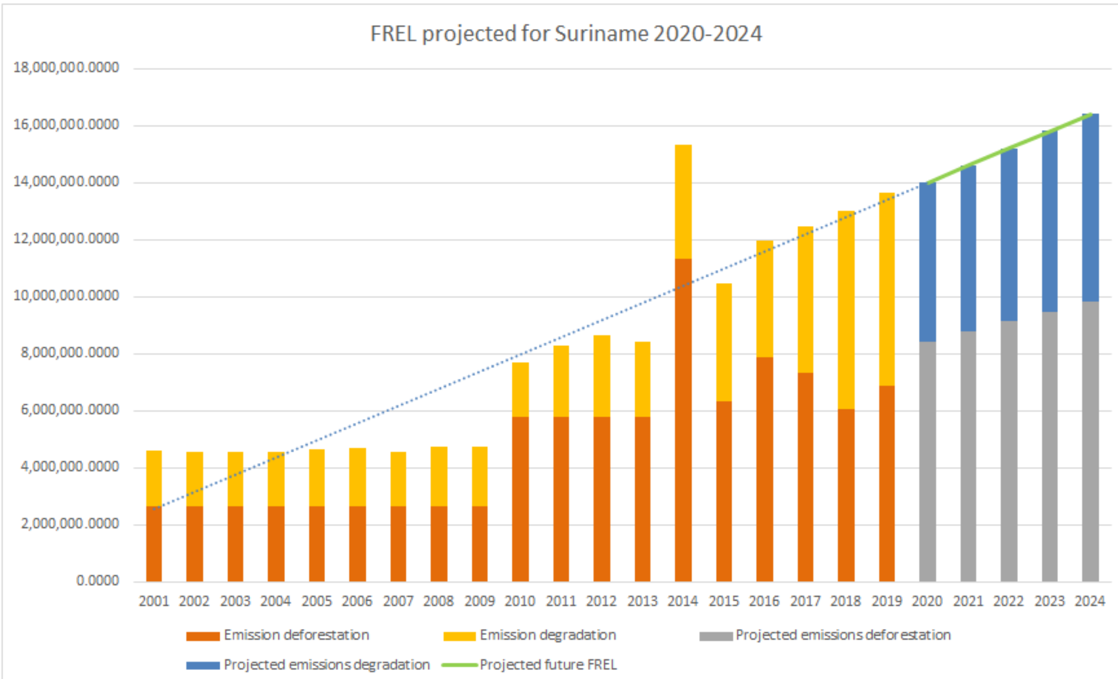

Figure 5. FREL projection until 2024 for Suriname

2.2 Activities included in the forest reference level

Deforestation

In the context of the 2FREL submission, gross deforestation was defined as "*the direct and/or induced conversion of forest cover to another type of land cover in a given timeframe of 10 years*".

This excludes areas that undergo a temporary loss of the forest cover, such as:

- **Shifting cultivation** (included in the definition of forest): As shifting cultivation areas have fallow periods of at least 4 years (Fleskens et al., 2010) and are smaller than one hectare;
- **Natural deforestation** where the forest cover will recover naturally such as small areas where windbreaks occur. This is usually observed as deforested areas in remote parts of the forest.

Forest degradation

Forest degradation is for the 2FREL submission was defined as "*human-induced or natural loss of the goods and services, provided by the forest land, in particular the forest carbon stocks, not qualifying as deforestation, over a determined period of time*".

The above-mentioned goods and services refer to a holistic approach that included a broad spectrum of aspects such as maintaining biodiversity and hydrological functions. The impact of legal logging and the extraction of firewood, as well as the non-CO2 emissions from biomass burning in Shifting Cultivation reflected forest degradation within the 2FREL. Forest degradation is only temporary, with the forest expected to recover after a certain period of time. Regarding shifting cultivation, more research is needed to understand the carbon stock changes and emissions resulting from the rotational shifting cultivation activities taking place after the fallow periods.

2.3 The territorial forest area covered

The 2nd FREL covered the entire forest area of the country, because the government structure of the country is centralized and most data is available on the national level.

2.4 Date of the forest reference level submission and date of the final technical assessment report

The 2nd FREL was submitted on 8 January 2021 and the final technical assessment report was published on 03 June 2022.

2.5 The period of the assessed forest reference level

The 2nd FREL uses the reference period of 2000-2019.

2.6 Summary of the technical analysis of the submitted forest reference level and actions taken by Suriname

The report covered the technical assessment of the voluntary submission of Suriname on its proposed Second forest reference level (FRL) in accordance with decision 13/CP.19 and in the context of results-based payments.

The 2nd FREL proposed by Suriname covered the activities reducing emissions from deforestation and reducing emissions from forest degradation, which are among the activities included in decision 1/CP.16, paragraph 70. For its submission, Suriname developed a national FREL. The FREL presented in the original submission, for the results period 2020–2024, corresponds to 15,238,428 tonnes of carbon dioxide equivalent (t CO2 eq) for 2020, 15,858,865 t CO2 eq for 2021, 16,479,303 t CO2 eq for 2022, 17,099,741 t CO2 eq for 2023 and 17,720,179 t CO2 eq for 2024. As a result of the facilitative process during the technical assessment, the FREL was modified to 14,008,882 t CO2 eq for 2020, 14,612,231 t CO2 eq for 2021, 15,215,572 t CO2 eq for 2022, 15,818,913 t CO2 eq for 2023 and 16,422,255 t CO2 eq for 2024. The assessment team noted that the data and information used by Suriname in constructing its FREL were transparent, complete and in overall accordance with the guidelines contained in the annex to decision 12/CP.17.

As a result of the facilitative interactions with the AT during the TA, Suriname provided a modified version of its submission on 9 August 2021, which took into consideration the technical input of the AT. The modifications improved the clarity, transparency and overall consistency of the submitted FREL.

Chapter 3. Results estimates of emissions reductions from REDD+ Activities for the 2016-2018 period

3.1 Trend in emissions in Suriname 2020-2021

During the reference period (2000-2019), it was identified that the main driver of ***deforestation*** was mining due to gold mining (69%), followed by Infrastructure (18%) and Agriculture (5%) (SBB, 2021). The historical data showed a period where the gold price reached its peak (2014) and deforestation showed a sudden rise that year due to the increased mining activities. It was expected that the rise in the gold price since 2019 (reaching its highest peak yet) would likely result in an increase in annual deforestation after 2019. The results of the most recent post-deforestation LULC map (2000-2017) shows that Mining is the main driver of deforestation (69%), with 98% of mining resulting from gold mining activities (SBB, 2021).

During the results period (2020 and 2021), it was identified that the main driver of ***deforestation*** was still mining. This information can also be viewed at the KOPI statistical portal at kopi.sbb.sr

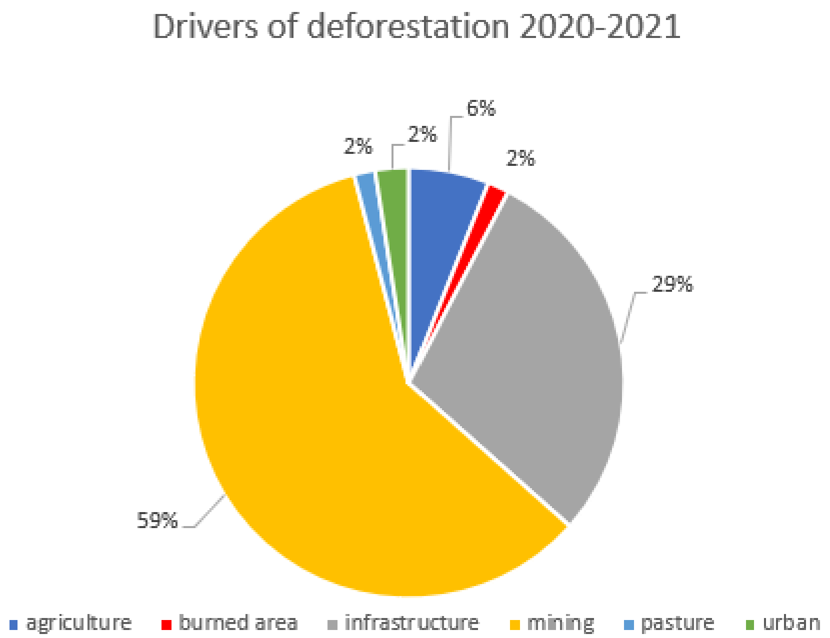

Figure 6. Drivers of deforestation for the period 2020-2021 (SBB, Kopi)

[5] https://franks-travelbox.com/en/suedamerika/surinam/naturschutzgebiet-zentral-surinam-surinam/

Table 3. Deforestation area per period Activity data: Historical deforestation (ha yr-1)

Activity --->>	(1.a) Conversion Forest to Non-forest (without Forest fire) in area ha		(1.b) Conversion Shifting cultivation to Non-forest (without Forest fire) in area ha		(1.c) Conversion Forest to Non-forest with Forest fire in area ha		**Total AD Deforestation**	
Year	**Area (ha yr-1)**	**Uncertainty (%)**	**Area (ha yr-1)**	**Uncertainty (%)**	**Area (ha yr-1)**	**Uncertainty (%)**	**Area (ha yr-1)**	**Uncertainty (%)**
2001	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2002	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2003	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2004	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2005	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2006	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2007	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2008	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2009	3,590	12.33%	45.2	13.28%	35.9	14.44%	3,672	12.06%
2010	7,370	6.25%	190.2	6.68%	457.4	5.34%	8,018	5.76%
2011	7,370	6.25%	190.2	6.68%	457.4	5.34%	8,018	5.76%
2012	7,370	6.25%	190.2	6.68%	457.4	5.34%	8,018	5.76%
2013	7,370	6.25%	190.2	6.68%	457.4	5.34%	8,018	5.76%
2014	15,197	11.28%	405.8	10.67%	153.4	9.97%	15,757	10.88%
2015	8,195	12.83%	1,027	12.46%	216.8	12.61%	9,439	11.23%
2016	10,618	11.85%	594	11.49%	173.5	11.85%	11,387	11.07%
2017	9,816	24.46%	537	22.01%	62.8	23.74%	10,417	23.08%
2018	7,834	2.77%	589	4.10%	296.1	2.62%	8,720	2.51%
2019	8,648	0.00%	999	0.00%	595.5	0.00%	10,243	0.00%
2020	7,944	0.00%	664	0.00%	251.7	0.00%	8,861	0.00%
2021	8,012	0.00%	645	0.00%	6.86	0.00%	8,664	0.00%

The main driver of ***forest degradation*** is selective logging, which takes place in ca. 30% of the country's area. Since only a few trees (1-5) per ha are removed during selective logging, it is unlikely that this activity will cause a tree crown cover of less than 30%.

Table 4. AD Degradation in volume m3 (logging) and area ha (shifting cultivation)

Strata-->>	National*		National	
Activity -->>	(2.a) Roundwood production in m3 volume+ (2.b) Fuelwood production in m3 volume		(2.c) Conversion Forest to Shifting cultivation with Forest fire in area ha	
Year	**Volume (m3)**	**Uncertainty (%)**	**Total area (ha yr-1)**	**Uncertainty (%)**
2001	283,571	7.02%	1462.00	32.26%
2002	272,117	7.11%	1462.00	32.26%
2003	270,881	7.01%	1462.00	32.26%
2004	272,017	6.87%	1462.00	32.26%
2005	290,749	6.47%	1462.00	32.26%
2006	300,235	6.25%	1462.00	32.26%
2007	270,930	6.55%	1462.00	32.26%
2008	299,408	6.08%	1462.00	32.26%
2009	306,501	5.93%	1462.00	32.26%

2010	343,257	5.56%	603.45	50.69%
2011	460,445	5.03%	603.45	50.69%
2012	527,969	4.89%	603.45	50.69%
2013	484,312	4.94%	603.45	50.69%
2014	580,685	4.81%	2296.74	0.74%
2015	653,890	4.77%	1765.38	0.76%
2016	666,947	4.76%	1549.64	0.81%
2017	944,389	4.75%	799.07	0.73%
2018	1,162,795	4.77%	2180.82	0.76%
2019	1,152,169	4.77%	1874.60	0.79%
2020	599,262	4.76%	1181.63	0.00%
2021	697,953	4.74%	702.54	0.00%

Remark: the assumption is that the m3 of roundwood and fuelwood and or the conversion to Shifting Cultivation are not coming from deforestation events*

**Note: Deforestation due to forest fire only occur in the strata: Coastal and Forest belt*

Suriname has continued implementing different policies and plans to address drivers and agents for deforestation and forest degradation. Some of them are listed in the following table:

Table 5 Summary of policies and plans relevant for drivers of emissions

Drivers of projected emissions level	% of total emissions in 2017	Policy, Law & Regulation and Development Plan relevant for the Forest Reference Emission Level (FREL)
Logging (degradation)	36%	Forest Management Act (1992), National Forest Policy (2005), Interim Strategic Action Plan for the Forest Sector, Code of Practice, National Development Plan 2017-2021, National REDD+ Strategy (2019), National Determined Contribution (2020), Environmental Framework Law (2020), The National Mangrove Strategy Suriname (2019).
Shifting cultivation (degradation)	4%	National Development Plan 2017-2021, National REDD+ Strategy (2019), National Determined Contribution (2020)
Mining (deforestation)	42%	Mining Decree (1986), Extractive Industries Transparency Initiative (EITI - member since 2017), Minamata Convention (ratified 2018), National Development Plan 2017-2021, National REDD+ Strategy (2019), Environmental Framework Law (2020), Tailor made mineral agreements.
Infrastructure (deforestation)	11%	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, National REDD+ Strategy (2019), National Determined Contribution (2020). Environmental Framework Law (2020).
Urbanization (deforestation)	2%	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, National REDD+ Strategy (2019).

Agriculture and pasture (deforestation)	Agriculture 3% Pasture 1%	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, National REDD+ Strategy (2019), National Determined Contribution (2020), Environmental Framework Law (2020).

While the emissions of deforestation mainly due to gold mining have reduced, there might be an increase again in the near future. This because most of the people working in the gold mining sector are people with no alternative livelihoods. To tackle this problem on a longer run, investments need to be done in the development of livelihoods, enforcement capacities of the institution responsible for the mining sector, a better implementation of a land use planning and the development/ implementation of techniques that have less impact on the environment.

Emissions due to forest degradation have decreased significantly. This can be linked to the launch of the Suriname Forestry Information System Suriname (SFISS) mid 2019 which was fully implemented in 2020. Parallel to the launch of this system, all logging activities need to be preceded by a harvest plan based on an inventory. This together with the COVID-19 pandemic and the increased costs of the export, have caused a significant reduction in the yearly timber production and the resulting emissions.

Table 6. Total Average emissions due to Deforestation and degradation

Year	**Grand Total Historical emissions due to Deforestation & Degradation**	**Grand Total projected emissions due to Deforestation & Degradation**	**Estimated Total emissions**
	Total Emissions (t CO2e yr-1)	**Total Emissions (t CO2 yr-1)**	
2001	4,590,666		
2002	4,537,967		
2003	4,538,078		
2004	4,550,330		
2005	4,653,661		
2006	4,708,898		
2007	4,562,866		
2008	4,716,286		
2009	4,758,684		
2010	7,674,347		
2011	8,287,294		
2012	8,642,609		
2013	8,421,353		
2014	15,327,204		
2015	10,447,381		
2016	11,962,911		
2017	12,471,132		
2018	13,024,072		
2019	13,658,481		
2020		14,008,889	9,610,512
2021		14,612,231	9,772,841

Table 7 Comparison of estimated vs projected emissions for the years 2020 and 2021

Year	Grand Total Historical emissions due to Deforestation	Grand Total Historical emissions due to Degradation	Total projected emissions due to Deforestation	Total Projected emissions due to Degradation	Estimated emissions DEFORESTATION	Estimated emissions DEGRADATION
	Total Emissions (t CO2e yr-1)					
2001	2,627,560	1,963,106				
2002	2,627,560	1,910,407				
2003	2,627,560	1,910,518				
2004	2,627,560	1,922,770				
2005	2,627,560	2,026,101				
2006	2,627,560	2,081,338				
2007	2,627,560	1,935,307				
2008	2,627,560	2,088,726				
2009	2,627,560	2,131,124				
2010	5,795,935	1,878,412				
2011	5,795,935	2,491,360				
2012	5,795,935	2,846,675				
2013	5,795,935	2,625,418				
2014	11,351,994	3,975,210				
2015	6,320,143	4,127,237				
2016	7,862,822	4,100,090				
2017	7,340,615	5,130,517				
2018	6,040,216	6,983,856				
2019	6,858,725	6,799,757				
2020			8420597.24	5588291.98	6,040,835.54	3,569,676.24
2021			8775256.18	5836974.42	5,943,411.14	3,829,429.84

In parallel, the Government of Suriname wants to invest in diversification of the economy. While no trade markets are yet fully functional for ecosystem services, such as biodiversity and water regulation, the Green Climate Fund (GCF) is currently initiating a mechanism for results-based payment for REDD+.

These mechanisms will need to make it possible for a country in development to preserve its standing forest, avoiding that there will be leakages from the countries that are slowing down deforestation and forest degradation to countries where deforestation or forest degradation previously did not take place, or took place to a more limited extent. Hereby, the opportunity cost of gold mining, the main driver of deforestation in Suriname, needs to be considered. This opportunity cost is so high that it is difficult for potential incomes of carbon credits to compete (SBB et al., 2017b). Planning, research, sustainable forest management and restoration of previously deforested areas will be key to reducing negative impacts and maintaining the country's contribution to the local and global environment. The policies for each driver of emissions are described in table 5. These values presented are based on the results of the most recent Post deforestation LULC 2000-2017 data (SBB, 2021).

Another challenge Suriname is facing is the potentially high climate change adaptation costs. The country's low-lying coast makes the country extra vulnerable to the effects of sea level rise. Within the National Adaptation Plan 2019-2029 (GOS, 2019b), which was submitted to UNFCCC in 2020, two goals are emphasized: (1) impact reduction through adaptation and resilience building and (2) integration and mainstreaming in a coherent manner, into relevant new and existing policies, programs, activities and development planning processes and strategies, across multiple sectors and levels as appropriate.

The priority activities identified:

- Sustainable coastal and riverbank protection to protect the fertile agricultural land, the housing of the population and most infrastructural facilities.

- Reduce CO2-emissions from the energy sector, application of environmentally friendly electricity generation facilities, attendant job creation through investments and scaling up of green energy projects. Priorities are driven by the productive sectors. The NAP is built upon the assumption of a financial compensation for the mitigation of climate change for the implementation of the REDD+ program. Therefore, the activities are based on an environmentally related use of the forest.

- Development of agrarian and regional development plans.

- Financing for pre and post disaster actions especially climate-related disasters (local storms, floods, droughts).

Beside the decrease in the gold price, the Suriname Government also implemented some measures to manage the artisanal gold mining sector. The establishment of the Organization for the Regulation of the Gold Mining Sector (OGS), the approval of the Minamata agreement in 2018, restricting the mercury trade have caused reduced deforestation due to gold mining. Nevertheless, to maintain this and to reduce the impact on the environment, much more investments are needed.

For forest degradation, the emissions show an increasing trend for the period 2016-2019. This because of large investments from mainly Asian companies, focusing on the export of round logs. While the Government started talking about the ban on the export of round logs, exporting companies were still trying to use the opportunity to export large volumes of round logs, assuming that the ban could be implemented at any moment, but also affecting the supply of logs for the local processing industry. In this period also exceptions were made to work without harvest planning for small loggers and communities. Nevertheless in 2019 nearby 50% of the logging activities were without a harvest plan (based on a stock inventory).

Using the same methodological approach and data sources as the FRL, Suriname estimated the following emissions for the period 2020- 2021.

During the results period (2020 and 2021), it was identified that the main driver of ***forest degradation*** was still logging.

3.2 The REDD+ results relative to the Forest Reference Level in terms of CO2 equivalent

While the emissions of deforestation mainly due to gold mining have reduced, there might be an increase again in the near future. This because most of the people working in the gold mining sector are people with no alternative livelihoods. To tackle this problem on a longer run, investments need to be done in the development of livelihoods, enforcement capacities of the institutions responsible for the mining sector, a better implementation of a land use planning and the development/ implementation of techniques that have less impact on the environment.

Forest degradation has reduced due to the introduction of SFISS, COVID-19 and the increased export cost. To structurally transform the forestry sector and reduce the emissions, we should use two approaches: 1) focus on improved practices on the ground (better logging practices like RIL-C) 2) Reduce the export of round logs and strengthen the wood processing sector. Of course, it is also important to strengthen the country's national institutions. There are already ongoing programs related to improve this, but to successfully tackle degradation, the country still needs a lot of technical and financial support.

Table 8. REDD+ Results for Suriname for 2020 and 2021

Year	**Grand Total Historical emissions due to Deforestation & Degradation**	**Grand Total projected emissions due to Deforestation & Degradation**	**Estimated Total emissions**	**REDD+ RESULTS**
	Total Emissions (t CO2e yr-1)	Total Emissions (t CO2 yr-1)		
2001	4,590,666			
2002	4,537,967			
2003	4,538,078			
2004	4,550,330			
2005	4,653,661			
2006	4,708,898			
2007	4,562,866			
2008	4,716,286			
2009	4,758,684			
2010	7,674,347			
2011	8,287,294			
2012	8,642,609			
2013	8,421,353			
2014	15,327,204			
2015	10,447,381			
2016	11,962,911			
2017	12,471,132			
2018	13,024,072			
2019	13,658,481			
2020		14,008,889	9,610,512	4,398,377
2021		14,612,231	9,772,841	4,839,390

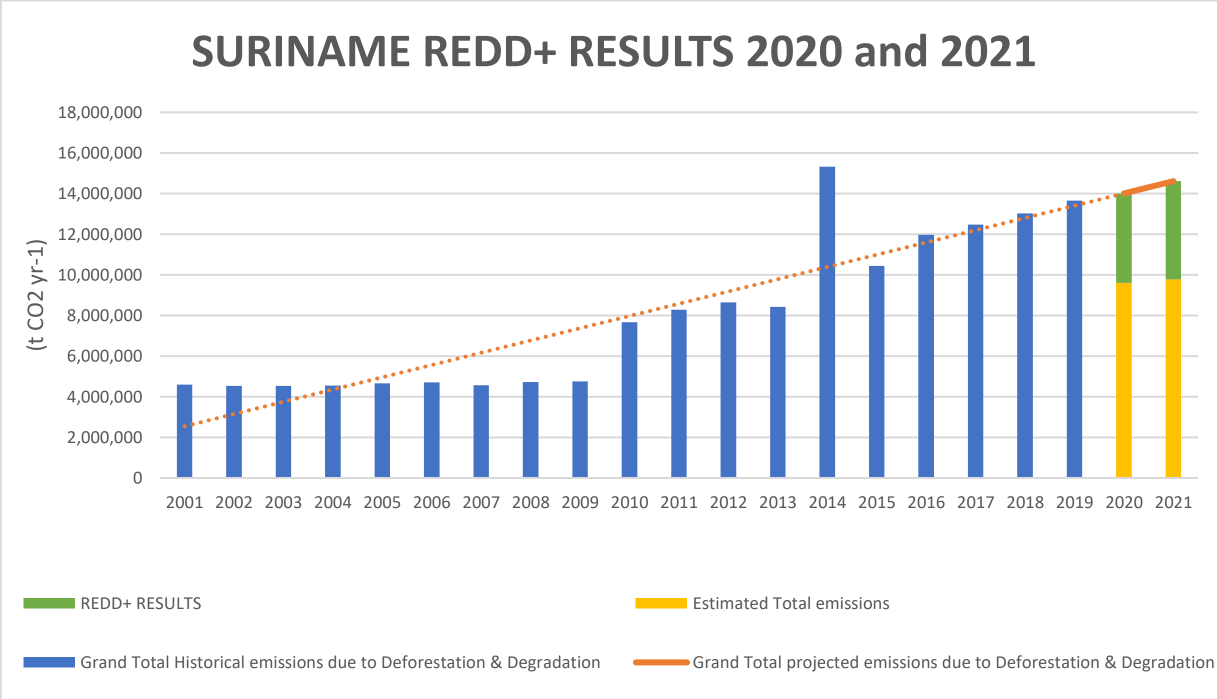

Figure 7. Suriname REDD+ Results 2020 and 2021

3.3 Consistency with National GHG Inventory and Forest Reference Level

The 2FREL and REDD+ results were developed following the guidance provided in Decision 12/CP.17, decision 4/CP.15, paragraph 7. The second FREL and the NC3 were being produced simultaneously, leading to consistency of these two reports. The forest related emissions within the GHG inventory were estimated based on expert knowledge and research, before the NFMS was established. The national GHG inventory, the FREL and REDD+ results were estimated following the 2006 IPCC Guidelines. The reports are based on the same database, methods, and assumptions and apply the same estimation procedures.

6

[6] Photo: https://www.gettyimages.com.mx/

Chapter 4. Consistency of methods used to obtain the 2020-2021 results relative to methods used to establish the assessed Forest Reference Level

The methods used to obtain the annual emissions and removals for the period 2020-2021 are consistent with those used to calculate the first FRL submitted by Suriname. The same REDD+ activities, greenhouse gases, carbon pools, activity data and emission factor estimation methods and data sources, as well as methods for mapping land use were used in estimating annual emission and removals of both the FRL and the results presented in this Technical Annex. Table 6 summarizes how the methods used to obtain the FRL and those used to obtain the 2020-2021 results are consistent.

Table 9. Consistency between FRL 2000-2019 and Technical Annex Results 2020-2021

Parameter	2FREL for 2000 to 2019	Technical Annex Results 2020-2021
IPCC Guidelines	IPCC GL 2006	IPCC GL 2006
REDD+ Activities	Deforestation and forest degradation	Deforestation and forest degradation
Greenhouse Gases	CO_2, CH_4 and N_2O	CO_2, CH_4 and N_2O
C pools	Above-Ground Biomass (AGB), Below-Ground Biomass (BGB) and Lying and standing dead wood (DW).	Above-Ground Biomass (AGB), Below-Ground Biomass (BGB) and Lying and standing dead wood (DW).
Forest stratification	- Mangrove forest - Coastal plain - Forest belt - Forest in the interior	- Mangrove forest - Coastal plain - Forest belt - Forest in the interior
Estimating Activity Data	Suriname is currently operating mostly at Tier 2 and Approach 3 level: - Annual wall-to-wall monitoring of the Activity Data (AD) using Landsat and Sentinel 2A imagery, following a standard protocol and applying the methodology recommended by Olofsson et al. (2014) and Olofsson et al., (2020) for land-use and land-use change area estimations. This is done according to Approach 3. - Activity data are disaggregated by drivers of deforestation. This has been	Suriname is currently operating mostly at Tier 2 and Approach 3 level: - Annual wall-to-wall monitoring of the Activity Data (AD) using Landsat and Sentinel 2A imagery, following a standard protocol and applying the methodology recommended by Olofsson et al. (2014) and Olofsson et al., (2020) for land-use and land-use change area estimations. This is done according to Approach 3. - Activity data are disaggregated by drivers of deforestation. This has been

	done using ancillary data and field experience from multiple institutions. Throughout this process, guidelines for the visual interpretation of the different land use and land cover classes (LULC) were developed and adjusted (SBB, 2021). This is according to Approach 3.	done using ancillary data and field experience from multiple institutions. Throughout this process, guidelines for the visual interpretation of the different land use and land cover classes (LULC) were developed and adjusted (SBB, 2021). This is according to Approach 3.
Estimating Emission Factors	The forest carbon stocks have been assessed by assembling a national database bringing together data from 212 forest inventory plots scattered over the country. In 2019, 11 additional mangrove NFI plots were also established in the coastal area (SBB, 2019), resulting in a total of 13 mangrove plots. Within this national database, above-ground biomass and dead wood (lying and standing) were assessed according to Tier 2, based on national data, but using pantropical allometric estimates. Belowground biomass was assessed using Tier 2. - To calculate the emissions due to logging, a field procedure was developed and carried out in ten locations using a randomly stratified approach; where 200 felled trees were measured, 150 skid trail plots were established, 100 log yards and 200 road widths were measured, haul roads within nine concessions were partly mapped and skid trails were mapped and measured in about 550 ha of logging units (Zalman et al., 2019). These emission factors are considered Tier 2.	The forest carbon stocks have been assessed by assembling a national database bringing together data from 212 forest inventory plots scattered over the country. In 2019, 11 additional mangrove NFI plots were also established in the coastal area (SBB, 2019), resulting in a total of 13 mangrove plots. Within this national database, above-ground biomass and dead wood (lying and standing) were assessed according to Tier 2, based on national data, but using pantropical allometric estimates. Belowground biomass was assessed using Tier 2. - To calculate the emissions due to logging, a field procedure was developed and carried out in ten locations using a randomly stratified approach; where 200 felled trees were measured, 150 skid trail plots were established, 100 log yards and 200 road widths were measured, haul roads within nine concessions were partly mapped and skid trails were mapped and measured in about 550 ha of logging units (Zalman et al., 2019). These emission factors are considered Tier 2.

Chapter 5. National Forest Monitoring System

The National Forest Monitoring System (NFMS) includes a Measuring, Reporting and Verification (MRV) function and other monitoring functions. Guiding principles for the NFMS in Suriname are national ownership, open data accessibility and transparency, cost efficiency, and adaptation to context (e.g. different contexts require a different monitoring approach specific for each aspect of the FREL, such as methods used for determining emissions from forest degradation and deforestation) (SBB, 2017).

The NFMS Roadmap (GOS 2016) is the plan that has been followed for improving and expanding in scope and functions forest monitoring in Suriname, in order to institutionalize these activities into a fully functional national forest monitoring system, in line with the requirements of a REDD+ Program and the efficient management and supervision of the country's forest resources. A full implementation of the NFMS is therefore a key part of the REDD+ strategy and has been executed in its entirety.

Capacity for satellite land monitoring has been built up in Suriname through the Amazon Cooperation Treaty Organization (ACTO) project 'Monitoring the Forest Cover in the Amazon Region', through which a Forest Cover Monitoring Unit (FCMU) was established in 2012 and officially launched in 2013. Figure 5 shows the NFMS with the 6 components it consists of.

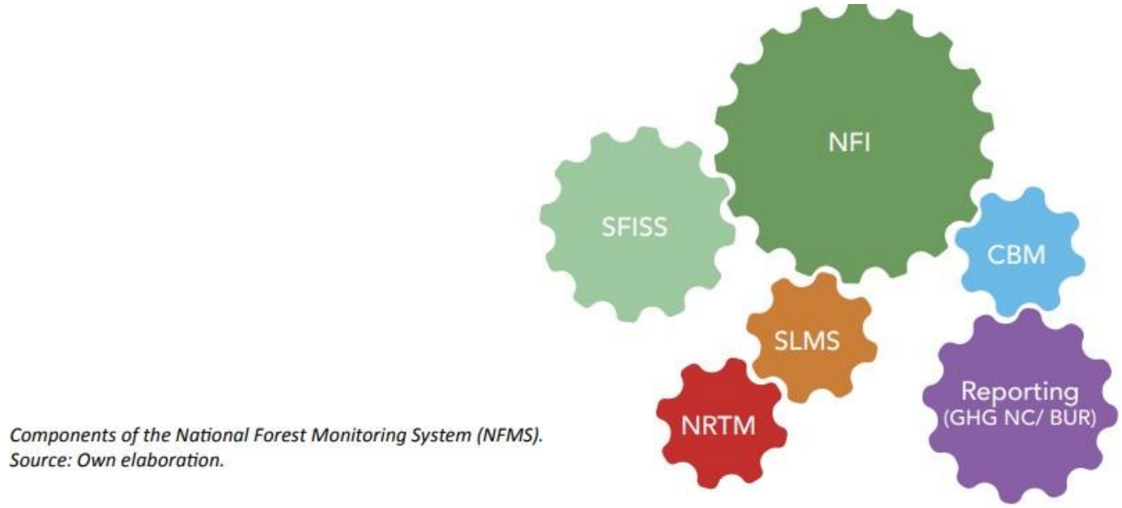

Figure 8. Components of the National Forest Monitoring System

[7] Photo: https://www.gettyimages.com.mx/

5.1 Tools within the National Forest Monitoring System:

To safeguard our forests and to maintain the balance between the different ecosystems, it is important to set up a National Forest Monitoring System. To make this system effective and efficient, modern technologies are used and there is close cooperation with local communities, government offices and the private sector.

The National Forest Monitoring System (NFMS) consists of six components:

1) Satellite Land Monitoring System

With satellite images, deforestation maps are produced annually to provide an overview of where most deforestations take place. Post-deforestation Land Use and Land Coverage Maps are produced every two years to reflect the different causes of deforestation. Besides this, also national LULC maps are produced every 5 years showing all natural and human-made land use and land cover. Data produced within the SLMS is validated in the field and during workshops with all other relevant institutions/partners. Data on land cover and land use offers the government the opportunity to implement better spatial planning, forest management plans and other policy making.

2) Near Real Time Monitoring

This is an alarm or alert system, with the aim of detecting unplanned deforestation activities and sending alerts to institutions responsible for enforcing the policy. At the moment SBB is only focusing on unplanned logging activities, but there are intentions to support the mining institutes to implement this monitoring system.

3) Sustainable Forestry Information System

In order to provide even more efficient services and transparency for the timber sector, the Foundation for Forest Management and Forest Supervision (SBB) has launched a public log traceability system, the Sustainable Forestry Information System Suriname (SFISS). The work for both the SBB and the private sector can take place more smoothly and in a more structured way. Within this system the sustainability rules are included from the felling of the tree to the processing and export of round timber. For more info also visit: http://sbbsur.com/sfiss/

4) Involving communities in forest monitoring

To promote transparency and cooperation with the communities, they are closely involved in the measurement system within the forestry sector. To do this, information sessions are organized by means of Krutu's and training community representatives to map out planned logging activities.

5) National Forest Inventory

Making an inventory of our forests is important to know, among other things, where the various ecosystems are located and the coherence of biodiversity. While Suriname has a National Forest Inventory planned, the resources are not available to carry it out as yet. A pilot NFI was carried out in 2013-2014, which we are currently looking for resources at the moment. An inventory was carried out in 2019 in the mangrove forests and data is currently available on the occurrence of mangrove in the coastal plain of Suriname. The mangrove forest can be viewed on the Gonini geoportal at www.gonini.org.

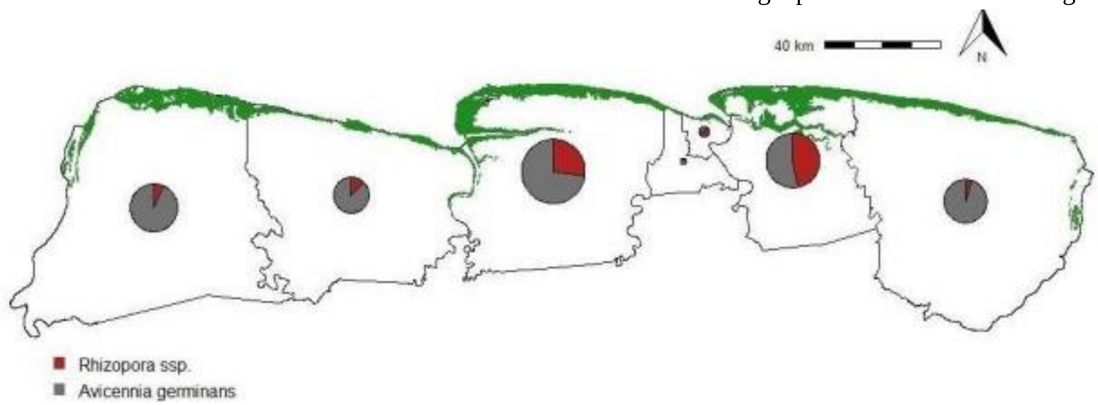

Figure 9. Mangrove coverage 2019 (Gonini)

6) Reporting

Suriname has national and international reporting obligations. For this reason, it is therefore important that information is up to date and available. Reports are also important to support development plans.

For transparency and open data accessibility SBB launched a geoportal called Gonini (https://www.gonini.org/), in 2016. This is an online database with geographic forest related information about Suriname.

All information used to quantify deforestation and emission factors due to deforestation and forest degradation are originating from the multipurpose National Forest Monitoring System (NFMS) (SBB, 2017).

Chapter 6. Information necessary to reconstruct results

All information used to quantify activity data (AD) and emission factors (EF) due to deforestation and forest degradation are originating from the multipurpose National Forest Monitoring System (NFMS) (SBB, 2017).

The NFMS includes a Measuring, Reporting and Verification (MRV) function and other monitoring functions such as biodiversity monitoring, land use planning and log tracking. Suriname's NFMS is composed of an operational Satellite Land Monitoring System (SLMS), a National Forest Inventory (NFI), a Sustainable Forestry Information System Suriname (SFISS), a Near Real Time Monitoring system (NRTM) and several cross-cutting activities (e.g. mangrove monitoring), with broad participation of other institutions and stakeholders. Guiding principles for the NFMS in Suriname include national ownership, open data accessibility and transparency, cost efficiency, and adaptation to context (SBB, 2017).

According to Decision 12/CP.17, developing country parties implementing REDD+ can use a stepwise approach to construct reference levels, incorporating better data, improved methodologies and, where appropriate, additional pools. Forest Reference (Emission) Levels should be updated periodically, taking into account new knowledge, new trends and any modification of scope and methodologies. The NFMS will continue to serve this purpose in Suriname.

In the Annex section, the completed methodology used is described.

Data sets and information

FREL calculation tool 2021:

https://drive.google.com/drive/folders/1Hk31K8Iy7JAY31auGrabd_OmS-tRL_sq?usp=sharing

REDD+ data results are available on the KOPI statistical database via www.kopi.sbb.sr and in the following link:
https://drive.google.com/drive/folders/1fisCZyUZ8GdyYyVtS2evIS6eq9nrM_6r?usp=share_link

Chapter 7. Description of how the elements contained in decision 4/CP.15, paragraph 1 (c) and (d), have been taken into account.

7.1 Use of the most recent IPCC guidance and guidelines for estimating anthropogenic forest related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes

Suriname 2FRL and this 2REDD+ Technical Annex both use the methodologies described in the IPCC Guidelines, 2006 as the basis for estimating the changes in carbon stock in forested areas converted to other land uses. Suriname applies the basic method for estimating emissions suggested by IPCC, i.e., emissions are estimated as the product of activity data and emission factor for a given activity.

7.2 Establishment of a robust and transparent National Forest Monitoring System according to national circumstances and capabilities

UNFCCC decisions provide detail on three sub-items of the NFMS representing the functions of measurement/monitoring, reporting and verification. Regular measurement and reporting of emissions and carbon stocks have to be implemented at the national level, while validation is a process managed by the UNFCCC Secretariat. Measurement/monitoring is expected to be undertaken following the IPCC Guidelines, while reporting and verification are described in UNFCCC decisions such as 1/CP.17 and 9- 15/CP.19. Figure 10 shows how measurement and reporting typically relate to each other. It should also be noted that this arrangement is not specific to the REDD+ mechanism but applies to the whole Agriculture, Forestry and other sectors (AFOLU)- activities. The NFMS can meet multiple purposes depending on the needs of each country, which can go far beyond REDD+.

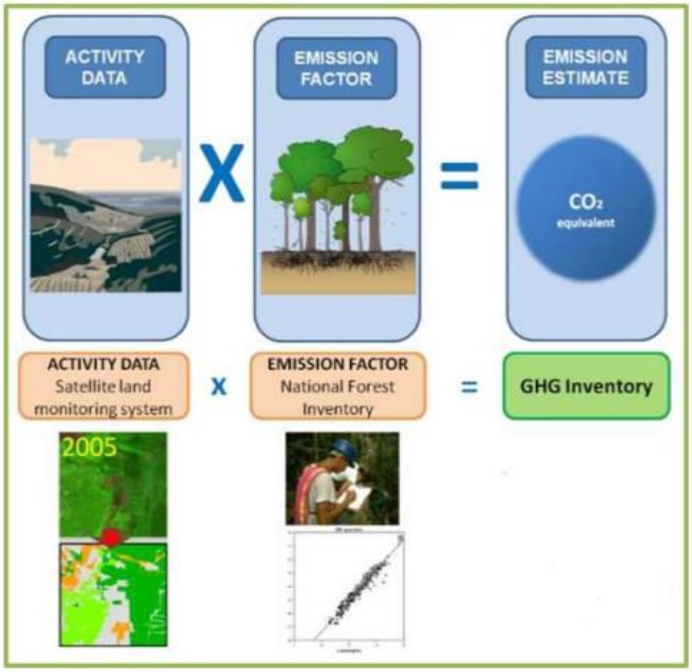

Figure 10. Measurement of AD x EF= GHG reporting

Measurement, reporting and verification (MRV) are the three main components of the NFMS required for REDD+, as defined by UNFCCC decision 4/CP.15. Of those three functions, verification is organized by the Secretariat of the UNFCCC. Suriname therefore has to set up its NFMS to support the functions of measurement and reporting. Of the two, measurement is by far the most complex to design and implement, while reporting requirements are largely determined by COP decisions and IPCC Guidelines (see chapter 3). The measurement component of the NFMS can be broken down in two main blocks: The Satellite Land Monitoring System (for determining Activity Data) and the National Forest Inventory (for establishing Emission Factors). The reporting component corresponds with the forest sector component of the national GHG-inventory.

To ensure the quality of GHG inventories, the IPCC guidelines 2006 provide a set of good practices that Suriname applied as follows:

- **Transparency:** Suriname's background information for the REDD+ technical Annex is openly available. National reports and documentation are made available through an online shared folder[8]. This folder also includes Suriname's "REDD+ technical Annex calculation tool", which provides insights on how all AD and EF data was used to calculate the emissions in this REDD+ technical Annex. All spatially explicit information on forest cover change is available through the open-access geoportal "Gonini"[9]. Since 2021, SBB has also launched a geoportal where national logging specific data is made available[10]. There is a multi-stakeholder collaboration in the development of national Land Use Land Cover (LULC) Maps and an exchange of data between these stakeholders, which promotes transparency regarding spatial data in Suriname. Reports and documents on spatial and non-spatial information such as Emission Factors (EF), Timber production and Forest Inventory data are

[8] Data and documents related to this FREL are available at: FREL Suriname Background Information
[9] https://www.gonini.org/
[10] SBB Forestry Statistic Information portal

published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the website of the SBB (www.sbbsur.com).

- **Accuracy:** Area estimations based on remote sensing are generated following the good practices recommended by (Olofsson *et al.* 2014; Olofsson et al. 2020) and GFOI (2017) and the tools developed by FAO (2016). To reassure the quality of the field measurements, field plots were reassessed. In case of large deviations, the plots were re-measured by the field teams. The accuracy of the timber production is determined based on expert estimations by SBB, with SBB data approved by other local institutions such as the General Bureau of Statistics and the National Planning Office.

- **Completeness:** All methodologies used, intermediate results and decisions made are presented and documented so that it is possible to reconstruct the REDD+ technical Annex

  Consistency: The FREL and the REDD+ Results Annex are full consistent because they are based on the same methodologies, emission factors and activity data were estimated in the same way.

Chapter 8. Uncertainty assessment

REDD+ TECHNICAL ANNEX

The uncertainty for each emission source included in the FREL, was calculated based on the uncertainty related to the associated AD and EF. Table 10 below provides an overview of how uncertainties were determined for each AD and EF.

Table 10. Overview of the uncertainties for each AD and EF

REDD+ Activities	Activity in FREL	Input data for uncertainty calculation	
		Activity Data (AD)	Emission Factor (EF)
(1) Deforestation	(1.a) Conversion Forest to Non-forest (without Forest fire)	QA/QC results of Deforestation maps l (SBB, 2021)	Forest carbon stock (SBB, 2017a) and Mangrove carbon stock (SBB, 2019) database from SBB
	(1.b) Conversion Shifting cultivation to Non-forest (without Forest fire)		Carbon stock changes reported by Pelletier et al. (2017)
	(1.c) Conversion Forest to Non-forest through Forest fire		Forest carbon stock (SBB, 2017a) and Mangrove carbon stock (SBB, 2019) database from SBB
(2) Degradation	(2.a) Roundwood production	Expert judgement (SBB FREL working group)	Logging emissions study done by Zalman et al.(2019)
	(2.b) Fuelwood production	Expert judgement (SBB FREL working group)	
	(2.c) Conversion Forest to Shifting cultivation through Forest fire	QA/QC results of Deforestation maps (SBB, 2021)	Forest carbon stock (SBB, 2017a) and Mangrove carbon stock (SBB, 2019) database from SBB

[11] Photo: https://www.superstock.com/stock-photos-images/4413-217369

			+ Carbon stock changes reported by Pelletier et al. (2012)

The AD, EF and emissions uncertainty calculations are done using the IPCC (2006) Volume 1 Chapter 3, equation[12] 3.1 for multiplication, equation 3.2 for addition and subtraction, and equation 3.2A for combining uncertainties. These are presented below.

Equation 5 Combining uncertainties - Multiplication

$$Total = \sqrt{1^2\ i^2\ n^2}$$

Where:

$Total$ = the percentage uncertainty in the product of the quantities (half the 95 percent confidence interval divided by the total and expressed as a percentage)

i = the percentage uncertainties associated with each of the quantities

Equation 6 Combining uncertainties - Addition and subtraction

$$total = \frac{\sqrt{11^2\ ii^2\ nn^2}}{|\ 1\ i\ n\ |}$$

Where:

= the percentage uncertainty in the sum of the quantities (half the 95 percent confidence interval divided by the total (i.e., mean) and expressed as a percentage)

i = quantities to be combined; xi may be a positive or a negative number

i = the percentage uncertainties associated with each of the quantities

Equation 7 Combining uncertainties - AD EF*

$$Total = \sqrt{AD^2\ EF^2}$$

Where:

$total$ = the percentage uncertainty in the product of the quantities

AD = the percentage uncertainty related to the activity data

[12] IPCC (2006) Volume 1

EF = the percentage uncertainty related to the emission factor

References

REDD+ TECHNICAL ANNEX

ABS, 2020. Trade statistics 2016 - 2019. General Bureau of Statistics

Alder, D. and van Kuijk, M., 2009. Proposals for a National Forest Biomass Monitoring System in Guyana. Guyana Forestry Commission.

Alvarez, E., Duque, A., Saldarriaga, J., Cabrera, K., de las Salas, G., del Valle, I., Lema, A., Moreno, F., Orrego, S., Rodríguez, L., 2012. Tree above-ground biomass allometries for carbon stocks estimation in the natural forests of Colombia. For. Ecol. Manage. 267, 297–308. doi:10.1016/j.foreco.2011.12.013

Arets, E.J.M.M., B. Kruijt, K. Tjon, V.P. Atmopawiro, R.F. van KantenS. Crabbe, O.S. Bánki and S.Ruysschaert. 2011. Towards a carbon balance for forests in Suriname. Wageningen, Alterra, Alterra report 1977. 42p.

Brown, S., Mahmood, A.R.J., 2016. Forest Degradation Around Mined Areas : Methods and Data Analyses for Estimating Emission Factors : Version 2.

Brown, S., Lugo, A.E., Iverson, L., 1992. Processes and Lands for Sequestering carbon in the tropical forest landscape. Water. Air. Soil Pollut. 64, 139–155.

Cairns, M.A., Brown, S., Helmer, E.H., Baumgardner, G.A., Cairns, M.A., Brown, S., Helmer, E.H., Baumgardner, G.A., 1997. Root Biomass Allocation in the World's Upland Forests. Oecologia 111,

Chave, Jérôme, Maxime Réjou-Méchain, Alberto Búrquez, Emmanuel Chidumayo, Matthew S. Colgan, Welington B. C. Delitti, Alvaro Duque, Tron Eid, Philip M. Fearnside, Rosa C. Goodman, Matieu Henry, Angelina Martínez-Yrízar, Wilson A. Mugasha, Helene C. Muller-Landau, Maurizio Mencuccini, Bruce W. Nelson, Alfred Ngomanda, Euler M. Nogueira, Edgar Ortiz-Malavassi, Raphaël Pélissier, Pierre Ploton, Casey M. Ryan, Juan G. Saldarriaga, and Ghislain Vieilledent. 2014. “Improved Allometric Models to Estimate the Aboveground Biomass of Tropical Trees.” Global Change Biology 20(10):3177–90. doi: 10.1111/gcb.12629. 1–11. doi:10.1007/s004420050201

Casanoves F.; Pla L.; Di Rienzo J.A.; Díaz S. 2010. FDiversity: a software package for the integrated analysis of functional diversity. Methods in Ecology & Evolution doi: 10.1111/j.2041-210X.2010.00082)

Cedergren, J. 2009. Measurement and Reporting of Forest Carbon in Guyana: Preparing for REDD Implementation. UN-REDD PROGRAMME. MRV Working Paper 6.

[13] Photo: https://kabalebo.com/site/en/packages/daily-birding-tour/

Chave, J., Andalo, C., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Fölster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B.W., Ogawa, H., Puig, H., Riéra, B., Yamakura, T., 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145, 87–99. doi:10.1007/s00442-005-0100-x

Couteron, P., Barbier, N., Gautier, D., 2006. Textural Ordination Based on Fourier Spectral Decomposition: A Method to Analyze and Compare Landscape Patterns. Landsc. Ecol. 21, 555–567. doi:10.1007/s10980-005-2166-6

Crabbe, S., Somopawiro, R., Hanoeman, W., Playfair, M., Tjon, K., Djosetro, M., Pinas, B., Wortel, V., Sanches, M., Sanches, C., Soetosenojo, A., 2012. Results of forest carbon assessment and monitoring project Suriname. Paramaribo.

Dezécache, C., Faure, E., Gond, V., Salles, J.-M., Vieilledent, G., Hérault, B., 2017. Gold-rush in a forested El Dorado: deforestation leakages and the need for regional cooperation. Environ. Res. Lett. 12, 34013. doi:10.1088/1748-9326/aa6082

Dijn, B. de, 2018. Natural History and Ecology of Suriname. LM Publishers. ISBN: 9789460224386

Ellis, Peter W., Trisha Gopalakrishna, Rosa C. Goodman, Francis E. Putz, Anand Roopsind, Peter M. Umunay, Joey Zalman, Edward A. Ellis, Karen Mo, Timothy G. Gregoire, and Bronson W. Griscom. 2019. "Reduced-Impact Logging for Climate Change Mitigation (RIL-C) Can Halve Selective Logging Emissions from Tropical Forests." Forest Ecology and Management 438:255–66. doi: 10.1016/j.foreco.2019.02.004.

FAO, 2015. Global Forest Resources Assessment (FRA) 2015. Rome.

FAO, 2016. Map Accuracy Assessment and Area Estimation: A Practical Guide. p. 69.

FAO, 2020. Forest Resource Assessment 2020.

Filho, A., Adams, C., Murrieta, R. 2013. The impacts of shifting cultivation on tropical forest soil: a review

FSC, 2020. Facts and figures 2020. Forest Stewardship Council. https://fsc.org/en/facts-figures

Frey, C., Penman, J., Hanle, L., Monni, S., Ogle, S., 2006. Uncertainties. IPCC Guidel. Natl. Greenh. Gas Invent. Vol. 1 Gen. Guid. Report. 3.1-3.66. doi:10.1111/j.1749-6632.2009.05314.x

Global Forest Observation Initiative (GFOI), Global Observation of Forest and Land Dynamics (GOFC-GOLD), Norwegian Space Center (NSC), 2017. 2nd Expert workshop on lessons learned from Accuracy Assessments in the context of REDD +. Oslo, pp. 1–12.

Gomez Pompa and Kaus, A. 1992. Taming the wilderness myth. Bioscience 42 (4).

Goodman, R.C., Phillips, O.L., Del Castillo Torres, D., Freitas, L., Cortese, S.T., Monteagudo, A., Baker, T.R., 2013. Amazon palm biomass and allometry. For. Ecol. Manage. 310, 994–1004. doi:10.1016/j.foreco.2013.09.045

GOS, 2005. National Forest Policy of Suriname. Paramaribo, Suriname.

GOS, 2009. Suriname biodiversity profile. http://www.gov.sr/media/232015/country_profile_suriname_aug2009.pdf

GOS, 2017a. Suriname's pledge at UNFCCC COP23, Bonn, Germany: http://unfccc.int/files/meetings/bonn_nov_2017/ statements/application/pdf/suriname_cop23cmp13cma1-2_hls.pdf

GOS, 2017b. 2017-2021 Development Plan for the period 2017-2021 by the Government of the Republic of Suriname, publication of the National Planning Office Suriname (Stichting Planbureau Suriname). August 2017

GOS, 2017c. Report of the Strategic Environmental and Social Assessment (SESA) accompanying the development of the National REDD+ Strategy of the Republic of Suriname. AAE and Tropenbos International Suriname. November 2017.

GOS, 2018. Forest Reference Emission Level for Suriname's REDD+ Programme Modified version. Paramaribo, Suriname.

GOS, 2019a. National REDD+ Strategy of Suriname. Paramaribo, Suriname.

GOS, 2019b.Suriname National Adaptation Plan (NAP) 2019-2029. Paramaribo, Suriname.

GOS, 2020a. Nationally Determined Contribution 2020. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Suriname%20Second/Suriname%20Second%20NDC.pdf

GOS, 2020b. First Summary of Information on REDD+ Safeguards by Suriname. Paramaribo, Suriname.

Griscom, B., Ellis, P., Putz, F.E., 2014. Carbon emissions performance of commercial logging in East Kalimantan, Indonesia. Glob. Chang. Biol. 20, 923–937. doi:10.1111/gcb.12386

Guitet, S., Cornu, J.F., Betbeder, J., Carozza, J.-M., Richard-Hansen, C., 2013. Landform and landscape mapping, French Guiana (South America). J. Maps 9, 325–335.

Guitet, S., Pélissier, R., Brunaux, O., Jaouen, G., Sabatier, D., 2015. Geomorphological landscape features explain floristic patterns in French Guiana rainforest. Biodivers. Conserv. 24.

Haas, M., 2015. Carbon Emissions from Forest Degradation caused by Selective Logging in Fiji.

Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Song, D.-X., Townshend, J.R., 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Sci. Adv. 1, e1500052–e1500052. doi:10.1126/sciadv.1500052

Hansen, M.C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science (80-.). 342, 850–853. doi:10.1126/science.1244693

Harmon, M.E., Sexton, J., 1996. Guidelines for measurements of woody detritus in forest ecosystems.

Heemskerk, M., 2000. Driving Forces of Small-scale Gold Mining Among the Ngjuka Maroons: A Cross-scale Socio-economic Analysis of Participation in Gold Mining in Suriname, PhD Proposal. doi:10.1017/CBO9781107415324.004

Heemskerk, M., Negulic, E., Duijves, C., 2016. Reducing the Use and Release of Mercury by Artisanal and Small- Scale Gold Miners in Suriname.

Howard, J., S. Hoyt, K. Isensee, M. Telszewski, E. Pidgeon, and eds. 2014. "Coastal Blue Carbon: Methods for Assessing Carbon Stocks and Emissions Factors in Mangroves, Tidal Salt Marshes, and Seagrasses." CIFOR. Retrieved November 27, 2020 (https://www.cifor.org/knowledge/publication/5095/).

Hunter, Maria, Michael Keller, Daniel Victoria, and Douglas Morton. 2013. "Tree Height and Tropical Forest Biomass Estimation." Biogeosciences 10:8385–99. doi: 10.5194/bg-10-8385-2013.

Inglada. J and Christophe, E., 2009. "The Orfeo toolbox remote sensing image processing software," in IEEE International Geoscience and Remote Sensing Symposium, IGARSS'09, Cape Town, South Africa, 2009.

IPCC, 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use Chapter 4 forest land 2006. Forestry 4, 1–29. doi:10.1016/j.phrs.2011.03.002

Landburg, 2017. Bepaling van het houtzaag rendement en benutting mogelijkheden voor houtresten die vrijkomen in Surinaamse houtzagerijen. Anton de kom Universiteit van Suriname.

Larjavaara, Markku, and Helene C. Muller-Landau. 2013. "Measuring Tree Height: A Quantitative Comparison of Two Common Field Methods in a Moist Tropical Forest." Methods in Ecology and Evolution 4(9):793–801. doi: https://doi.org/10.1111/2041-210X.12071.

Loftus, Sabá, and Sara Svensson. REDD+ for the Guiana Shield 1st Working Group Report. REDD+ for the Guiana Shield project, ONF International. December 5, 2013. Accessed August 23, 2016. https://reddguianashield.files.wordpress.com/2013/12/1st-working-group-report.pdf.

Fleskens L. and Jorritsma F." A Behavioral Change Perspective of Maroon Soil Fertility Management in Traditional Shifting Cultivation in Suriname". 2010. Human Ecology (2010) 38:217–236. doi: 10.1007/s10745-010-9307-5

Matai R. Jagessar R. Egerton L. Houtenergie in Suriname . Bijdrage van de Bossector an de Energievoorziening. Stichting voor Bosbeheer en Bostoezicht. Paramaribo 2015

McGroddy, M.E., Silver, W.L., Oliveira, R.C. de, 2004. The Effect of Phosphorus Availability on Decomposition Dynamics in a Seasonal Lowland Amazonian Forest. Ecosystems 7, 172–179. doi:10.1007/s10021-003-0208-y

Ministry of Labour, Technological Development and Environment. 2013. The National Biodiversity Action Plan (NBAP) 2012-2016.

Mitchell A.M. (1996) Draft Report on Forest Management, Ministry of Natural Resources, Suriname with FAO, Strengthening National Capacity for the Sustainable Development of Forests on Public Lands.

Mokany, Karel, R. John Raison, and Anatoly S. Prokushkin. 2006. "Critical Analysis of Root : Shoot Ratios in Terrestrial Biomes." Global Change Biology 12(1):84–96. doi: 10.1111/j.1365-2486.2005.001043.x.

Olofsson, P., Foody, G.M., Herold, M., Stehman, S. V., Woodcock, C.E., Wulder, M.A., 2014. Good practices for estimating area and assessing accuracy of land change. Remote Sens. Environ. doi:10.1016/j.rse.2014.02.015

Oloffson P., Arevalo P.,Espejo A., Green C., Lindquist E., McRoberts R., Sanz M., 2020. Mitigating the effects of omission errors on area and area change estimates. Remote Sensing of Environment. doi:10.1016/j.rse.2019.111492

Ouboter, P.E., 2015. Review of mercury pollution in Suriname. Acad. J. Suriname 6, 531–543.

Pearson, T.R.H., Brown, S., Casarim, F.M., 2014. Carbon emissions from tropical forest degradation caused by logging. Environ. Res. Lett. 9, 34017. doi:10.1088/1748-9326/9/3/034017

Pelletier, Johanne, Claude Codjia, and Catherine Potvin. 2012. "Traditional Shifting Agriculture: Tracking Forest Carbon Stock and Biodiversity through Time in Western Panama." Global Change Biology 18(12):3581–95. doi: https://doi.org/10.1111/j.1365-2486.2012.02788.x.

Peterson, G.D. and M. Heemskerk, 2001. Deforestation and forest regeneration following small-scale gold mining in the Suriname Amazon. Environmental Conservation 28(2): 117-126

Playfair, M., 2007. Law Compliance and Prevention and Control of Illegal Activities in the Forest Sector in Suriname: country assessment preliminary version. Washington, DC: World Bank.

Rahm, M., Thibault, P., Shapiro, A., Smartt, T., Paloeng, C., Crabbe, S., Farias, P., Carvalho, R., Joubert, P., 2017. Monitoring the impact of gold mining on the forest cover and freshwater in the Guiana Shield- Reference year 2015.

Rahm M., Smartt T., Totaram J., Sukhu B., Thornhill-Gillis D., Amin N., Thomas R., Sookdeo C., Paloeng C., Kasanpawiro C., Moe Soe Let V., Hoepel I., Pichot C., Bedeau C., Farias P., Carvalho R., Weber JL., and Lardeux C. (2020). Mapping land use land cover change in the Guiana shield from 2000 to 2015. ECOSEO project. pp.69

Richard-Hansen, C., Jaouen, G., Denis, T., Brunaux, O., Marcon, E., Guitet, S., 2015. Landscape patterns influence communities of medium- to large-bodied vertebrates in undisturbed terra firme forests of French Guiana. J. Trop. Ecol. 31, 423–436. doi:10.1017/S0266467415000255

Roopsind, A., Wortel, V., Hanoeman, W., Putz, F.E., 2017. Quantifying uncertainty about forest recovery 32-years after selective logging in Suriname. For. Ecol. Manage. 391, 246–255. doi:10.1016/j.foreco.2017.02.026

Sarmiento, G., Pinillos, M., Garay, I., 2005. Biomass Variability in Tropical American Lowland Rainforests. Ecotropicos 18, 1–20.

Soares-Filho, et. al, *Dinamica—a stochastic cellular automata model designed to simulate the landscape dynamics in an Amazonian colonization frontier*, In Ecological Modelling, Volume 154, Issue 3, 2002, Pages 217-235.

SBB, 2016. Bosbouwstatistieken. Productie, export en import van hout en houtproducten in 2015. Stichting voor Bosbeheer en Bostoezicht, directoraat Bosbouw Economische Diensten, afdeling Statistieken. Mei 2016, Paramaribo.

SBB, 2017. NFMS Roadmap - Status and Plans for Suriname National Forest Monitoring System.

SBB, CELOS, CATIE, ADEKUS, 2017a. Technical Report State-of-the-art study: Best estimates for emission factors and carbon stocks for Suriname 1–56.

SBB, NIMOS, UNIQUE, 2017b. Background study for REDD+ in Suriname: Multi-Perspective Analysis of Drivers of Deforestation, Forest Degradation and Barriers to REDD+ Activities.

SBB, 2019. GCCA+ Suriname Adaptation Project. Setting up a mangrove biodiversity monitoring system. November 2019. Paramaribo, Suriname.

SBB, 2020a. Surinaamse Bosbouwsector Statistieken 2019. Stichting voor Bosbeheer en Bostoezicht, directoraat Bosbouw Economische Diensten, afdeling Statistieken. December 2020, Paramaribo.

SBB, 2020b. SBB logging database. Accessed on 01/11/2020

SBB, 2021. Technical report: Forest cover monitoring in Suriname using remote sensing techniques. Stichting voor Bosbeheer en Bostoezicht, directoraat Onderzoek en Ontwikkeling, afdeling Forest Cover Monitoring Unit. Juni 2021, Paramaribo.

Schnitzer, S.A., DeWalt, S.J., Chave, J., 2006. Censusing and Measuring Lianas: A Quantitative Comparison of the Common Methods1. Biotropica 38, 581–591. doi:10.1111/j.1744-7429.2006.00187.x

Ter Steege, H. 2001. Biomass estimates for forests in Guyana and their use in carbon offsets. Georgetown, Guyana, Iwokrama International Centre for Rain Forest Conservation and Development/UNDP, 44 p.

Tropenbos, 2013. Marketing opportunities for potential Surinamese wood species. Tropenbos International Suriname.

Tropenbos, 2015. Lesser known timber species factsheet. Tropenbos International Suriname.

UNFCCC, 2001. Marrakesh Accords.

Feldpausch, T. R., J. Lloyd, S. L. Lewis, R. J. W. Brienen, M. Gloor, A. Monteagudo Mendoza, G. Lopez-Gonzalez, L. Banin, K. Abu Salim, K. Affum-Baffoe, M. Alexiades, S. Almeida, I. Amaral, A. Andrade, L. E. O. C. Aragão, A. Araujo Murakami, E. J. M. M. Arets, L. Arroyo, G. A. Aymard C., T. R. Baker, O. S. Bánki, N. J. Berry, N. Cardozo, J. Chave, J. A. Comiskey, E. Alvarez, A. de Oliveira, A. Di Fiore, G. Djagbletey, T. F. Domingues, T. L. Erwin, P. M. Fearnside, M. B. França, M. A. Freitas, N. Higuchi, E. Honorio C, Y. Iida, E. Jiménez, A. R. Kassim, T. J. Killeen, W. F. Laurance, J. C. Lovett, Y. Malhi, B. S. Marimon, B. H. Marimon-Junior, E. Lenza, A. R. Marshall, C. Mendoza, D. J. Metcalfe, E. T. A. Mitchard, D. A. Neill, B. W. Nelson, R. Nilus, E. M. Nogueira, A. Parada, K. S. H. Peh, A. Pena Cruz, M. C. Peñuela, N. C. A. Pitman, A. Prieto, C. A. Quesada, F. Ramírez, H. Ramírez-Angulo, J. M. Reitsma, A. Rudas, G. Saiz, R. P. Salomão, M. Schwarz, N. Silva, J. E. Silva-Espejo, M. Silveira, B. Sonké, J. Stropp, H. E. Taedoumg, S. Tan, H. ter Steege, J. Terborgh, M. Torello-Raventos, G. M. F. van der Heijden, R. Vásquez, E. Vilanova, V. A. Vos, L. White, S. Willcock, H. Woell, and O. L. Phillips. 2012. "Tree Height Integrated into Pantropical Forest Biomass Estimates." Biogeosciences 9(8):3381–3403. doi: https://doi.org/10.5194/bg-9-3381-2012.

Verbesselt, J., Hyndman, R., Newnham, G., Culvenor, D., 2010. Detecting trend and seasonal changes in satellite image time series. Remote Sens. Environ. 114, 106–115. doi:https://doi.org/10.1016/j.rse.2009.08.014

Werger, M. J.A (ed.). 2011. Sustainable management of tropical rainforest: the CELOS Management

System. Tropenbos International, Paramaribo, Suriname. 282 p.

Worldbank, 2015. Extractives Policy Note - Suriname 2015.

Wortel V, Sewdien A. 2020. Validation of pantropical and national allometric models for estimation of tree biomass and commercial volume in Suriname. CELOS. Paramaribo, Suriname.

Zalman, Joey, Peter W. Ellis, Sarah Crabbe, and Anand Roopsind. 2019. "Opportunities for Carbon Emissions Reduction from Selective Logging in Suriname." Forest Ecology and Management 439:9–17. doi: 10.1016/j.foreco.2019.02.026.

Zanne, A.E., Lopez-Gonzalez, G., DA, C., Ilic, J., Jansen, S., Lewis, S., Miller, R.B., Swenson, N., Wiemann, M., Chave, J., 2009. Data from: Towards a worldwide wood economics spectrum. Ecol. Lett. doi:doi:10.5061/dryad.234

Annexes

ANNEX I. Information used to construct the FREL and RESULTS

Definitions and information used to construct the FREL

Forest definition for Suriname

Suriname has chosen to map forest based on nationally appropriate criteria chosen in line with the Marrakesh Accords (UNFCCC, 2001) . During the preparation of the Summary of Information on REDD+ Safeguards (GOS, 2020b), the forest definition has also been analyzed comprehensively.

Forest definition:

Land covered primarily by trees, but also often containing shrubs, palms, bamboo, herbs, grass and climbers, with a minimum tree crown cover of 30% (or equivalent stocking level), with the potential to reach a minimum canopy height at maturity in situ of 5 meters, and a minimum area of 1.0 ha.

The forest definition in Suriname excludes:

1. *Crown cover from trees planted for agricultural purposes (including palm trees such as coconut, oil palm etc.);*
2. *Tree cover in areas that are predominantly under urban or agricultural use.*

It should be noted that shifting cultivation (slash and burn agriculture) is included as forest and not as non-forest, so conversion from Forest to Shifting Cultivation is not classified as deforestation, but as forest degradation, as long as it is done in a traditional way. These cultivated areas are usually smaller than one hectare and have a fallow period of at least four years (Fleskens et al., 2010), after which the slash and burn activity is repeated. Also, the ITPs were consulted during the Strategic Environmental and Social Assessment (SESA) (GOS, 2017b), and there it was concluded that shifting cultivation can be seen as a land use within the forest land, and not as a driver of deforestation.

[14] Photo: https://www.gettyimages.com.mx/

For reporting done within the FAO Forest Resource Assessment, the above-mentioned criteria to define forest is applied. This will also be implemented in the next Greenhouse Gas Inventory for the NC3 in order to ensure consistency among different reporting purposes. The considerations of choosing the above-mentioned definition of forest and its parameters are described in the first FREL report (GOS, 2018).

Deforestation

In the context of this FREL submission, gross deforestation is defined as "the direct and/or induced conversion of forest cover to another type of land cover in a given timeframe of 10 years".

This excludes areas that undergo a temporary loss of the forest cover, such as:

- Shifting cultivation (included in the definition of forest): As shifting cultivation areas have fallow periods of at least 4 years (Fleskens et al., 2010) and are smaller than one hectare;
- Natural deforestation where the forest cover will recover naturally such as small areas where windbreaks occur. This is usually observed as deforested areas in remote parts of the forest.

Forest degradation

Forest degradation is for this FREL submission defined as "human-induced or natural loss of the goods and services, provided by the forest land, in particular the forest carbon stocks, not qualifying as deforestation, over a determined period of time".

The above-mentioned goods and services refer to a holistic approach that includes a broad spectrum of aspects such as maintaining biodiversity and hydrological functions. The impact of legal logging and the extraction of firewood, as well as the non-CO2 emissions from biomass burning in Shifting Cultivation reflect forest degradation within this FREL. Forest degradation is only temporary, with the forest expected to recover after a certain period of time. Regarding shifting cultivation, more research is needed to understand the carbon stock changes and emissions resulting from the rotational shifting cultivation activities taking place after the fallow periods.

Compliance with IPCC Guidance

Decision 12/CP.17 annex states that information used to develop a reference level should be guided by the most recent IPCC guidance and guidelines. Therefore, the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (AFOLU sector) were used for technical guidance during the formulation of this FREL.

Good Practice

To ensure the quality of GHG inventories, the IPCC guidelines 2006 provide a set of good practices that Suriname applied as follows:

- **Transparency:** FREL Suriname background information is openly available. National reports and documentation are made available through an online shared folder . This folder also includes Suriname's "FREL calculation tool", which provides insights on how all AD and EF data was used to calculate the emissions in this FREL. All spatially explicit information on forest cover change is available through the open-access geoportal "Gonini" . Since 2021, SBB has also launched a geoportal where national logging specific data is made available . There is a multi-stakeholder collaboration (annex 2) in the development of national Land Use Land Cover (LULC) Maps and an exchange of data between these stakeholders, which promotes transparency regarding spatial data in Suriname.

Reports and documents on spatial and non-spatial information such as Emission Factors (EF), Timber production and Forest Inventory data are published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the website of the SBB (www.sbbsur.com).

- **Accuracy**: Area estimations based on remote sensing are generated following the good practices recommended by (Olofsson et al. 2014; Olofsson et al. 2020) and GFOI (2017) and the tools developed by FAO (2016). To reassure the quality of the field measurements, field plots were reassessed. In case of large deviations, the plots were re-measured by the field teams. The accuracy of the timber production is determined based on expert estimations by SBB, with SBB data approved by other local institutions such as the General Bureau of Statistics and the National Planning Office.
- **Completeness:** All methodologies used, intermediate results and decisions made are presented and documented so that it is possible to reconstruct the FREL (in agreement with decision 13/CP.19).
- **Consistency:** The FREL and the Suriname GHG national inventories were not consistent yet during the development of the first FREL. At the moment, the second FREL and the NC3 are being produced simultaneously, leading to consistency of these two reports. The forest related emissions within the GHG inventory were estimated based on expert knowledge and research, before the NFMS was established. Since the NFMS became operational, regular data is available on the forest cover change using well described national methodologies, and additional data was collected and processed on emissions due to selective logging and carbon stocks. The subsequent GHG inventories will use the data provided by the NFMS. Another example is the national forest definition, which has been updated in the FREL and will be used in a consistent manner for the NC3 and other forthcoming documents.

The national staff responsible for the NFMS and FREL has developed strong capacity by designing methodologies and procedures and building the different data collection components in-house, with support from international partner organizations. This assures consistent application of the methodologies in the future.

Tiers and approaches

A system of tiers and approaches has been developed by the IPCC to represent different levels of methodological complexity. Tier 1 is the basic method, Tier 2 is intermediate and Tier 3 is the most demanding in terms of complexity and data requirements (Chapter 4 of IPCC guidelines 2006). Activity Data are assessed using three different approaches: Approach 1: total land-use area, no data on conversions between land uses; Approach 2: Total land-use area, including changes between categories; Approach 3: Spatially-explicit land-use conversion data (Chapter 3, IPCC guidelines 2006).

Suriname is currently operating mostly at Tier 2 and Approach 3 level:

- Annual wall-to-wall monitoring of the Activity Data (AD) using Landsat and Sentinel 2A imagery, following a standard protocol and applying the methodology recommended by Olofsson et al. (2014) and Olofsson et al., (2020) for land-use and land-use change area estimations. This is done according to Approach 3.
- Activity data are disaggregated by drivers of deforestation. This has been done using ancillary data and field experience from multiple institutions. Throughout this process, guidelines for the visual interpretation of the different land use and land cover classes (LULC) were developed and adjusted (SBB, 2021). This is according to Approach 3.
- While no full National Forest Inventory (NFI) covering the whole country has been carried out, the forest carbon stocks have been assessed by assembling a national database bringing together data from 212 forest inventory plots scattered over the country. In 2019, 11 additional mangrove NFI plots were also established in the coastal area (SBB, 2019), resulting in a total of 13 mangrove plots. Within this national database, above-ground biomass and dead wood (lying and standing) were assessed according to Tier 2, based on national data, but using pantropical allometric estimates. Belowground biomass was assessed using Tier 2.
- To calculate the emissions due to logging, a field procedure was developed and carried out in ten locations using a randomly stratified approach; where 200 felled trees were measured, 150 skid trail

plots were established, 100 log yards and 200 road widths were measured, haul roads within nine concessions were partly mapped and skid trails were mapped and measured in about 550 ha of logging units (Zalman et al., 2019). These emission factors are considered Tier 2.

Suriname will keep taking steps for gradual improvement towards a combination of Tier 2 and Tier 3.

Pools / Gases

For deforestation and shifting cultivation (degradation), the following carbon pools are included in this FREL for Suriname:

- Above-Ground Biomass of trees, palms and lianas (AGB);
- Below-Ground Biomass of trees and palms (BGB);
- Lying and standing dead wood (DW).

Litter

Based on Crabbe et al. (2012), litter contributes ca. 2-6% to the total carbon stock. This litter includes 1-5% lying non-living biomass with a diameter larger than 5 cm, which is included within the FREL. This means that the remaining litter component with a diameter smaller than 5cm contributes less than 5% to the total carbon stock. Because of no reliable complete national dataset, as well as the presented data showing that the contribution of litter smaller than 5 cm is not significant, litter is not included in this FREL. National data will be collected during the coming years, when the next national forest inventory will be carried out.

Soil Organic Carbon

Based on Crabbe et al. (2012) Soil Organic Carbon (depth 0-30 cm) contributes 26.2 t C ha-1 ± 6.7 to the total carbon stock of non-mangrove forests. For mangrove forests along the coast the SOC was determined to be 78.3 t C ha-1 ± 7.6 (0-30 cm) and 243.6 t C ha-1 ± 26.0 (0-100cm). Nevertheless, this dataset was collected only for a very limited sample, for a limited part of the country. Because no further national data was available, Soil Organic Carbon was not included in this FREL.

For logging (forest degradation), the following pools are included in the FREL:

- Above-Ground Biomass of trees and palms (AGB);
- Below-Ground Biomass of trees (BGB);
- Downed and standing dead wood (DW).

Measuring the damage to lianas after timber harvesting is an almost impossible task (they are mostly already decomposed or grow further in another tree). Because of the limited number of trees extracted per hectare (3-4 stems per ha), the associated emissions related to lianas are even more limited (less than 1%) and are therefore not included in forest degradation emissions for this FREL. Within a future submission, methods to increase consistency will be evaluated. For forest remaining forest land, the Tier 1 approach assumes that Soil Organic Carbon and litter are in equilibrium. Changes in carbon stock for Soil Organic Carbon and litter are assumed to be zero.

Gases

The main GHG that is included in this FREL is carbon dioxide (CO2). The estimations of the emissions of non-CO2 gases (nitrous oxide, N2O, and methane, CH4) from burned forest land are also included in the case of deforestation and shifting cultivation. These estimations are based on the IPCC 2006 AFOLU method and factors, after which they are converted to CO2-equivalents for reporting in the FREL. CH4 is also released when swamp or mangrove areas are deforested, but swamp areas being deforested contribute approximately less than 1% to the total deforestation and these non-CO_2 gas emissions are excluded.

Annex II. Deforestation: Activity data, emission factors, methodology and results

Activity data
Conversion Forest and Shifting cultivation to Non-forest (without Forest fires)

The Activity Data (AD) for the conversion from Forest and Shifting cultivation to Non-forest without forest fires have been extracted from the deforestation maps that were developed by the Forest Cover Monitoring Unit (FCMU) at SBB. The satellite images that were used for the wall-to-wall mapping of the deforestation maps are shown in table 4.2, which is also described in the SBB technical report (SBB, 2021). These maps underwent a QA/QC resulting in stratified estimated areas and confidence intervals. The generation of the maps started within the Amazon Cooperation Treaty Organization (ACTO) regional project “Monitoring the Forest Cover of the Amazon region”, followed by the REDD+ program in the framework of the National Forest Monitoring System (NFMS) in Suriname. Up until now, there are eight deforestation maps produced for the following periods: 2000-2009, 2009-2013, 2013-2014, 2014-2015, 2015-2016, 2016-2017, 2017-2018 and 2018-2019. The map of 2000-2009 covers the deforestation from 2001 until 2009 and the map of 2009-2013 covers the deforestation from 2010 until 2013. The deforestation map of 2013-2014 should be interpreted as the deforestation of 2014 and so on.

For creating the 2017-2018 deforestation map, Suriname decided to create the maps using the higher resolution Sentinel 2 imagery, with a resolution of 10 meters, which had recently become available. The use of higher spatial resolution images such as Sentinel 2 resulted in more accurate mapping. Previously, Landsat images with a resolution of 30 meters were used for producing the deforestation maps. The first reference map was also based on Landsat data and was made for the year 2000.

Table 11. Overview of the satellite images that have been used for deforestation maps

Map produced	Data used		
	Satellite	**Sensor**	**Year**
Basemap 2000	Landsat 5	Thematic mapper (TM)	1999, 2000 and 2001
Deforestation map 2000-2009	Landsat 5	Thematic mapper (TM)	2000-2009
Deforestation map 2009-2013	Landsat 7	Enhanced Thematic Mapper plus (ETM+)	2013
	Landsat 8	Operational Land Imager (OLI)	
Deforestation map 2013-2014	Landsat 8	Operational Land Imager (OLI)	2014
Deforestation map 2014-2015	Landsat 8	Operational Land Imager (OLI)	2015

Deforestation map 2015-2016	Landsat 8	Operational Land Imager (OLI)	2016
Deforestation map 2016-2017	Landsat 8	Operational Land Imager (OLI)	2017
Deforestation map 2017-2018	Sentinel 2A and 2B	Multispectral Instrument (MSI)	2018
Deforestation map 2018-2019	Sentinel 2A and 2B	Multispectral Instrument (MSI)	2019

The method for monitoring deforestation in Suriname is divided into three main stages:

1. Pre-processing: image processing;
2. Core-processing: supervised classification;
3. Post-processing: final classification.

In the pre-processing stage the satellite images are collected, made cloud-free and are used to produce a mosaic, which can further be used in the core-processing stage. During the core-processing stage the supervised classification is executed on the mosaic, based on training samples. Finally in the post-processing stage, the supervised classification is adjusted where necessary.

The method for producing the deforestation maps can be seen as a semi-automatic classification in QGIS using Orfeo Toolbox (Inglada and Christophe, 2009), followed by a post-processing step in TerraAmazon (GIS software developed by INPE), where the classes were visually checked and adjusted where necessary. This methodology used by Suriname is extensively explained in the SBB (2021) technical report.

Since the Sentinel satellite images became available in 2016, they have been used as input data for creating the deforestation maps from 2017 onwards. The spatial resolution of Sentinel 2 is 10m, which leads to a higher accuracy and lower uncertainty of the deforestation maps compared to using Landsat. The data goes through a QA/QC process, which results in stratified estimated areas and confidence intervals. Table 4.3 shows the difference of the stratified estimated areas and the confidence interval when using Landsat versus Sentinel 2 images for each of the deforestation maps. The number of samples that was used for the QA/QC process is given in table 12.

Table 12. Stratified estimated area and confidence interval of the deforestation data

Period deforestation maps	Map area (ha)	Stratified estimated area (ha)	Confidence interval (ha)	Input data
2000-2009	24,784	33,051.00	5,361.000	Landsat data
2009-2013	30,833	32,071.05	2,388.009	
2013-2014	17,222	15,757.49	2,081.609	
2014-2015	12,308	9,442.39	1,620.402	
2015-2016	10,990	11,386.56	1,886.047	
2016-2017	8,891	10,667.03	3,162.109	
2017-2018	9,861	8,817.96	315.409	Sentinel 2 data
2018-2019	10,490	10,243.41	0.002	

The intention is to keep using Sentinel imagery for creating maps, until alternative free higher quality images become available that can be used to improve the current monitoring method.

Since the availability of Sentinel images, data is also being managed and analyzed differently. The increasing availability of bulk remote sensing data has led to a method that is carried out using a more automated workflow, where massive remote sensing data can now be processed using cloud-based methods such as using Google Earth Engine (GEE).

The three main stages (pre-processing, core-processing and post-processing) are still applied for all deforestation maps. More detailed information regarding the methodology of the map production is described in the technical report of SBB (2021).

Conversion Forest to Non-forest through Forest fires

The AD for the conversion of Forest to Non-forest through Forest fires is extracted from the deforestation maps and post-deforestation LULC maps. The post-deforestation LULC maps show the drivers of deforestation for specific periods and were analyzed cumulatively starting from 2000 to each specific year. Currently, the following periods of the post-deforestation LULC maps are available: 2000-2009, 2000-2013, 2000-2015 and 2000-2017. Based on the Post-Deforestation LULC data from these periods (cumulative deforestation) and the deforestation data (expansion) for each period and year, the burned areas were extracted for the periods or years. The Fire Information for Resource Management System (FIRMS) data was used as ancillary data to identify the burned areas. Figure 4.1 shows how the FIRMS forest fire data is predominantly occurring in shifting cultivation, savanna and agriculture areas.

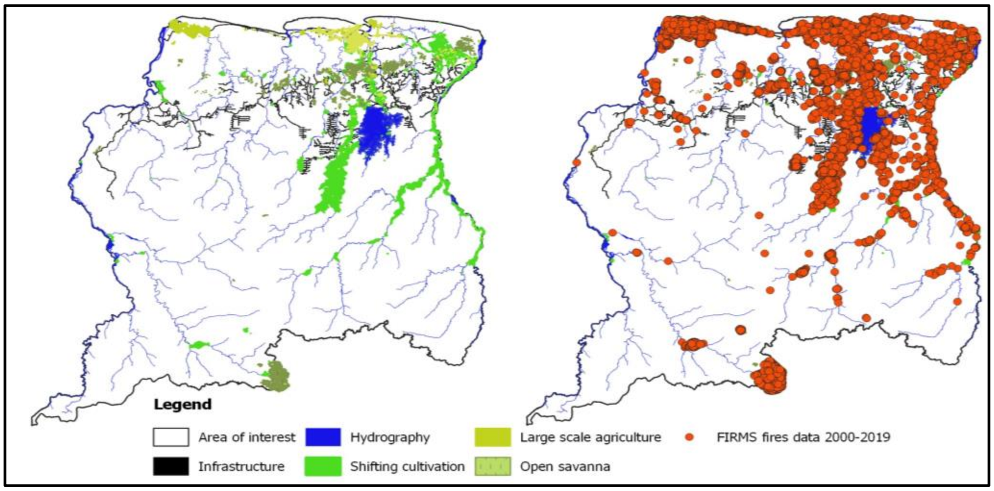

Figure 11.FIRMS forest fires data from the MODIS sensor

Quality Assessment/ Quality Control (QA/QC)

The first quality assessment on the forest cover change maps was executed with support of the UN-REDD program using the method developed by the FAO. The method includes a set of "Good Practice" recommendations for designing and implementing an accuracy assessment of a change map and estimating area based on the reference sample data. The set of "good practice" recommendations address three major components: sampling design, response design and analysis (P. Olofsson et al, 2014).

Sampling design

The sampling design that was applied here is a stratified random sampling design. A stratified random sampling is generated based on the final land cover data to be validated, making use of the SEPAL Stratified Area Estimator (SAE)-Design tool. The strata used for the final land cover data are deforestation, stable forest and a forest buffer area. Figure 12 illustrates the strata of the land cover data to be used in the sampling design. Since deforestation is a rare class in Suriname, a buffer is used to mitigate the effects of omission errors (Oloffson et al., 2020). A spatial buffer in this context is an area mapped as forest around deforested pixels, with a radius of 1300 meters. The buffer of 1300m is based on a research study that was executed on the prediction of deforestation risk in Suriname (Kasanpawiro C., 2015)[15]. The study shows that the radius of 1300m was estimated as the maximum distance where deforestation is more likely to occur, away from previous deforested areas.

[15] Link to report by Kasanpawiro C.pdf

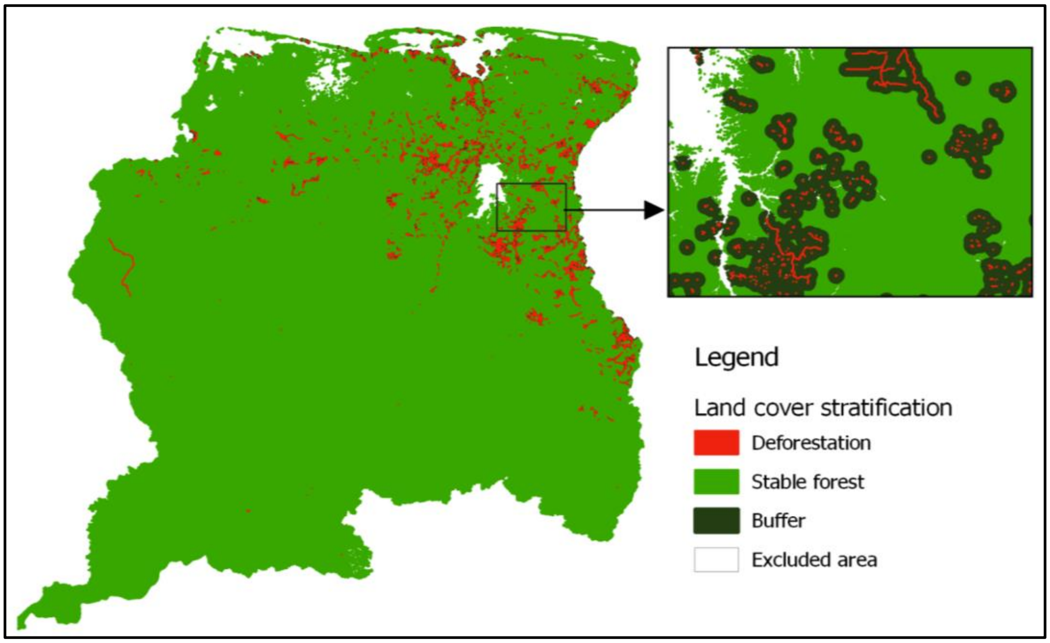

Figure 12. Stratification of the land cover classification to be used in the sampling design

With this stratification as input, the SAE-design tool generates a set of stratified random points that are placed in each of the different land cover classes represented in the strata. The number of points in each class will be scaled to the area that each class covers on the map. In the sampling design, the sample size for each map category was calculated to ensure that the sample size is large enough to produce sufficiently precise estimates of the area of the class. Figure 4.3 shows the proportionally distributed points, using the stratification as input.

Equation below calculates an adequate overall sample size for stratified random sampling that can then be distributed among the different strata (Oloffson (2014, (Eq.13)). For calculating an adequate overall sample size for stratified random sampling:

$$n = \frac{(\sum W_i S_i)^2}{[S(\widehat{O})]^2 + (1/N)\sum W_i S_i^2} \approx \left(\frac{\sum W_i S_i}{S(\widehat{O})}\right)^2$$

Where:

- N is number of units in the area of interest (number of overall pixels if the spatial unit is a pixel, number of polygons if the spatial unit is a polygon)
- S(O) is the standard error of the estimated overall accuracy that we would like to achieve
- Wi is the mapped proportion of area of class i
- Si is the standard deviation of stratum i.

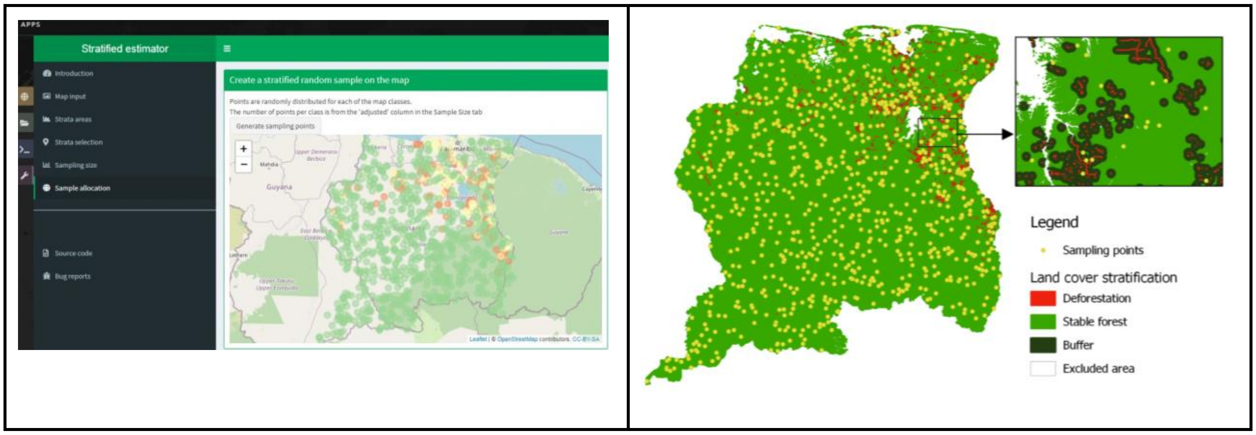

Figure 13. Proportionally distributed points, using the stratification as input

The final samples can be manually adjusted, taking into account that the minimum number of samples should be at least 30 in order to be representative. A minimum sample per strata is set at 100, so that enough sample points are distributed to small rare classes (where proportionally zero samples would have been distributed). Table 14 gives an overview of the samples allocated per stratum per period.

The column Dataset represents each time a QA/QC was executed for the specific map periods.

Dataset 1 has less points than the following datasets. The quality assessment of dataset 1 was carried out in 2016 with guidance from the FAO, assessing the period 2000-2015. After that moment, there was a need for doing the quality assessment of each map for consistency and reporting purposes.

For this reason, the second QA/QC (dataset 2) included the period 2009-2013, even though this was already included in the first dataset. The sampling points of 2009-2013 were then removed from dataset 1 and added in dataset 2, resulting in a total sampling points of 517 for dataset 1.

Table 13. Sampling points distributed per stratum for the time periods

Data-set	Period	Sample point allocation/stratum					
		Non-forest 2000	Hydrography	Forest	Deforestation	Buffer	Total
1	2000-2009	100	100	217	100		517
2	2009-2013			490	100	100	990
	2013-2014				100		
	2014-2015				100		
	2015-2016				100		
3	2016-2017			601	100	100	801
4	2017-2018			700	100	100	900

5	2018-2019			767	100	100	967

Response design

The team for the response design consists of 3 interpreters. Area and error estimates are based on the human interpreter's labelling of the sample; therefore, it is important that the labels are correct and that the labelling across interpreters is consistent. To ensure this, interpretation keys have been developed. Interpretation keys are used to interpret and classify the sample points in a systematic way. These are described in detail in the updated Technical report of SBB (2021). Both Landsat and Sentinel images were used in the response design. Table 15 shows the sources of the map and reference classification used for each map period.

Table 14. Sources of map classification and reference classification

Data products	Map classification	Reference classification
Reference map 2000	Landsat	Landsat
Deforestation 2000-2009	Landsat	Landsat
Deforestation 2009-2013	Landsat	Landsat
Deforestation 2013-2014	Landsat	Landsat, SPOT4, 5, 6 data
Deforestation 2014-2015	Landsat	Landsat, SPOT 4, 5, 6 data
Deforestation 2015-2016	Landsat	Sentinel 2A
Deforestation 2016-2017	Landsat	Sentinel 2A and 2B
Deforestation 2017-2018	Sentinel 2A and 2B	Sentinel 2A and 2B
Deforestation 2018-2019	Sentinel 2A and 2B	Sentinel 2A and 2B

Analyses

The resulting data from the response design have been further analyzed in Ms-Excel where an error/confusion matrix is created. The error matrix is a simple cross-tabulation of the class labels allocated by the classification of the remotely sensed data against the reference data for the sample sites. The error matrix organizes the acquired sample data in a way that summarizes key results and aids the quantification of accuracy and areas. The main diagonal of the error matrix highlights correct classifications, while the off-diagonal elements show omission (the columns) and commission errors (the rows). The User's Accuracy (UA) and the Producer's

Accuracy (PA) are also given in the confusion matrix. UA corresponds to error of commissions (inclusion) and PA corresponds to error of omissions (exclusion). Table 16 shows an example of a confusion matrix. This matrix is from the map period 2018-2019.

Table 15. Confusion matrix of map period 2018-2019 with the PA and the UA included

	Reference						
Map	***deforestation 2000 - 2018**	**deforestation during 2018-2019**	**hydrography**	**non-forest**	**forest**	**Grand Total**	**UA**
***deforestation 2000-2018**	1025			75	0	1100	93%
deforestation during 2018-2019		83			2	85	98%
hydrography			581	27		608	96%
non-forest			22	806	87	915	88%
forest	3				1605	1608	100%
Grand Total	**1025**	**83**	**603**	**908**	**1694**	**4316**	
PA	100%	100%	96%	89%	95%		

**The non-forest class only indicates the non-forest areas from the year 2000, while deforestation 2000-2018 represents all deforested areas for this period.*

The confusion matrix provides the basis for estimating the areas. Area estimations should be based on the proportion of area derived from the reference classification. Table 17 shows the proportional confusion matrix based on shows the standard error and the 95% confidence interval.

Table 16. Proportional confusion matrix

Proportional confusion matrix						
	Previous deforestation	**deforestation 2018-2019**	**hydrography**	**non-forest**	**forest**	**Map area**
Previous deforestation	0.93			0.07	0.00	114,571.40
deforestation 2018-2019		0.98			0.02	10,490.24
hydrography			0.96	0.04		331,238.70
non-forest			0.02	0.88	0.10	777,138.75
forest	0.00				1.00	15,133,386.16
						16,366,825.25

For the stratified estimator of proportion of area of class k, the standard error is estimated by the following equation (Olofsson, 2014 (Eq.10)

Stratified estimator of proportion of area

$$S(\hat{p}_{\cdot k}) = \sqrt{\sum_i W_i^2 \frac{\frac{n_{ik}}{n_{i\cdot}}\left(1-\frac{n_{ik}}{n_{i\cdot}}\right)}{n_{i\cdot}-1}} = \sqrt{\sum_i \frac{W_i \hat{p}_{ik} - \hat{p}_{ik}^2}{n_{i\cdot}-1}}$$

Where:

S (pk) = standard error for the stratified estimator of the proportion of area

Wi = area proportion of map class i

N ik = sample count of map class i in the error matrix that corresponds with reference map

Ni = total samples for class i on the map

Equation 4.6: The standard error for the estimated area (Olofsson, 2014 (Eq.11))

$$S\left(\hat{A}_k\right) = A \times S(\hat{p}_{\cdot k}).$$

Where:

S(Ak) = standard error of the estimated area of class k

A = total map area

Table 17. Standard error and 95% confidence interval

Matrix of weighted variances					
	Previous deforestation	**deforestation 2018-2019**	**hydrography**	**non-forest**	**forest**
Previous deforestation	2.83E-09			2.83E-09	0.00E+00
deforestation 2018-2019		1.12E-10			1.12E-10
hydrography			2.86E-08	2.86E-08	
non-forest			5.75E-08	2.59E-07	2.13E-07
forest	9.91E-07				
Total	9.94E-07	1.12E-10	8.61E-08	2.91E-07	2.13E-07

Standard error	1.63E+01	2.00E-03	1.41E+00	4.76E+00	3.49E+00
95%Confidence Interval	3.19E+01	4.00E-03	2.76E+00	9.33E+00	6.84E+00

The uncertainty for the deforestation areas was calculated by dividing the confidence interval with the stratified estimated area, both available as outputs from the QA/QC of the deforestation maps (SBB, 2021). The stratified estimated areas and confidence interval are also shown in annex 9. The uncertainty calculations for the AD of deforestation can be seen in the tab "AD_DEF" in the FREL calculation sheet for Suriname. More detailed information regarding the quality assessment of the maps is described in the updated technical report of (SBB) 2021.

Deforestation trends and land use

Figure 14 illustrates the annual deforestation for the time periods based on the results of the QA/QC assessment. The annual data shows a general increase of deforestation in the period 2009-2014, whereafter it decreased and continues to follow a stable trend until 2019. This trend may be partially explained by the sharp increase of the gold price in 2009-2014, followed by a decreased and then stable gold price until 2019. The historical trend of the gold price[16] is illustrated in figure 15. This also shows that after 2019 the gold price increases, which could eventually lead to a high rate of deforestation after 2019.

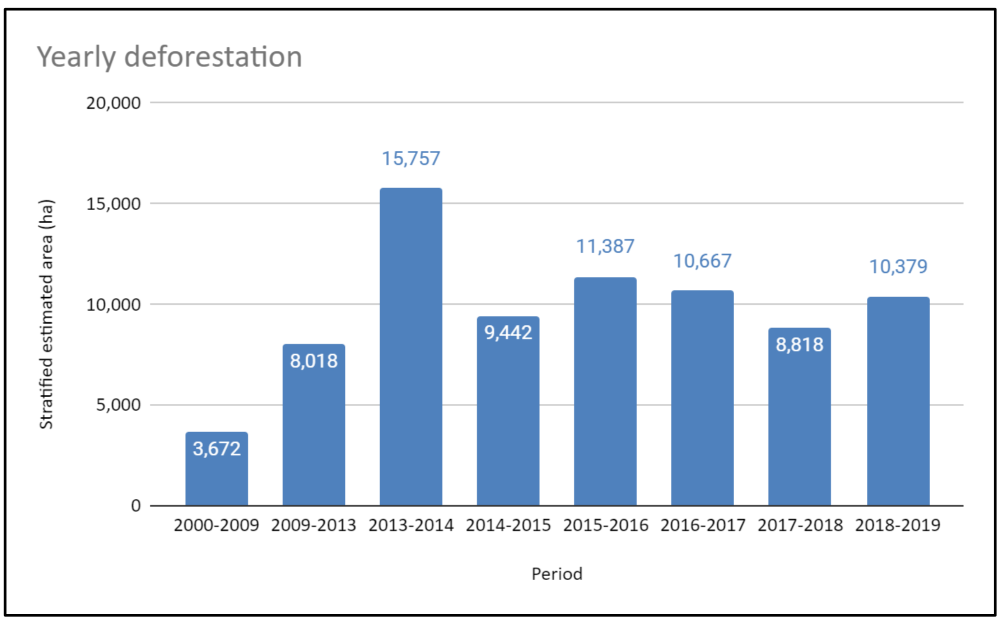

Figure 14. Annual average estimated area of deforestation (SBB, 2021)

[16] www.goldprice.org

Figure 15. Historical gold price data

Post-deforestation Land Use Land Cover (LULC) maps

Based on the deforestation maps, post-deforestation Land Use Land Cover (LULC) maps are produced showing the different drivers of deforestation. Within the regional ACTO project it was agreed by all member countries that these maps will be produced every two years, in order to monitor the land use changes. The post-deforestation LULC maps have been produced for the periods: 2000-2009, 2000-2013, 2000-2015 and 2000-2017. The drivers were determined through multi-sectoral collaboration. For these maps, the following classes were considered: Agriculture, Burned area, Infrastructure, Mining, Pasture, Built area, Other and Secondary vegetation. Forest fire (Burned areas class) is considered for the estimation of the non-CO_2 gasses. The data for the Burned area have been extracted from the post-deforestation LULC maps 2000-2009, 2000-2013, 2000-2015 and the deforestation data from 2016-2017 and 2018-2019.

The results of the most recent post-deforestation LULC map (2000-2017) shows that Mining is the main driver of deforestation (68%), with 98% of mining resulting from gold mining activities (SBB, 2021). According to the regional study where the impact of gold mining on the forest cover in the Guiana Shield region was assessed, the rate of gold mining has doubled when comparing the periods 2000-2008 and 2008-2014 (Rahm M. et al., 2015). In the recent Ecosystem Services Observatory of the Guiana Shield (ECOSEO) regional project, it seems that there was a more stable trend of gold mining during the period 2016-2018, compared to the previous period (Rahm M. et al., 2020). This could be due to the stable price of gold on the international market. Based on a general assessment, 80% of the gold mining areas are artisanal small-scale gold mining (ASGM).

In Suriname, the other two main drivers of deforestation for the period 2000-2017, followed by Mining are Infrastructure (18%) and Agriculture (5%) (SBB, 2021). Figure 16 shows an overview of the drivers of deforestation for the period 2000-2017. These activities are assumed to cause long term deforestation (more than 10 years), which is in line with the FRA deforestation standard which states that[17] *"an area cannot be defined as deforestation when the forest regenerates in this area within 10 years"*.

Infrastructure is the second largest cause of deforestation, as many new roads are built to reach new logging areas in the interior of the country. This is related to the increase in the annual logging production, as increased logging means that more logging areas have to be reached. These roads can also serve a dual purpose by making remote communities accessible. Logging infrastructure is also built in the Greenstone belt resulting from the

[17] FRA 2000

expansion of mining activities. Deforestation or conversion from forested land to other types of land is monitored in Suriname using the IPCC Approach 3.

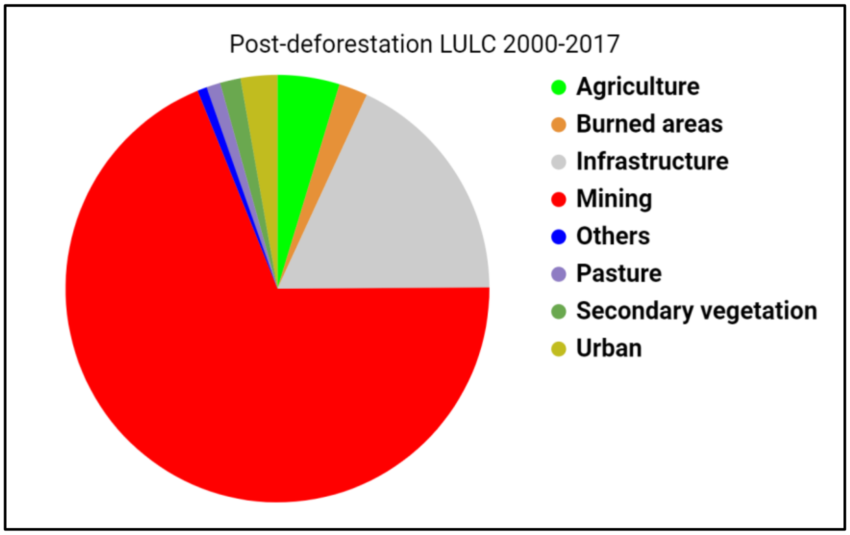

Figure 16. Drivers of deforestation areas for the period 2000-2017

Source and compilation of data for carbon stocks

Within the country's REDD+ Readiness phase, a study was carried out bringing together data from different forest inventory programs as shown in figure 4.7 (more details on the inventories can be found in annex 4). This study, *Technical Report State-of-the-art study: Best estimates for emission factors and carbon stocks for Suriname* done by SBB in collaboration with CATIE, CELOS and AdeKUS (SBB *et al.*, 2017a) was an update of earlier work carried out by Arets *et al.* (2011). Also, data from 11 new mangrove NFI plots (SBB, 2019) and 2 previously executed NFI plots has been included in this FREL. The method for harmonizing, quality checking and processing the NFI data was similar for all the NFI's carried out.

The forest inventory databases went through a harmonization process, including a QA/QC component, making sure that all data were comparable, after which they were merged into one database. The first step in performing data quality control was to unify criteria for identifying and standardizing categorical and numerical variables. This included unifying the names of the variables, encoding variables and converting the numerical value of dbh and height to the same measurement units.

Subsequently, the following protocol for data analysis was established (more details to be found in SBB *et al.* (2017a)):

- Detection of outliers using minimum and maximum function. This activity was performed using the dbh variable component, and identifying the maximum and minimum values;
- Identification of a unique scientific name for each species. All scientific names were reviewed to identify synonyms and inaccurate writing, for which the software F-Diversity (Casanoves *et al.*, 2010) was used;
- Identification of outliers through standardization. When the databases had several species, the identification of outliers had to be performed for each species. In order for standardization to correctly identify unusual values, the species in question must have a considerable number of individuals. The equation used in this study to standardize the data sets was:

Standardization equation

$$Z = \frac{X - \mu}{\sigma} N(0; 1)$$

Where:

X the value of the response variable,

μ the overall mean of that variable in one species,

σ the square root of the variance of the variable within a species.

By applying this, dbh records of each species were standardized, and values > 3.5 standard deviations and <-3.5, were considered outliers. These atypical values were revised and then corrected or discarded (SBB *et al.*, 2017a).

Vernacular tree species names were converted to scientific names using an update of the regional tree species list[18] and cross checked with the Taxonomic Name Resolution Service (TNRS)[19] into the most recent scientific name. This allows the tree species to be linked with the wood density values.

Forest stratification

With the country being entirely part of one ecoregion, the Guiana Shield, it is a challenge to effectively categorize forest diversity for modeling the main ecosystem services. As no nationally approved area estimations for forest types is available, the forest type classification was not further considered and an approach using four more general strata was implemented for now.

For this FREL, a stratification of the country was made combining physical (e.g. natural boundaries) and administrative boundaries (e.g. protected areas, southern border of the forest belt) (SBB *et al.*, 2017a). The coming greenhouse gas inventory report will also include the emissions factors per strata in order to streamline the reports. Figure 4.7 shows an overview of the stratification of the country. The boundaries are similar to the boundaries used in the first FREL, with only the mangrove delineation being updated by the SBB (2019) mangrove NFI.

[18] https://reddguianashield.com/studies/improving-knowledge-sharing-on-tree-species-identification-in-the-guiana-shield/

[19] http://tnrs.iplantcollaborative.org/

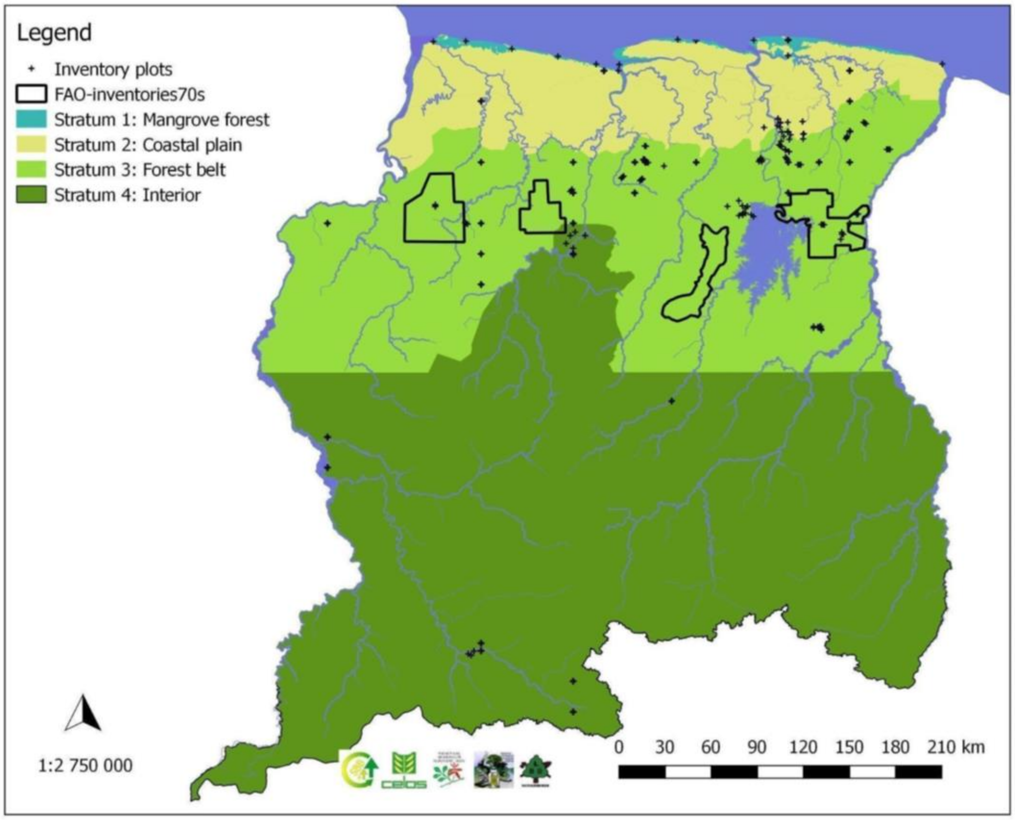

Figure 17. Preliminary stratification of Suriname with NFI plot locations

The four general strata are delineated based on a general understanding of large different landscapes:

Stratum 1**:** Mangrove forest, because of its specific characteristics and dynamics, but also the role this forest type plays in both climate change mitigation and adaptation. The borders of the mangrove stratum have been updated based on the mangrove NFI study results (SBB, 2019);

Stratum 2**:** "Younger" Coastal plain. This stratum is delineated based on the occurrence of the precambrian Guiana Shield;

Stratum 3**:** The Forest belt, the area where logging concessions are granted (North of the 4° Northern Latitude);

Stratum 4**:** Forest areas where very limited activities are carried out (south of the 4° Northern Latitude) including the Central Suriname Nature Reserve, where little anthropogenic activities are carried out.

While a full NFI is currently being prepared to be carried out in the coming years (SBB, 2017), the EF due to deforestation was calculated using these four general strata, based on this compiled database. The emission factors for deforestation (equal to average carbon stocks) used for the different strata are displayed in table 4.10.

Deforestation emission factors

The 2006 IPCC Guidelines provides definitions for five carbon pools: Above-Ground Biomass, Below-Ground Biomass, dead wood, litter and soils (Chapter 1, Volume 4, IPCC 2006). Based on the available data in the database described in section 4.4.2, Suriname will include the carbon pools[20] within this FREL as indicated in table 4.9. To avoid biased estimates for carbon stock, all data within the harmonized database was weighed by the plot size. The average carbon stocks and related uncertainties were calculated under a stratification sample frame.

To determine the carbon content in the different carbon pools, the biomass is converted to carbon. The IPCC 2006 recommends to use a factor of 0.47, based on McGroddy *et al.* (2004). In table 4.10 the average carbon stocks in t CO_2 per hectare per pool per stratum are shown.

The emission factors for deforestation per stratum (table 4.11) are calculated by converting the carbon stocks per stratum (table 4.10) to its CO_2-equivalent by using the factor 44/12.

Table 18. Carbon pools and methods to estimate carbon in forest biomass in Suriname

Above-Ground Biomass (AGB)
Trees (dbh ≥ 5 cm): Since Suriname has not yet developed specific allometric equations, the pantropical equation developed by Chave *et al.* (2014) was used for estimating the AGB for trees (including mangrove). This is an improvement compared to the previous FREL in which the equation from Chave et al. (2005) was used, although it was not validated. The choice for Chave 2014 is based on the results of the 2020 (Wortel & Sewdien) national allometry validation study , where 31 trees were destructively sampled at 6 locations in Suriname (In the coastal plain and forest belt strata) to determine which is the most suitable pantropical allometric model to use for Suriname. The result of this study showed that the AGB model 7 developed by Chave *et al.* (2014) performed the best in estimating the AGB for trees in Suriname. Model 7 is developed so that AGB can be inferred in the absence of height measurements. The parameters for the Chave 2014 included the dbh in cm, the measure of environmental stress (E) and wood density values (ρ) in g cm^{-3}. The wood densities were obtained from the Global Wood Density Database (Zanne *et al.*, 2009). A community weighted mean of 0.68 g cm^{-3} was found for the wood density in this dataset and used for unknown species. The E was extracted from the global gridded layer of E at 2.5 arc sec resolution (available at http://chave.ups-tlse.fr/pantropical_allometry.htm), by using the plot locations of the trees harvested. **Palm trees:** For estimating the AGB of palms, four specific genus equations and one general family equation were used, according to Goodman *et al.* (2013). **Lianas (D ≥ 5 cm):** To calculate the biomass stored in lianas, the equation developed by Schnitzer *et al.* (2006) was used.
Below-Ground Biomass (BGB)
To obtain the BGB value for all living trees, AGB values were multiplied by the 0.24 factor for tropical rainforests (Mokany *et al.*, 2006), as recommended by the IPCC 2006.
Lying Dead Wood (LDW)

[20] While there was data available on litter and Soil Organic Matter, this data was collected only in a limited geographic area (forest belt) (Crabbe *et al.,* 2012). Therefore, for the second FREL, Suriname will not report on these two carbon pools.

Biomass in lying dead wood was estimated from the volume of the tree using Smalian's formula, the community weighted mean (0.68 g cm^{-3}) and a biomass reduction factor approach (suggested by Harmon and Sexton, 1996). Factors used depended on the decomposition state of the tree. For solid wood the factor used was 0.46, for wood in advanced state of decomposition it was 0.40 and for decayed wood 0.34 (SBB *et al.*, 2017a). Lying dead wood data was not available for the mangrove strata. Lying dead wood was not quantified for the mangrove strata due to a lack of data.
Standing Dead Wood (SDW)
Biomass in standing dead trees was estimated based on the dbh measured in the field and using the Chave *et al.* (2014) equation developed for estimating biomass in living trees. After this, knowing that the wood density is lower for standing dead trees, it was assumed that all standing dead trees were decomposing, thus a biomass reduction factor representing 75% of the individual total weight was applied to each individual, as suggested by Brown *et al.* (1992) and Saldarriaga *et al.* (1998), cited by Sarmiento, Pinillos and Garay (2005). This is also supported by Howard *et al.*, (2014) for mangrove SDW.

The vegetation of Suriname can be classified into three main types: Hydrophytic, Xerophytic and Mesophytic. Mesophytic vegetation, mainly consisting of high tropical lowland forest with a diverse species mix, is considered the most valuable from a commercial perspective (LBB, 1990 in Mitchell, 1996). The forest belt has a higher average carbon stock than the interior where only very limited anthropogenic activities are carried out. This could be explained by the fact that the interior is difficult to access, resulting in a limited number of plots there or by a sparser tree cover in the interior because of the mountainous landscape and/or savanna. The mangrove carbon stock data in this FREL is updated with new mangrove NFI data collected (SBB, 2019). Previously there were 2 mangrove NFI plots included. Here the carbon stock data was collected at 11 additional locations in the mangrove belt of Suriname, resulting in a total of 13 NFI plots in mangrove forest. This new data shows that the mangrove carbon stocks are several times higher than estimated in the previous FREL. Uncertainties for each carbon pool are presented in detail in Suriname's "FREL calculation tool"[21].

Table 19. Carbon stocks in the selected pools in each stratum updated from SBB et al. (2017a)

Carbon Pools		**Forest carbon stock (t C02 ha^{-1})**			
		Mangrove forest	**Coastal plain**	**Forest belt**	**Interior**
Above-Ground Biomass	Living trees (dbh ≥ 5cm)	439.38	474.06	548.24	488.68
	Palms	0.00	18.61	3.90	8.28
	Lianas	0.00	2.35	10.36	8.72
Below-Ground Biomass	Roots	105.45	118.24	132.51	119.27
Dead Wood	LDW	0.00	11.86	42.30	16.51
	SDW	102.23	4.79	11.50	7.04

[21]Link to Suriname's FREL calculation tool.

Total		647.05	629.91	748.82	648.50

Compared to the first FREL, the AGB calculated with Chave 2014 is lower than with Chave 2005. Reason for this may be that, as stated in Chave 2014, one major issue with the Chave et al. (2005) allometry relates to the importance of direct tree height measurements in AGB stock estimation.

If total tree height is available, allometric models usually yield less biased estimates. However, tree height has often been ignored in carbon-accounting programs because measuring tree height accurately is difficult in closed-canopy forests (Hunter et al. 2013; Larjavaara and Muller-Landau 2013). Feldpausch 2012 also stated that across the tropics including height reduces errors from 41.8 t C ha^{-1} (range 6.6 to 112.4) to 8.0 t C ha^{-1} (−2.5 to 23.0). Thus, if tropical forests span 1668 million km2 and store 285 Pg C (estimate including H), carbon storage is overestimated by 35 Pg C (31–39 bootstrapped 95 % CI) if H is ignored. Tree H is an important allometric factor that needs to be included in future forest biomass estimates to reduce error in estimates of tropical carbon stocks and emissions due to deforestation (Wortel and Sewdien, 2020).On the other hand, the results calculated with available data in Suriname appear to be consistent with results from other studies such as Alder and Kuijk (2009), cited by (Cedergren 2009), who reported AGB carbon stocks for the Guiana Shield of 152 t C ha^{-1}, while ter Steege (2001) found carbon stocks in Guyana between 111.5 and 146.5 t C ha^{-1}. Furthermore, Arets *et al.* (2011) reports that AGB carbon stocks in Suriname range from 121 to 265 t C ha^{-1}. Activities are planned to improve these estimations, especially through the implementation of a full multipurpose National Forest Inventory.

Table 20. Deforestation emission factors resulting from changes in forest carbon stock

Stratum	Forest to non-forest (no forest fires)		Shifting cultivation to non-forest	
	t CO_2 ha^{-1}	**Uncertainty**	**t CO_2 ha^{-1}**	**Uncertainty**
Mangrove forest	647.05	32.40%	191.40	14.18%
Coastal plain	629.91	17.30%	191.40	14.18%
Forest belt	748.82	4.14%	191.40	14.18%
Interior	648.50	8.89%	191.40	14.18%

The emission factor for each strata was determined using the carbon stocks, based on the assumption that deforestation results in instant total emissions of the carbon stock. A different emission factor was applied for deforestation in areas where previous shifting cultivation had taken place, as the carbon stock of these areas was significantly lower. It was assumed that the carbon stock of an area where shifting cultivation had taken place was reduced to 191.40 t CO_2 ha^{-1} as proposed by Pelletier et al. (2012). Uncertainties related to shifting cultivation may be underestimated as the emission factor data is not based on local data but based on Pelletier et al. (2012). Conversion from forest to agriculture resulted in a 99% loss of carbon stock (SBB, 2017a), and has been included as deforestation as the remaining carbon stock is not seen as significant. In the case of deforestation through forest fires, additional non-CO_2 related gasses are taken into account and added as additional emission, as described below.

Non-CO_2 emissions from deforestation through forest fire

Emissions from deforestation through forest fire include not only CO_2, but also other greenhouse gases, or precursors of greenhouse gases that originate from incomplete combustion of the fuel. These include carbon monoxide (CO), methane (CH_4), non-methane volatile organic compounds (NMVOC) and nitrogen (e.g., N_2O, NO_x) species. In this FREL, the only non-CO_2 gases included are CH_4 and N_2O (IPCC, 2006). The emissions were estimated by using equation 4.8, extracted from IPCC (2006), cf. Volume 4, Chapter 2, and Section 2.4.

Calculation method for the non-CO2 forest fire emissions from deforestation

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

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG (CH_4, N_2O)

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha^{-1}

Note: This includes aboveground biomass and dead wood.

C_F = combustion factor, dimensionless (default values in Table 2.6)

G_{ef} = emission factor, g kg^{-1} dry matter burnt (default values in Table 2.5)

The resulting non-CO_2 (CH_4 and N_2O) related emission factors from deforestation through forest fire are converted to the CO_2-equivalent values and presented in table 4.12 and 4.13 for respectively conversion from Forest to Non-forest and Forest to Shifting cultivation.

Table 21. Non-CO2 emissions factors for the conversion of Forest to Non-forest through forest fire

	CH_4		N_2O	
	t CO_2e ha^{-1}	Uncertainty (%)	t CO_2e ha^{-1}	Uncertainty (%)
Mangrove forest	16.16	56.74%	7.01	48.52%
Coastal plain	15.26	49.68%	6.63	40.04%
Forest belt	18.38	46.76%	7.98	36.35%
Interior	15.79	47.41%	6.85	37.19%

Table 22. Non-CO2 emissions factors for the conversion of Forest to Shifting cultivation through forest fire

	CH_4		N_2O	
	t CO_2e ha^{-1}	Uncertainty (%)	t CO_2e ha^{-1}	Uncertainty (%)
Mangrove forest	13.59	52.96%	5.90	44.04%
Coastal plain	13.08	48.54%	5.68	38.61%
Forest belt	16.63	46.78%	7.22	36.38%

Interior	13.64	47.19%	5.92	36.90%

Historical emission due to deforestation

Emissions caused by deforestation are determined following IPCC (2006) , by multiplying the AD with the EF for gross deforestation (the average carbon stock of the forest in t C per ha). While more detailed carbon stocks for other land use types need to be determined, it was assumed that the carbon stock after deforestation is zero. This is because most of the deforestation was caused by all mining (69%), urban (3%) and infrastructure (18%) (SBB, 2021), which are land use classes corresponding to a carbon stock of zero.

Table 23. Emissions due to deforestation for the period 2000-2019

	CO_2		**CH_4 (CO_2-equivalent)**		**N_2O (CO_2-equivalent)**		***Total CO_2-equivalent***	
Year	*Total Emissions (t CO_2 yr^{-1})*	*Uncertainty (%)*	*Total Emissions (t CO_2 yr^{-1})*	*Uncertainty (%)*	*Total Emissions (t CO_2 yr^{-1})*	*Uncertainty (%)*	*Total Emissions (t CO_2 yr^{-1})*	*Uncertainty (%)*
2001	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2002	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2003	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2004	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2005	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2006	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2007	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2008	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2009	*2,626,631*	*13.15%*	*648*	*44.88%*	*281*	*36.11%*	*2,627,560*	*13.14%*
2010	*5,784,726*	*6.99%*	*7,815*	*35.13%*	*3,393*	*27.80%*	*5,795,935*	*6.97%*
2011	*5,784,726*	*6.99%*	*7,815*	*35.13%*	*3,393*	*27.80%*	*5,795,935*	*6.97%*
2012	*5,784,726*	*6.99%*	*7,815*	*35.13%*	*3,393*	*27.80%*	*5,795,935*	*6.97%*
2013	*5,784,726*	*6.99%*	*7,815*	*35.13%*	*3,393*	*27.80%*	*5,795,935*	*6.97%*
2014	*11,348,421*	*11.91%*	*2,492*	*37.39%*	*1,082*	*30.48%*	*11,351,994*	*11.90%*
2015	*6,314,776*	*12.98%*	*3,743*	*37.87%*	*1,625*	*30.72%*	*6,320,143*	*12.96%*

2016	*7,858,575*	*12.60%*	*2,961*	*36.66%*	*1,286*	*29.76%*	*7,862,822*	*12.60%*
2017	*7,339,174*	*24.73%*	*1,005*	*44.83%*	*436*	*38.54%*	*7,340,615*	*24.73%*
2018	*6,033,253*	*4.48%*	*4,855*	*35.17%*	*2,108*	*28.10%*	*6,040,216*	*4.47%*
2019	*6,844,691*	*3.54%*	*9,785*	*34.90%*	*4,248*	*27.82%*	*6,858,725*	*3.53%*

The historical emissions for the period 2000-2019 are calculated based on activity data (deforested area) and emission factors. The total emissions from deforestation in the period 2000-2019 were 92,606,292 t CO_2 with an uncertainty of 3.17%.

Annex III. Forest degradation: Activity data, emission factors, methodology and results

Activity data

Activity data for total roundwood (logging)

Activity data for total roundwood is divided into fuelwood and industrial roundwood. The total roundwood production is visualized in Figure 18 and table 25.

Industrial roundwood

The production of roundwood is carried out following the selective logging procedures, meaning that only few commercial trees are removed per hectare. This results in forestry activities being reported as forest degradation. Only the construction of haul roads for logging and log yards are not included here, but within the deforestation LULC class ‘infrastructure’.

According to the CELOS Harvesting System, the maximum allowable harvesting volume per ha is 25 m^3, when applying the cutting cycle of 25 year. These rules have been incorporated in the national logging regulations and are enforced by SBB. The average harvested wood volume per ha in the past 3 year was 8.72 m^3 (SBB, 2020a). SBB roundwood production registration is not based on spatial monitoring of logging activities, but is based on data from the “Cutting Register" documentation procedure. The Cutting Register is the document that is used to register all legally produced roundwood. Production data before 2000 was recorded by the Forest Service (LBB), and since 1999 SBB has been responsible for forest monitoring and the registration of roundwood production. To improve the administrative process, a log tracking system (LogPro) was developed, which was replaced in 2019 with an upgraded system “Sustainable Forestry Information System Suriname" (SFISS). SFISS is an online platform based on state-of-the-art technology and provides transparency and easy data flows between the public and the private sector. Since 2020, the SFISS system has been fully operational. The SFISS allows for near-real-time monitoring of the wood flow in the country. The total industrial roundwood production from 2000-2019 is presented in Table 4.15. In the period 2000-2008, the industrial roundwood production showed a constant trend, with an average annual production of around 170,000 m^3. From 2009 the production showed an increased trend and reached more than 1 million m^3 in 2018[22]. The production is increasing and the maximum sustainable production for the country is estimated to be 1-1.5 million m^3 according to the National Forest Policy (2005). The indicated production forest area is 4.5 million ha, of which about 2.7 million ha is issued for timber production.

[22]See SBB website www.sbbsur.com for the annual industrial roundwood production statistics.

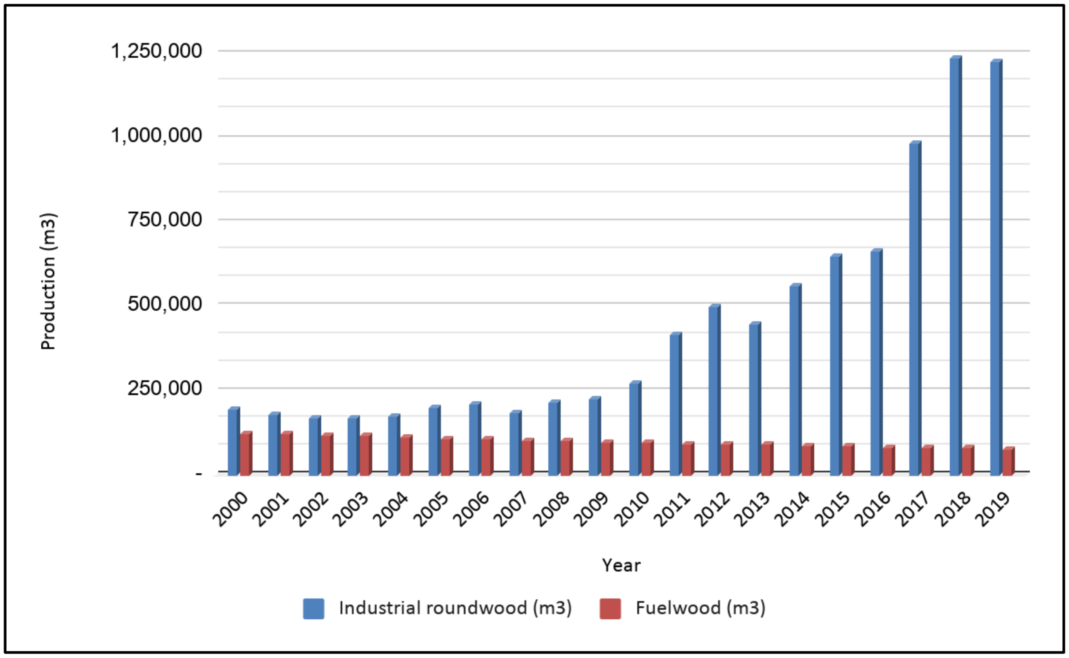

Figure 18. Total logging production for the period 2000-2019 (SBB, 2020a)

Fuel wood

A survey of fuel wood consumption was conducted in 2013 by SBB. Results of this survey and research done by the General Bureau of Statistics on fuel wood consumption by households show that the production is declining with about 2.5% per year. The estimated production in 2000 was 124,294 m^3 and it declined by 38% to 77,459 m^3 in 2019 (SBB, 2020a).

Uncertainty assessment

The uncertainties for roundwood and fuelwood production were based on expert estimations, which are the results of FREL working group discussions. For Industrial roundwood an uncertainty of 5% was estimated, as it is assumed that small errors can be made during registration of roundwood in the LOGPRO program. Even though the registration of logs passes various checkpoints in the field and in the office, this small chance of errors is still taken into account. For fuelwood an uncertainty of 15% was estimated by the FREL working group, as the data on fuelwood is more difficult to register than industrial roundwood due to the nature of the materials. Fuelwood does not only include industrial roundwood, but also smaller pieces of wood which are more difficult to measure accurately.

Table 24 Logging activity data 2000 - 2019.

	Roundwood production in m^3		**Fuelwood production in m^3**		**Total logging production in m^3**	
Year	Volume (m^3)	Uncertainty (%)	Volume (m^3)	Uncertainty (%)	Volume (m^3)	Uncertainty (%)
2001	162,308	5.00%	121,263	15.00%	283,571	7.02%
2002	153,812	5.00%	118,305	15.00%	272,117	7.11%
2003	155,461	5.00%	115,420	15.00%	270,881	7.01%
2004	159,412	5.00%	112,605	15.00%	272,017	6.87%
2005	180,891	5.00%	109,858	15.00%	290,749	6.47%
2006	193,056	5.00%	107,179	15.00%	300,235	6.25%
2007	166,365	5.00%	104,565	15.00%	270,930	6.55%
2008	197,394	5.00%	102,014	15.00%	299,408	6.08%
2009	206,975	5.00%	99,526	15.00%	306,501	5.93%
2010	246,158	5.00%	97,099	15.00%	343,257	5.56%
2011	365,715	5.00%	94,730	15.00%	460,445	5.03%
2012	435,549	5.00%	92,420	15.00%	527,969	4.89%
2013	394,146	5.00%	90,166	15.00%	484,312	4.94%
2014	492,773	5.00%	87,912	15.00%	580,685	4.81%
2015	568,176	5.00%	85,714	15.00%	653,890	4.77%
2016	583,376	5.00%	83,571	15.00%	666,947	4.76%
2017	862,907	5.00%	81,482	15.00%	944,389	4.75%
2018	1,083,350	5.00%	79,445	15.00%	1,162,795	4.77%
2019	1,074,710	5.00%	77,459	15.00%	1,152,169	4.77%

Activity Data for shifting cultivation

Shifting cultivation is being monitored annually and is classified within the deforestation maps alongside deforestation. In the Basemap 2000 this class was mapped for the first time based on Landsat data. When the Basemap 2000 was created, the shifting cultivation areas already in a rotational system were mapped where small deforested patches are clustered with regenerating forest areas. This was done because on Landsat images, shifting cultivation is detected as a combination of small deforested patches (mostly < 1ha) embedded in an area with fallow land at different stages of regeneration. Within the shifting cultivation area there may be some deforested patches greater than 1 ha, but these are distinguished from permanent agriculture by their irregular shape and are classified as shifting cultivation.

The deforested patches greater than 1 ha in the shifting cultivation area that have more regular shapes are interpreted as permanent agriculture and are classified as deforestation. In the following years of monitoring, only the expansion of shifting cultivation was mapped. The temporal changes within the area of rotational shifting cultivation are not monitored yet, as no accurate method for mapping this has been developed for Suriname yet. This requires further in-depth research. With the availability of Sentinel images, more detailed information on shifting cultivation has been observed, but the same monitoring and mapping method is applied. Figure 19 illustrates the monitoring of the expansion of shifting cultivation.

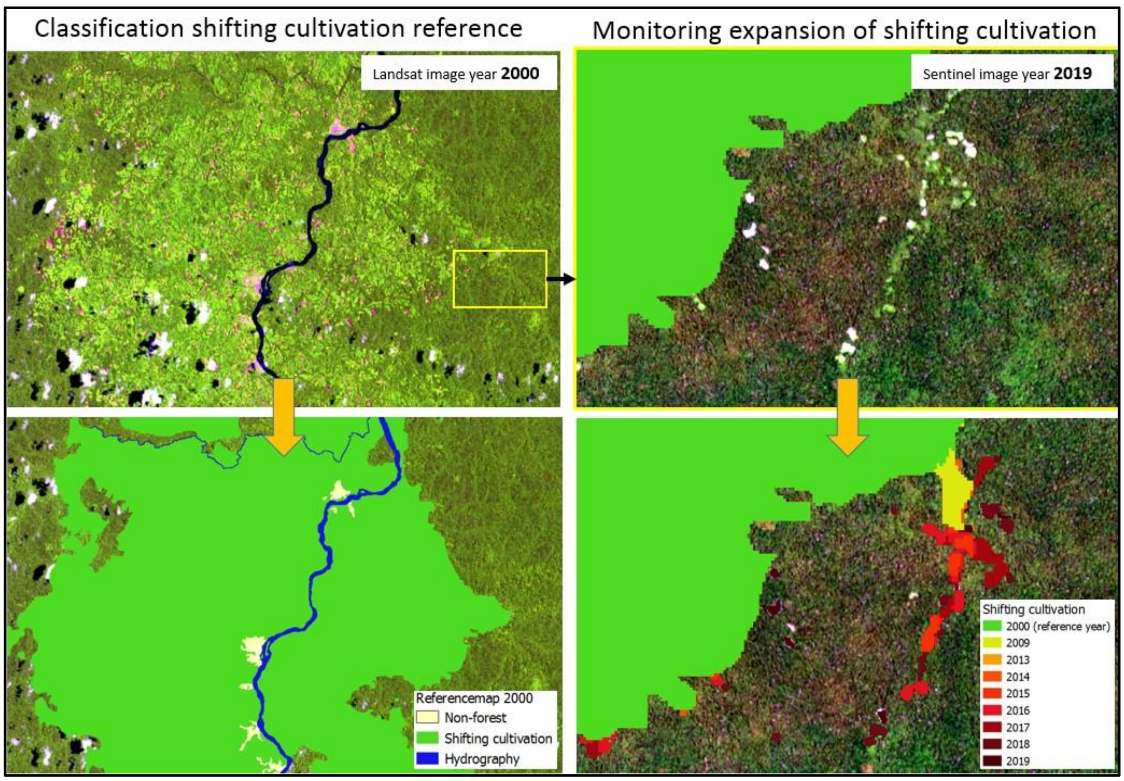

Figure 19. Monitoring expansion of shifting cultivation

QA/QC on shifting cultivation

As mentioned before, the QA/QC method includes a set of "Good Practice" recommendations that address three major components: sampling design, response design and analysis (Olofsson et al., 2014). The QA/QC for shifting cultivation was carried out for the period 2000-2019. The following time intervals were considered: 2000-2009, 2009-2013, 2013-2015, 2015-2017 and 2017-2019. The first two map periods (2000-2009 and 2009-2013) were assessed in 2016 with guidance from the FAO. The last three map periods were assessed recently, using a time interval of two years between the periods. Annual assessments would create too many strata with very small areas of changes, which can be neglected.

Sampling design

The stratified random sampling design was also applied on the shifting cultivation assessment, using the SEPAL SAE-Design tool. The strata that were used are given in table 26. Besides the strata within the shifting cultivation class, there was also a forest buffer included. The buffer is used to mitigate the effects of omission errors (Oloffson et al., 2020) and has a radius of 1300m.

Table 25. Number of sampling points allocated in the strata of shifting cultivation assessment

Dataset	Stratum	Area (ha)	Description of the stratum	Number of points
1	sc00-09	14,334	Expansion of shifting cultivation between 2000 and 2009	100
	sc09-15	4,639	Expansion of shifting cultivation between 2009 and 2015	100
2	Forest buffer	486,549	Buffer around shifting cultivation in the forested area	756
	sc13	1,753	Expansion of shifting cultivation in 2013 and deforested after 2013	8
	sc13-15	949	Stable shifting cultivation in period 2013-2015 and deforested after 2015	9
	sc13-17	1,621	Stable shifting cultivation in period 2013-2017 and deforested after 2017	10
	sc13-19	204,198	Stable shifting cultivation in period 2013-2019 and deforested after 2019	328
	sc15	69	Expansion of shifting cultivation in 2015 and deforested after 2015	10
	sc15-17	33	Stable shifting cultivation in period 2015-2017 and deforested after 2017	7
	sc15-19	2,838	Stable shifting cultivation in period 2015-2019 and deforested after 2019	10
	sc17	20	Expansion of shifting cultivation in 2017 and deforested after 2017	9
	sc17-19	1,688	Stable shifting cultivation in period 2017-2019 and	9

			deforested after 2019	
	sc19	2,961	Expansion of shifting cultivation in 2019 and deforested after 2019	9
	Total	702,679		1165

Response design

In the response design the sample points were interpreted and classified. In order to interpret the sample points in a systematic way, interpretation keys have been developed. The interpretation keys give guidance in the classification of the sample points.

Shifting cultivation is distinguished from deforestation due to the patterns and the shape of it. In figure 4.9, where the expansion of shifting cultivation is shown, it seems that the areas of secondary forest or regeneration in the rotational shifting cultivation areas are light green compared to the surrounding forest area. A sample point that falls within this light green area is then classified as shifting cultivation and not as forest. It is therefore important to look at the neighboring area of the sample point, in order to give the correct classification. The distinction between deforestation and a shifting cultivation area greater than 1 ha, is that deforestation has a more regular shape while shifting cultivation has an irregular shape. When a sample point falls within this deforested area greater than 1 ha, it is important to know how to distinguish these two classes.

Analyses

An error/confusion matrix has been created based on the resulting data from the response design. An example of the confusion matrix for the shifting cultivation assessment is given in table 27.

Table 26. Confusion matrix for the forest and shifting cultivation 2013-2015 sampling

Map	Reference		
	forest	**shifting cultivation between 2013-2015**	**Grand Total**
forest	629	123	752
shifting cultivation between 2013-2015	3	378	381
Grand Total	632	501	1133

The main diagonal of the error matrix highlights correct classifications, while the off-diagonal elements show omissions (the columns) and omission errors (the rows). Based on table 27 a proportional confusion matrix is being created (see table 28), followed by an adjusted area confusion matrix (see table 29). The proportional confusion matrix shows the proportion of forest and sc13-15 compared to the total sample points (e.g.

629/752=0.84). When the proportions of the two classes have been calculated, this is used to create the adjusted area confusion matrix based on the map areas (e.g. forest: 0.84 * map area = 406,967.40 ha).

The corrected totals in table 29 show the stratified estimated areas e.g. the stratified estimated area for shifting cultivation between 2013-2015 is 76,308.66 + 209,544.02 = 285,852.6 ha. After this the confidence interval is calculated. A 95% confidence interval gives an indication about the probability of agreement between samples in map data and reference data. If the confidence interval is high, then the agreement of samples on map data and reference data is also high

Table 27. Proportional confusion matrix for the forest and shifting cultivation 2013-2015

Proportional confusion matrix			
	forest	shifting cultivation between 2013-2015	Map area (ha)
forest	0.84	0.16	486,549.26
shifting cultivation between 2013-2015	0.01	0.99	211,460.58

Table 28. Adjusted area confusion matrix for the forest and shifting cultivation 2013-2015

Adjusted area confusion matrix (ha)			
	forest	shifting cultivation between 2013-2015	Map area
forest	410,240.59	76,308.66	486,549.26
shifting cultivation between 2013-2015	1,916.56	209,544.02	211,460.58
Corrected Total	412,157.15	285,852.68	698,009.84

The results show an overall accuracy of 88%. Table 30 shows the trend of shifting cultivation and provides the QA/QC results propagated for the different years.

Table 29. AD for Conversion Forest to Shifting cultivation through Forest fire

Year	Annual map area (ha)	Propagated area (ha)	Uncertainty (%)
2001	1,638	1,462	32.26%
2002	1,638	1,462	32.26%
2003	1,638	1,462	32.26%
2004	1,638	1,462	32.26%
2005	1,638	1,462	32.26%

2006	1,638	1,462	32.26%
2007	1,638	1,462	32.26%
2008	1,638	1,462	32.26%
2009	1,638	1,462	32.26%
2010	440	603	50.69%
2011	440	603	50.69%
2012	440	603	50.69%
2013	440	603	50.69%
2014	1,678	2,297	0.74%
2015	1,291	1,765	0.76%
2016	1,130	1,550	0.81%
2017	583	799	0.73%
2018	1,597	2,181	0.76%
2019	1,373	1,875	0.79%

Emission factors due to forest degradation

Emission factors due to forest degradation caused by logging

To estimate the carbon losses caused by forest degradation due to selective logging, the emission factors (t carbon per m^3) of produced timber were established. The method used is a gain-loss approach and focuses on the direct losses in live biomass, namely the extracted logs (ELE), incidental logging damage to other trees caused by tree felling (LDF), and the skid trail infrastructure (LIF) establishment (Pearson *et al.*, 2014). The field methods used to estimate the logging emission factor for Suriname (Zalman et al., 2019) are based on the field methods used by Griscom *et al.* (2014).

The work was carried out in Suriname in the first half of 2017 by SBB, with support of The Nature Conservancy, the University of Florida and CELOS. Since the IPCC guidelines (2006) do not provide enough details on how to calculate emissions from logging activities, the methodology developed by Pearson *et al.* (2014) and tested by Haas (2015) was applied.

The following criteria were used for the calculations:

- All timber extracted is emitted at the time of the event, according to IPCC Tier 1.
- Above-Ground tree biomass was estimated using allometry by Chave *et al.* (2014).
- No measurements were done in areas overlapping with other land use, mainly gold mining, because this could result in an over- or underestimation of the emissions related to selective logging.

Field data collection

Because the emissions can vary as a function of the management types as defined in SBB (2017a, 2017b), different logging intensities and physical terrain conditions, a random stratified sampling approach was conducted over the whole range of active logging concessions (including community forest). In total four intensive/controlled, four extensive/conventional and two FSC certified sampling units (logging units) were randomly selected, based on the number of logging units of each type in the country.

Emission calculation

The Total Emission Factor (TEF) in t of carbon emitted per m^3 timber extracted from selective logging is estimated using equation below (Pearson *et al*., 2014). All logging emission factors are presented in t C m^{-3}, making it possible to estimate the emissions from the logging sector using the annually registered timber production data (m^3) from SBB. These emission factors were calculated for each of the 10 sampled locations. The final national emission factors and the related uncertainties were determined by taking the average of the results of the 10 locations.

Equation. Calculation method for the Total Emission Factor (TEF)

$$\mathbf{TEF = ELE + LDF + LIF}$$

Where:

TEF = Total Emission Factor in t C m^{-3}

ELE = Extracted Log Emissions in t C m^{-3}

LDF = Logging damage factor in t C m^{-3}

LIF = Logging infrastructure factor in t C m^{-3}

Extracted Log Emissions (ELE)

The ELE is equal to the carbon emission of the extracted log parts and thus related to the timber harvest itself, which are calculated based on the volume of the extracted logs and the carbon content of these logs. The volume of the extracted log was calculated using the Smalian's formula[23], which uses the measured log length and the log diameters (top and bottom diameters of extracted logs). This volume was converted to biomass using the wood density of the tree species (Zanne *et al.*, 2009). The ELE value was calculated for logging units by dividing the sum of the calculated carbon emission for that logging unit by the sum of the extracted log volume.

[23] The Smalian's formula states that the volume of a log can be closely estimated by multiplying the average of the areas of the two log ends by the log's length: Volume = (A1+A2)/2 × Length

Calculation of the ELE

ELE = (Σ (WD × GAPVol× CF)) / Volume extracted from cutting block

Where:

ELE=	Extracted log emissions (t C m^{-3})
WD=	Wood density of felled trees (10^3 kg m^{-3})
CF=	Carbon fraction, which is 0.47
GAPVol=	Volume of timber over bark extracted in gap (m^3)

Logging Damage Factor (LDF)

The LDF, also referred to as DW (dead wood), reflects the emissions from the decomposition of dead wood caused by felling trees. This includes the emissions from parts of the felled tree that were not extracted, such as the stump, left behind timber, the crown, and dead wood of incidentally killed trees (collateral damage). The amount of incidentally damaged trees identified as dead wood is determined by the damage types, where only snapped and grounded trees are included as actual fatalities, as advised by regional experts (Zalman et al., 2019).

A total of 258 felled trees were sampled with the goal to determine the associated emissions from extracted timber and the timber left behind (damaged trees and unextracted tree parts). The AGB of the total tree is estimated by using the equation from Chave *et al.* (2014) and the AGB for palms was calculated using the equations from Goodman *et al.* (2013). The BGB was calculated using an equation proposed by Mokany *et al.* (2006). The tree biomass left behind equals the sum of the AGB and BGB of the total tree minus the extracted log piece. The carbon losses from collateral damage were calculated by measuring all the grounded and snapped trees in the felling gaps (location where felling took place) and calculating the emitted carbon for those trees using the same equations.

As seen in equation below, the carbon emission for each felling gap per m^3 was calculated by dividing the emitted carbon in the gap by the volume extracted from that gap.

: Calculation method for the LDF

LDF = {$\sum_{gaps}$ ([f (dbh) - (GAPVol × WD × CF) + (BI × CF))] / GAPVol) } / Number of gaps

Where:

DW or LDF=	Dead wood carbon stock in t C m^{-3} or logging damage factor (LDF)
f (dbh, h, WD)=	Allometric function for calculating tree biomass in carbon in t C
GAPVol=	Volume of timber over bark extracted in gap in m^3
WD=	Wood density of felled trees (103 kg m^{-3})
CF=	Carbon fraction of 0.47
BI=	Biomass of fatally damaged/killed trees in t gap^{-1}
Number of gaps=	Total number of gaps inventoried

Logging Infrastructure Factor (LIF)

The LIF is carbon emitted when creating forestry infrastructure, such as skid trails, haul roads and logging decks (also called log yards). For the establishment of the FREL, only the LIF related to the establishment of skid trails will be considered, because the emissions related to the construction of haul roads and logging decks are included in the deforested AD as conversion from forest to non-forest. In the deforestation maps, all roads and log landings are being updated annually and have a lower uncertainty, resulting in more accurate estimations of these emissions. High uncertainties for the LIF (haul roads and log landings) can be explained by the limited number of locations sampled and the varying methods (e.g. machine types) loggers use to make logging infrastructure.

To calculate the LIF, it is necessary to estimate the SF (Skid Trail Factor) in tonne carbon emissions per hectare of skid trail. This is calculated by estimating how much biomass is lost per area of skid trail constructed. For this, the biomass damaged on the skid trails was measured using sample plots on the skid trails. Snapped and grounded trees on the skid trail were measured to determine emissions from skidding. The skid trail area (SA) for each sample unit was calculated by multiplying the average measured width of the skid trails by the total length of the skid trails in the sampling unit.

The LIF is calculated by dividing the total skid trail emissions within a sampling unit by the extracted wood volume from that sampling unit. The tree volume data from the harvested trees sampled is used to calculate the total production (extracted volume) for each sampling unit. Equation that follow is used to calculate the final LIF.

Calculation method for the LIF

$$LIF = (SF \times SA) / \text{Total Sample Volume}$$

Where:

LIF= Logging Infrastructure Factor in t C m^{-3}

SF= Skid trail factor in t C ha^{-1}

SA= Area of skid trails in ha

Resulting EF for roundwood logging

The total emission factor (TEF) for forest degradation due to roundwood logging was estimated to be 1.4 1 t C m^{-3} with an uncertainty of 13.28 % (seen in table 31). The contributions of the LIF, LDF unextracted wood, LDF collateral damage and ELE to the TEF were respectively 0.22 t C m^{-3}, 0.4 9 t C m^{-3}, 0.40 t C m^{-3} and 0.30 t C m^{-3}. The high uncertainties in LIF and LDF can be explained through the large variation between samples in the field and the small sample size (n=10).

Table 30. Emission factors for logging

	Logging emission factors (t C m^{-3})				
	LIF - Skid trails	**LDF - unextracted wood**	**LDF - Collateral damage**	**ELE**	**TEF**

mean	0.22	0.49	0.40	0.30	1.41
C.I. 95%	0.12	0.07	0.10	0.01	0.26
Uncertainty (%)	0.54	0.15	0.26	0.05	0.13

Emission factors due to forest degradation caused by fuelwood logging

Fuelwood data has been added to this new FREL and it is registered separately from the industrial roundwood data. Fuelwood is harvested in a different way than industrial roundwood, resulting in a different emission factor used. Fuelwood is harvested at a much smaller scale than roundwood and is mostly harvested by traditional communities. Fuelwood collected often involves very small trees that are felled in the forest on a small scale, meaning that there is no logging damage around the felled trees (LDF - collateral damage) and usually no extra infrastructure built (LIF), resulting only in emissions from the remaining tree pieces (LDF unextracted wood) and the extracted logs themselves (ELE).

Shifting cultivation emission factors

For the estimation of the emissions due to forest degradation caused by shifting cultivation, it was taken into account that not all carbon of the impacted area is emitted. For the conversion from Forest to shifting cultivation, the carbon stock is reduced to the 52.2 t C ha^{-1} based on Pelletier et al., (2017).

The CO_2 emissions are calculated by subtracting the 52.2 t C ha^{-1} from the total carbon stock of the forest (for that specific strata) present before the conversion.

Additional non-CO_2 emissions are calculated, as shifting cultivation is a traditional slash and burn activity that involves the use of forest fires to clear the land. These non-CO_2 emissions resulting from the fires were estimated by using equation 2, extracted from IPCC (2006, Volume 4, Chapter 2, and Section 2.4). These non-CO_2 emission factors are calculated based on the forest carbon stock reduction resulting from the shifting cultivation activity, and are converted to their CO_2 equivalent and presented in table 32. The uncertainties proposed by Pelletier et al., (2017) are also applied, as these uncertainties are specific to shifting cultivation, and because there are no standard values reported in table 4.7 of IPCC (2006) volume 4, chapter 4 regarding shifting cultivation.

Table 31. Emission factors for shifting cultivation

Stratum	CH_4 (CO_2 equivalent)		N_2O (CO_2 equivalent)		CO_2		Total EF	
	t CO_2 ha^{-1}	Uncertainty (%)	t CO_2 ha^{-1}	Uncertainty (%)	t CO_2 ha^{-1}	Uncertainty (%)	EF (t CO_2 ha^{-1})	Uncertainty (%)
Mangrove forest	13.59	52.96%	5.90	44.04%	455.65	25.22%	475.15	24.24%
Coastal plain	13.08	48.54%	5.68	38.61%	438.51	13.67%	457.27	13.19%
Forest belt	16.63	46.78%	7.22	36.38%	557.42	4.38%	581.26	4.44%
Interior	13.64	47.19%	5.92	36.90%	457.10	7.59%	476.66	7.41%

Historical emissions due to forest degradation

The historical forest degradation emissions for the period 2000-2019 (see table 4.23) are calculated using the activity data and emission factors for the categories roundwood logging, fuel wood logging and shifting cultivation expansion. Roundwood logging was the biggest contributor of degradation emissions.

Table 32. Forest degradation emissions for period 2000-2019

Year	Industrial Roundwood	Fuelwood	Forest to Shifting cultivation	Forest to Shifting cultivation		Total degradation	
	CO_2			CH_4 (CO_2 equivalent)	N_2O (CO_2 equivalent)	CO_2 equivalent	
	Total Emissions ($t\ CO_2\ yr^{-1}$)	Total Emissions ($t\ CO_2\ yr^{-1}$)	Total Emissions ($t\ CO_2\ yr^{-1}$)	Total Emissions ($t\ CO_2\ yr^{-1}$)	Total Emissions ($t\ CO_2\ yr^{-1}$)	Total Emissions ($t\ CO_2eq\ yr^{-1}$)	Uncertainty (%)
2001	841,527	354,632	735,482	21,940	9,526	1,963,106	14.35%
2002	797,477	345,982	735,482	21,940	9,526	1,910,407	14.59%
2003	806,027	337,543	735,482	21,940	9,526	1,910,518	14.59%
2004	826,512	329,311	735,482	21,940	9,526	1,922,770	14.55%
2005	937,875	321,279	735,482	21,940	9,526	2,026,101	14.13%
2006	1,000,947	313,443	735,482	21,940	9,526	2,081,338	13.95%
2007	862,561	305,798	735,482	21,940	9,526	1,935,307	14.52%
2008	1,023,439	298,339	735,482	21,940	9,526	2,088,726	13.95%
2009	1,073,114	291,063	735,482	21,940	9,526	2,131,124	13.83%
2010	1,276,268	283,964	305,127	9,102	3,952	1,878,412	13.23%
2011	1,896,141	277,038	305,127	9,102	3,952	2,491,360	12.77%
2012	2,258,213	270,281	305,127	9,102	3,952	2,846,675	12.73%
2013	2,043,549	263,688	305,127	9,102	3,952	2,625,418	12.79%
2014	2,554,906	257,096	1,115,485	33,276	14,447	3,975,210	9.29%
2015	2,945,851	250,669	892,532	26,625	11,560	4,127,237	10.23%

2016	3,024,660	244,402	796,933	23,773	10,322	4,100,090	10.56%
2017	4,473,959	238,292	401,106	11,965	5,195	5,130,517	12.41%
2018	5,616,901	232,335	1,088,071	32,458	14,092	6,983,856	11.46%
2019	5,572,105	226,526	960,053	28,639	12,434	6,799,757	11.66%

CONTRIBUTORS TO FREL 2

FREL development team (SBB):

- Joey A.P. Zalman, FREL Coordinator
- Sarah Crabbe, NFMS Coordinator & Deputy Director Research and Development Department, SBB
- Cindyrella Kasanpawiro, Forest Cover Monitoring Unit (FCMU) Team Leader
- Consuela Paloeng, NFMS Technical Assistant
- Valentien Moe Soe Let, Senior Remote Sensing Expert NFMS
- Rewiechand Matai, Director of the Department Forestry Economic Services, SBB

National reviewers:

- Bart de Dijn (Environmental Services & Support)
- Eunike Misikaba (Conservation International)
- John Goedschalk (Conservation International)
- Lisa Best (Tropenbos Suriname)
- Rudi van Kanten (Tropenbos Suriname)
- Sandra Bihari (REDD+ Suriname Coordinator)
- Santusha Mahabier (REDD+ Suriname Technical Assistant)
- Rene Somopawiro (Director Research and Development Department, SBB)

International reviewers:

- Anand Roopsind (Conservation International)
- Fabiano Godoy (Conservation International)
- Mario Chacon (Conservation International)
- Javier Fernandez (external consultant)

Stakeholder consultations and awareness moments, from which questions and comments were used as input to FREL:

- Presentation for management team at the Foundation for Forest Management and Production Control 2020-12-10
- Presentation for Ministry of Land Policy and Forest Management 2020-12-11
- National FREL validation workshop via online webinar (74 participants) 2020-12-14
- Presentation for Ministry of Spatial Planning and Environment 2020-12-22

Multi-stakeholders involved in the LULC mapping and scenario development

- General Bureau of Statistics
- The National Planning Office (Stichting Planbureau Suriname)
- Ministry of Natural Resources
- Ministry of Public Works

- Ministry of Agriculture, Fisheries and Husbandry
- Ministry of Regional Development
- Ministry of Ministry of Land Policy and Forest Management (previously called Ministry of Physical Planning, Land and Forest Management)
- Geological Mining Service (GMD)
- Grassalco
- National Institute for Environment and Development in Suriname (NIMOS)
- Stichting Bosbeheer en Bostoezicht (SBB)
- Management Instituut GLIS
- Center for Agricultural Research in Suriname (CELOS)
- Spatial Planners Association Suriname (SPASU)
- Asesoramiento Ambiental Estrategico (AAE)