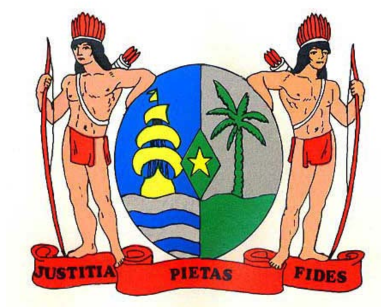
MODIFIED SECOND FOREST REFERENCE EMISSION LEVEL FOR SURINAME'S REDD+ PROGRAMME



2021

PARAMARIBO, SURINAME

Published by:

National Institute for Environment and Development in Suriname (NIMOS)
Suriname REDD+ Program

Mr. Jaggernath Lachmonstraat 100
Paramaribo, Suriname
Website: www.nimos.org
 www.surinameredd.org

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/

Please cite as follows:
Government of Suriname (2021). *Modified Forest Reference Emission Level for Suriname's REDD+ Programme.* Paramaribo, Suriname.

With thanks to

SBB wishes to thank everybody who contributed in completing this second Forest Reference Emission Level (FREL), including:

Activity data: The Forest Carbon Partnership Facility (FCPF) who funded the national staff in the Forest Cover Monitoring Unit (FCMU), Amazon Cooperation Treaty Organization (ACTO) for providing training in monitoring forest cover using satellite imagery, Food and Agriculture Organization of the United Nations (FAO) for training in accuracy assessment and technical support, World Wildlife Fund (WWF) Guianas and ONF International (ONFI) for providing training through a regional collaboration project, south-south collaboration partners and the Inter American Development Bank (IDB).

Emission factors: All providers of forest inventory data included in the *Technical Report State-of-the-art study: Best estimates for emission factors and carbon stocks for Suriname* and the Centre for Agricultural Research in Suriname (CELOS), the Tropical Agricultural Research and Higher Education Center (CATIE) and Anton de Kom University of Suriname (AdeKUS) who together with Foundation for Forest Management and Production Control (SBB) are authors of the study, and The Nature Conservancy (TNC) and the University of Florida for new research. National Herbarium (BBS), the Center for Agricultural Research Suriname (CELOS), the National Zoological Collection Suriname (NZCS) and the Nature Conservation Division (NB) of the ministry of Land Policy and Forest Management (GBB), as project partners, of SBB during the execution of Global Climate Change Alliance (GCCA+) project in Suriname: “Setting up a mangrove biodiversity monitoring system”.

National circumstances: The National Planning Office for coordinating and publishing the National Development Plan 2017-2021, Strategic Environmental Advice (AAE) for supporting the Suriname National REDD+ Strategy in close collaboration with a national team. The Project Management Unit (PMU) of REDD+ in Suriname for developing and publishing relevant documents such as the National REDD+ Strategy, the Safeguard Information System (SIS) and the Summary of Information (SoI).

Overall: All the national stakeholders who contributed to debates around the FREL. The Forest Carbon Partnership Facility (FCPF) for funding and the United Nations Development Programme (UNDP) as delivery partner for Suriname’s REDD+ readiness project. UNFCCC and other countries for all the FREL/FRLs online serve as inspiration and learning tools. UN-REDD for the REDD+ Academy and all contributors to south-south collaboration in the region. Ministry of Spatial Planning and Environment for final review, approval and submission of Suriname’s second FREL to the United Nations Framework Convention on Climate Change (UNFCCC).

Foreword

Suriname is located in the globally important Amazon forest and the biodiversity hotspot of the Guiana Shield. The country wishes to maintain its status as one of the world's most forested countries. In this context, reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) is seen as a tool for sustainable development. Through the REDD+ Readiness phase, Suriname has been successful in building capacity, estimating emission factors and activity data, and has formulated a national strategy for REDD+ implementation. This second Forest Reference Emission Level (FREL) has, like the first FREL of Suriname, been written in-country by a national team. It brings together the most robust national forest related data available and policy goals for the country's future. The purpose of the FREL is to enable results-based payments for REDD+ implementation that can help steer the current mining paradigm in Suriname into a more diversified economy with social equity and harmony with nature. In that way, Suriname can continue as a High Forest Cover and Low Deforestation Country (HFLD) into the future, with its forests offering a global service in terms of climate change mitigation.

The UNFCCC has defined Forest Reference (Emission) Levels (FREL/FRLs) as benchmarks for assessing each country's performance in reducing emissions and increasing removals associated with the implementation of REDD+ activities. The UNFCCC Conference of the Parties in Cancun (COP16) encouraged developing country parties to contribute to mitigation actions in the forest sector, in accordance with their respective capabilities and national circumstances, and stated that, *"more broadly, FREL/FRLs are considered relevant to assess the performance of countries in contributing to mitigation of climate change through actions related to their forests".* According to UNFCCC COP decision 12/CP.17, developing countries aiming to implement REDD+ activities are invited to submit a national forest reference level to the secretariat, on a voluntary basis and when deemed appropriate by the country. The information contained in the submission should be transparent, accurate, complete and consistent. It should also be developed pursuant to recent IPCC guidelines as adopted or encouraged by the COP.

The result can be found in this document, which we are pleased to share with the world. This second FREL for Suriname has some significant improvements compared to the first FREL, including more sources of emissions and streamlining national land use classes with IPCC classes.

Table of contents

List of tables

List of figures

List of 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
AT	Assessment Team
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
CH_4	Methane
CHS	CELOS Harvesting System
CI	Confidence Interval
CI	Conservation International
cm	Centimeter
CMRV	Community Measurement, Reporting and Verification
CO_2	Carbon dioxide
COP	Conference of the Parties (UNFCCC)
D	Diameter (lianas)
dbh	Diameter in breast height
DDFDB+	Drivers of Deforestation, Forest Degradation and Barriers to REDD+ activities
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
FOB	Free On Board
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
FSC	Forest Stewardship Council

g	Gram
GBB (Min)	Ministry of Land Policy and Forest Management
GCCA+	Global Climate Change Alliance
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEE	Google Earth Engine
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
Hg	Mercury
ICL	Incidental Cutting License
IDB	Inter-American Development Bank
INPE	National Institute for Space Research in Brazil
IPCC	Intergovernmental Panel for Climate Change
km	Kilometre
LBB	Dienst Lands Bos Beheer / 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)
MMU	Minimum Mapping Unit
MOP	Meerjaren Ontwikkelingsplan / Multi-Annual Development Plan
MRV	Measurement, Reporting and Verification
N	North (latitude)
N_2O	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
NMVOC	Non-Methane Volatile Organic Compound
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	Quantum Geographic Information System
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
ROS (Min)	Ministry of Regional Development and Sport
ROM	Ministry of Spatial Planning and Environment
R-PP	Readiness Preparation Proposal
SA	Skidtrail Area
SAE	Stratified Area Estimator
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
SFISS	Sustainable Forestry Information System Suriname
SIS	Safeguards Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SPS	Stichting Planbureau Suriname / National Planning Office Suriname
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

Executive summary

This document presents the second national Forest Reference Emission Level (FREL) for Suriname to the United Nations Framework Convention on Climate Change (UNFCCC). Suriname's FREL will serve as the baseline for measuring emissions reduction from the implementation of activities targeted at reducing emissions from deforestation and forest degradation, while recognizing the important role of conservation, sustainable forest management (SFM) and carbon stock enhancement (REDD+) under a results-based payment framework. In this second FREL, the emission factors, activity data and projections have been updated based on the previous UNFCCC assessment feedback and the proposed improvements from the first FREL. These changes in activity data and emission factors are presented in table A. The gases and carbon pools associated with each FREL activity are presented in table B.

Table A: Overview of the first and second FREL contents

<table>
<tr><th>FREL 2018</th><th>FREL 2020</th></tr>
<tr><td><u>Activity data</u>
Deforestation
● Forest to non-forest area, through forest fires (ha)
● Forest to non-forest area, excluding forest fires (ha)
Degradation
● Logging: Roundwood production (m^3)
*Above ground biomass: Chave et al., (2005) equation
<u>Emission Factors</u>
Deforestation
● Non-CO_2 forest fire emissions ($t\ C\ ha^{-1}$)
● Forest carbon stocks ($t\ C\ ha^{-1}$): Based on 208 NFI plots
● Mangrove forest carbon stocks ($t\ C\ ha^{-1}$): Based on 2 NFI plots
Degradation
● Roundwood production ($t\ C\ m^{-3}$): Unextracted wood, logging infrastructure and extracted wood
<u>Projections</u>
● Linear projection based on the sum of all historical emissions</td><td><u>Activity data</u>
Deforestation
● Forest to non-forest area, through forest fires (ha)
● Forest to non-forest area, excluding forest fires (ha)
● Shifting cultivation to non-forest
Degradation
● Logging: Roundwood production
● Logging: Fuelwood production (m^3)
● Shifting cultivation expansion (ha)
*Above ground biomass: Chave et al., (2014) equation
<u>Emission Factors</u>
Deforestation
● Non-CO_2 Forest fire emissions ($t\ C\ ha^{-1}$)
● Non-mangrove forest carbon stocks ($t\ C\ ha^{-1}$): Based on 212 NFI plots
● Mangrove forest carbon stocks ($t\ C\ ha^{-1}$):Based on 13 NFI plots
● Shifting cultivation to deforestation ($t\ C\ ha^{-1}$)
Degradation
● Roundwood production ($t\ C\ ha^{-1}$): Unextracted wood, logging infrastructure and extracted wood
● Fuelwood production ($t\ C\ ha^{-1}$): From extracted wood
● Shifting cultivation ($t\ C\ ha^{-1}$): Based on change in carbon stocks, though forest fires
<u>Projections</u>
● Linear projection based on the sum of all historical emissions</td></tr>
</table>

Table B: Carbon pools and gases included

REDD+ Activities	Activity in FREL	Gases	Carbon pools
(1) Deforestation	(1.a) Conversion Forest to Non-forest (without Forest fire) in ha	CO_2	AGB (trees, palms & lianas) + BGB(trees & palms) + DW (lying & standing)
	(1.b) Conversion Shifting cultivation to Non-forest (without Forest fire) in ha	CO_2	
	(1.c) Conversion Forest to Non-forest through Forest fire in ha	CO_2	
		Non-CO_2 (CH_4+N_2O)	AGB (trees, palms & lianas) + DW (lying & standing)
(2) Degradation	(2.a) Roundwood production in m^3	CO_2	AGB (trees & palms) + BGB (trees) + DW (lying & standing)
	(2.b) Fuelwood production in m^3	CO_2	
	(2.c) Conversion Forest to Shifting cultivation through Forest fire in ha	CO_2	AGB (trees, palms & lianas) + BGB(trees & palms) + DW (lying & standing)
		Non-CO_2 (CH_4+N_2O)	AGB (trees, palms & lianas) + DW (lying & standing)

The Suriname National REDD+ Strategy outlines the vision and mission for the role of forests in Suriname's sustainable development and the policies and measures to be implemented. Suriname aims to implement REDD+ as a tool for sustainable development, remaining a High Forest Cover and Low Deforestation (HFLD) country, while still actively pursuing national development goals. Suriname is currently finalizing the REDD+ Readiness phase, while simultaneously making preparations for the implementation phase with a grant from the World Bank Forest Carbon Partnership Facility (FCPF) delivered through the United Nations Development Programme (UNDP).

In accordance with UNFCCC guidelines the FREL is being developed in a manner that is:

- *Transparent*: with comprehensive and clear documentation of methods and data[1];
- *Accurate*: with estimates of emissions that are accurate and include estimates of uncertainty represented at the 95% confidence interval (Frey *et al.*, 2006), using the simple propagation of errors method given in chapter 5 of the IPCC GPG (2006) reporting instructions;
- *Complete*: providing all information, methodologies and results so that the FREL can be reconstructed (in agreement with decision 13/CP. 19);
- *Consistent*: with 'historical time period' emissions estimated in a manner that is consistent and shall remain functionally consistent during the REDD+ program. Methodologies and data are also consistent with the guidance agreed upon in the UNFCCC COPs.

[1] *2nd FREL Suriname Background Information folder*
National Geoportal: http://www.gonini.org/portal/
SBB Forestry Statistic Information portal

The current FREL submission is based on best available data, mostly generated by the National Forest Monitoring System (NFMS) at SBB, with a transparent analysis of uncertainty and remaining gaps. This FREL has been updated with the most recent data up to 2019. This corresponds to Decision 12/CP.17 Paragraph 1. Suriname will update its FREL periodically, based on new data, new knowledge, new trends and any modification of scope and methodologies.

The following decisions have been made for the FREL:

- The FREL is developed on a national scale;
- Inclusion of the different direct drivers of deforestation: Mining (mining covers ca. 69% of the total deforestation, whereas Artisanal Small-scale Gold Mining specifically covers ca. 68% of the total deforestation), Infrastructure (18%), Urbanization (3%), Agriculture (5%), Pasture (1%), Burned area (2%) and other deforestation (1%);
- Inclusion of forest degradation caused by logging and shifting cultivation;
- The definition of forest used is: "*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 IPCC pools included in this FREL are: Above-Ground Biomass (AGB), Below-Ground Biomass (BGB) and Dead Wood (DW). The pools that are not included, namely Litter and Soil Organic Carbon (SOC), will be included in a future FREL submission as soon as relevant data are available;
- Carbon dioxide (CO_2) is included in this FREL;
- Nitrous oxide (N_2O) and methane (CH_4) are also taken into account when deforestation is done through fire (burning), as well as in the case of the expansion of shifting cultivation areas (slash and burn activity);
- 'Historical period' calculations are based on the nineteen-year timespan from 2000-2019, and the FREL is established for a period of five years (2020-2024). After these five years, the FREL will be evaluated and adjusted as necessary.

Suriname's historical emissions show that the country has a low percentage of both deforestation (deforestation rate of 0.02 - 0.07% annually) and forest degradation, resulting in an effective forest cover of 93% of the land area (SBB, 2021).

Nevertheless, pressure on Suriname's forests has steadily increased in recent years, primarily due to strong incentives for the growth of economic activities from the mining sector, especially artisanal small-scale gold mining (ASGM). Recently, the gold price at the international market has shown an increasing trend and the expectation is that this will lead to an increased gold production, mostly by the unplanned gold mining activities. The steady expansion of Suriname's mining sector has brought economic growth, but at a significant environmental and public health cost. Forest degradation related to timber production has also increased mainly due to the increase of foreign investments.

Logging concession areas currently under a voluntary certification scheme have declined to 2% of all the total valid concessions. An initiative in cooperation with SBB, CI and the private sector to test and implement C RIL (Carbon loss reductions through reduced impact logging) in the logging sector, can create the foundation for a successful implementation of the REDD+ climate change mitigation approach by promoting sustainable forest management practices. Production in Suriname's agricultural sector has remained low in the 21st century (2-5% of the annual deforestation in the period 2000-2019), but a rapid expansion is expected in the near future due to various projects (e.g., oil palm plantations) planned to boost Suriname's economy.

Due to this expected increased growth in both the roundwood production and the mining sector, Suriname is presenting a FREL with an overall linear growth projection in calculating its future emissions. This corresponds with the results found through the scenario modeling process for future deforestation prediction executed in the framework of the Suriname National REDD+ Strategy, based on the National Development Plan of 2017-2021 and in-depth dialogue with partner institutions and stakeholders (Annex 6).

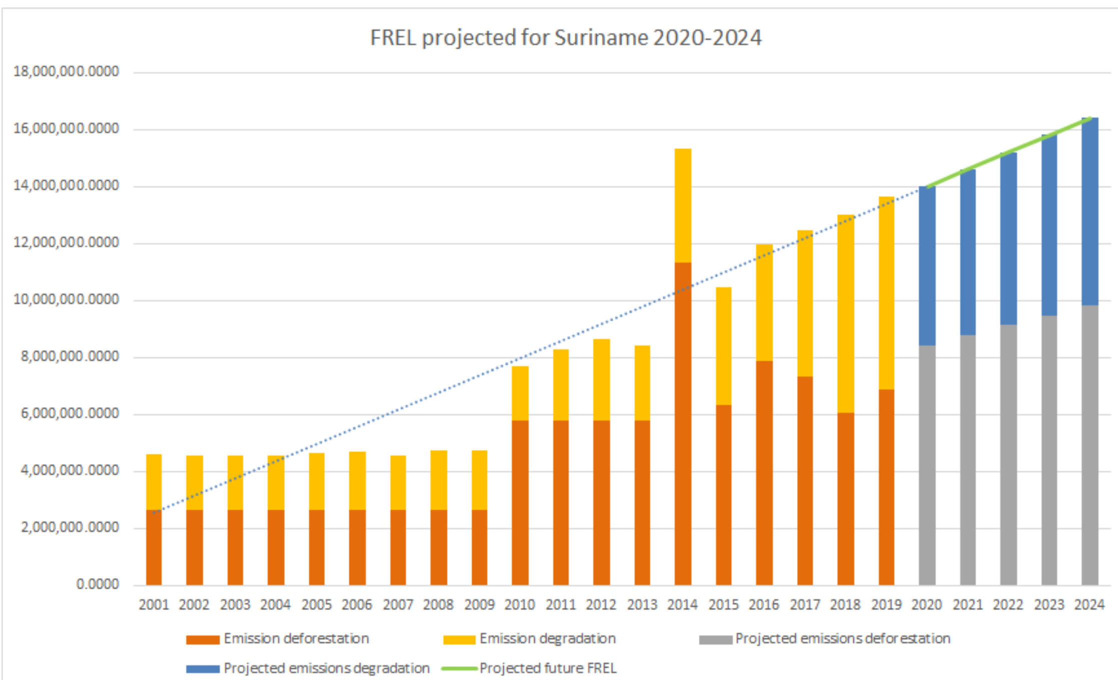


Figure A. FREL projection for Suriname based on 2000 - 2019 historical data

This modified second FREL predicts the following annual CO_2-Emissions (t CO_2-eq per year) based on the linear projection using the 2000 - 2019 historical data:

- 2020: 14,008,882 t CO_2
- 2021: 14,612,231 t CO_2
- 2022: 15,215,572 t CO_2
- 2023: 15,818,913 t CO_2
- 2024: 16,422,255 t CO_2

To implement the Suriname National REDD+ Strategy, technical and financial support from the global community will be necessary. Such support will make it possible for the country to diverge, through a stepwise economic diversification, away from an extractive economy based predominantly upon mining. Through the implementation of the Suriname National REDD+ Strategy, the country will maintain its status as a HFLD country. This strategy includes improved forest governance (including sustainable forest management), robust land use planning, forest conservation, and rehabilitation of forest land on mined out areas.

1. Introduction

To finalize the REDD+ Readiness process, Suriname has prepared an update of the first Forest Reference Emission Level (FREL). The second FREL was submitted in 2021 for a technical assessment in the context of REDD+ (*Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries*) under the United Nations Framework Convention on Climate Change (UNFCCC). This modified version of the second FREL is created based on the results of the technical assessment. The submission of this second modified FREL of Suriname is consistent with the Suriname National REDD+ Strategy (GOS, 2019a). Suriname intends to use REDD+ as an instrument to maintain its status as a High Forest cover and Low Deforestation (HFLD) country, thus contributing significantly to global climate change mitigation, being adequately compensated for this global service, and optimizing the sustainable use of its forest resources for national development. In February 2019, the Government of Suriname hosted the first HFLD conference on Climate Finance Mobilization, where the Krutu (meeting) of Paramaribo Joint Declaration was made, bringing to the attention of the international community that HFLD countries should be adequately compensated for the global service they are providing.

Furthermore, Suriname is in the process of preparing the Third National Communication (NC3) in the context of the United Nations Framework Convention on Climate Change (UNFCCC). This will be submitted in the first quarter of 2022. The methods and definitions to estimate the emissions from the AFOLU sector in the NC3 will be consistent with the methods and definitions used in this report.

The vision for REDD+ in Suriname, agreed through a multi-stakeholder process and included in the Suriname National REDD+ Strategy, is:

> *"Suriname's tropical forest continues to contribute to the improvement of the welfare and wellbeing of current and future generations, while continuing to offer a substantial contribution to the sustainable development of our country and the global environment, enabling the conditions for adequate compensation for this global service."*

Suriname aims to implement REDD+ as a tool for Suriname's sustainable development and to be eligible for results-based payments in accordance with decision 9/CP.19[2]. Together with other countries, Suriname was active in the UNFCCC negotiations to promote inclusion of the "+" activities in the REDD+ climate change mitigation approach. Suriname's REDD+ Readiness Preparation Proposal (R-PP) was approved by the Participants Committee of the World Bank Forest Carbon Partnership Facility (FCPF) on 21st March 2013. Consequently, Suriname was granted US$3.8 million to support REDD+ Readiness activities in the country.

[2] http://redd.unfccc.int/fact-sheets/forest-reference-emission-levels.html

With the UNDP as Delivery Partner, this grant was used to finance the project *strengthening national capacities of Suriname for the elaboration of the national REDD+ strategy and the design of its implementation framework*, carried out in the period 2014-2018. In January 2018, additional funding was confirmed from the FCPF for additional REDD+ readiness activities in Suriname until December 2021. The National Institute for Environment and Development in Suriname (NIMOS) is the Implementing Partner in charge of REDD+ Readiness coordination in Suriname. A national REDD+ strategy is finalized and a Safeguards Information System (SIS) has been developed, with the resulting Summary of Information (SOI) document, which has also been submitted to the UNFCCC in May 2021. The Foundation for Forest Management and Production Control (SBB) serves as the REDD+ Technical Partner responsible for preparation of the FREL and implementation of the National Forest Monitoring System (NFMS).

In accordance with UNFCCC decision 4/CP.15, this document shows transparently how the FREL for Suriname has been established considering national circumstances. Suriname underlines that pursuant to UNFCCC decisions 13/CP.19 (paragraph 2) and 14/CP.19 (paragraphs 7 and 8), the submission of forest reference emission levels (FRELs) and/or forest reference levels (FRLs), as well as subsequent Technical Annexes with results, are voluntary and exclusively meant for the purpose of obtaining and receiving payments for REDD+ actions. This submission therefore does not modify, revise or adjust in any way other actions currently being undertaken by Suriname. Suriname submitted its first FREL in January 2018 and with this new submission a more updated and accurate insight is provided. This is in line with the suggestions done by the AT during the technical assessment of the first FREL submission. Recent changes in the national circumstances, such as in the mining and logging sector, have also been described and taken into account in this FREL.

Formal submission of the FREL was done through the Ministry of Spatial Planning and Environment of the Republic of Suriname, as the National Focal Point to the UNFCCC, though NIMOS and SBB. Before its submission, the FREL went through an extensive consultation process with national stakeholders. Technical stakeholders provided substantive feedback that improved the FREL before submission. Special thanks are given to international experts who supported Suriname in technical preparations and review of the FREL. A list of national and international reviewers and contributors can be found in annex 1.

Suriname recognizes that the UNFCCC allows for a stepwise approach for the development of the FREL. The current submission is based on best available data, with a transparent analysis of uncertainty and remaining gaps. The country strives to constantly improve the availability and quality of data and intends to submit an improved FREL/FRL as needed, taking into account the feedback that will be provided through the technical assessment on this second submission.

2. Context of Suriname

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 km^2. 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 2.1 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).

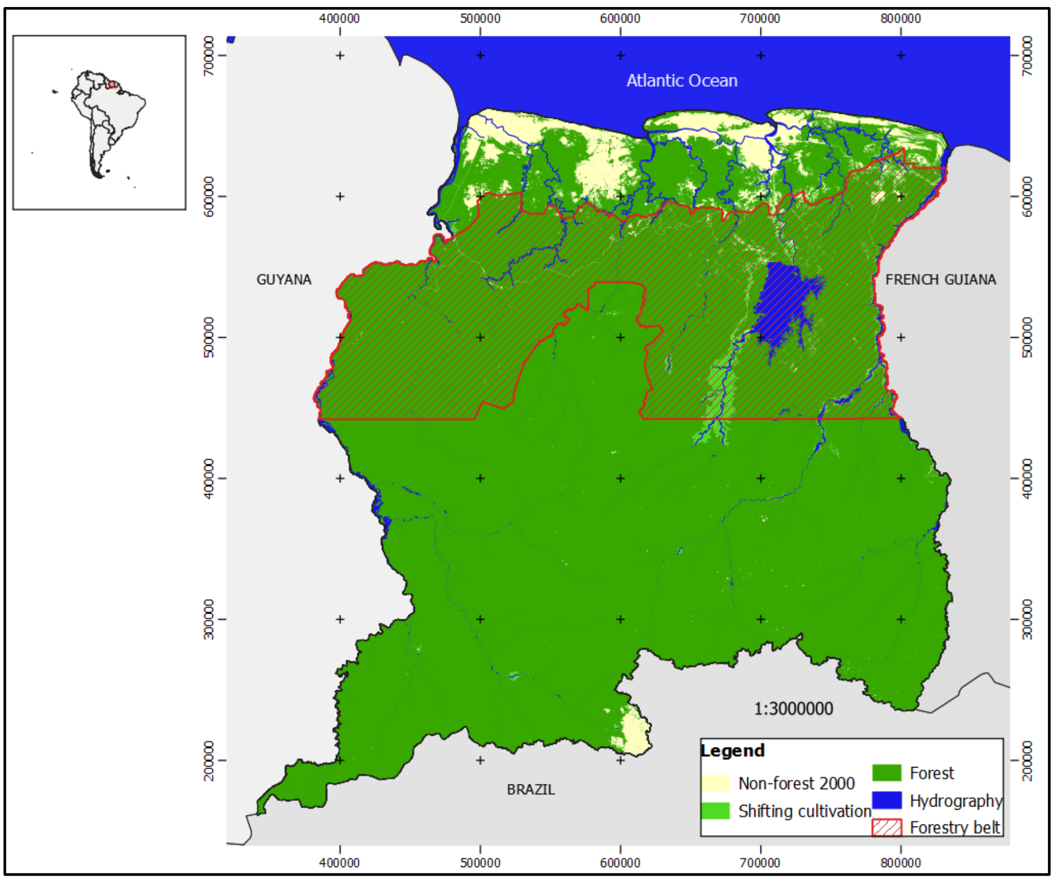


Figure 2.1: Monitoring area of Suriname with the Forestry belt

In terms of conservation, 13.5% of the country's surface is within protected areas (GOS, 2009). Suriname is currently drafting a new Nature Conservation Law in a participatory process, to enable improved management of its protected areas. This law will replace the Nature Conservation Act of 1954. In line with the UN Convention on Biological Diversity (CBD) Aichi targets[3]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 has historically been very low (0.02% for the period 2000-2009). However, due to an increased demand for natural resources, especially gold, the deforestation rate increased from 0.02% to 0.06% on average in the period 2009-2015. In the period 2016-2019 there is a constant average of 0.07%, which is most likely explained by the gold price on the international market (SBB, 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). 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[4] was established. Furthermore, this is also mentioned in the Nationally Determined Contribution[5] 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) by the government.

[3] Aichi Biodiversity Targets - Fliers

[4] 1 Krutu of Paramaribo Joint Declaration on HFLD Climate Finance Mobilization We, Heads of Delegation and representatives of High

[5] The Republic of Suriname Nationally Determined Contribution 2020

Shifting cultivation is another degradation activity that is taken into account in this FREL. 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 AFOLU 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 FREL report have been streamlined with the categories that will be incorporated in the GHG inventory (Annex 5). 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. The aim is to start having bilateral meetings and signing contracts with the relevant partners in the second half of 2021.

3. Scope and scale of the FREL

In line with decisions 4/CP.15, 12/CP.17 and 13/CP.19, countries preparing their FREL/FRL need to consider and make choices on, among others, the scale or geographic area covered, historical time period and scope of REDD+ activities included. Suriname is submitting a national FREL, because the government structure of the country is centralized and most data is available on the national level. This chapter presents and motivates decisions made on the scope and scale for this second FREL submission for Suriname.

3.1 Historical time period

The historical reference period used for the first FREL in Suriname was 2000-2015. Since the submission of the first FREL, more and updated information has been produced nationally. The historical time period that is used in the second FREL is 2000-2019. For this period, robust and locally produced information is available in terms of Activity Data (AD) linked to deforestation as well as to forest degradation. Table 3.1 gives an overview of each AD and for which period each dataset is available. The AD of the conversion from Forest to Non-forest through Forest fires were extracted from deforestation maps and post-deforestation Land Use Land Cover maps, which are also produced nationally. The data production also included a robust Quality Assurance and Quality Control (QA/QC) procedure.

The post-deforestation LULC maps show the drivers of deforestation for specific periods and were analyzed cumulatively starting from 2000 to each specific year such as 2000-2009, 2000-2013 and so on. Activity data (AD) for forest degradation due to logging (roundwood and fuel wood production) are available on an annual basis. Regarding the AD of the conversion from Forest to Shifting cultivation through Forest fires, the data is available for the same time intervals as the deforestation data. It is important to note that only the expansion of shifting cultivation has been monitored. As shown in table 3.1, the first and second time periods (2000-2009 and 2009-2013) of the conversion from Forest and shifting cultivation to Non-forest, have different time series. This is due to the fact that these data were produced as a contribution to regional Amazon deforestation maps[6]. After the period 2013-2014, this data was annually produced and the aim is to continue this every year.

[6] Within the project of the Amazon Cooperation Treaty Organization (ACTO): “Monitoring the forest cover of the Amazon region”

Table 3.1: Overview of the time periods for the types of Activity Data

REDD+ Activity	**Activity data**	**Time period**
Deforestation	Conversion Forest to Non-forest (without Forest fires)	2000-2009; 2009-2013; 2013-2014; 2014-2015; 2015-2016; 2016-2017; 2017-2018; 2018-2019
	Conversion Shifting cultivation to Non-forest (without Forest fires)	
	Conversion Forest to Non-forest (through Forest fires)	2000-2009; 2000-2013; 2000-2015; 2016-2017; 2018-2019
Forest degradation	Logging	Annually from 2000-2019
	Conversion Forest to Shifting cultivation through Forest fire	2000-2009; 2009-2013; 2013-2014; 2014-2015; 2015-2016; 2016-2017; 2017-2018; 2018-2019

3.2 Scope of activities

Deforestation

There are several drivers of deforestation in Suriname, as presented in the *Background Study for REDD+ in Suriname: Multi-perspective analysis of Drivers of Deforestation, Forest Degradation and Barriers to REDD+ activities* (SBB *et al.*, 2017b), the main ones being:

1. Mining;
2. Infrastructure;
3. Agriculture;
4. Urbanization.

Forest fires are also a driver of deforestation, but only a small percentage (3% based on the period 2000-2015) of deforestation is attributed to this driver (SBB, 2021).

Forest degradation

Taking into account the available data, as well as the estimated contribution of different sources of degradation to the overall CO_2 emissions, Suriname will only include logging and shifting cultivation as sources of forest degradation in this second FREL. After analyzing forest degradation due to mining, the results show that the CO_2 emissions only contributed to about 1% of the total emissions and was not seen as a significant source of emissions. Forest degradation due to mining is therefore not included in the second FREL. The method to determine this is described in annex 8. Another natural cause of forest degradation is windbreaks, but because of their natural character, they are not included here.

Conservation, sustainable management of forests and enhancement of forest carbon stocks

The three "+" activities of REDD+ – conservation, sustainable management of forests and enhancement of forest carbon stocks – are generally highly relevant for HFLD countries and are all included in the Suriname National REDD+ Strategy. The removals resulting from carbon stock enhancement have not been included in this second FREL, because at the moment there are no activities focusing on carbon removal. There are cases of natural regrowth, but these are small areas with no clear intention of being preserved as carbon removal areas.

4. Information used to construct the FREL

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)[7], 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[8].

4.1 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)[9]. During the preparation of the Summary of Information on REDD+ Safeguards (GOS, 2020b), the forest definition has also been analyzed comprehensively.

[7] 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.

[8] For more information, see the *NFMS Roadmap - Status and Plans for Suriname's National Forest Monitoring System* (SBB, 2017). Available data can be found on the Geoportal http://www.gonini.org and in published reports.

[9] Under the Marrakesh Accord (UNFCCC, 2001), forest is defined as having a minimum area of land of 0.05-1 ha with tree crown cover (or equivalent stocking level) of more than 10-30% with the potential to reach a minimum height of 2-5 m at maturity in situ.

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.

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) and can also be viewed in annex 3.

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-CO_2 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.

4.2 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.

4.2.1 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[10]. 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"[11]. Since 2021, SBB has also launched a geoportal where national logging specific data is made available[12]. 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).

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

- **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.
-

4.2.2 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 (see chapter 6).

4.2.3 Uncertainty assessment

The uncertainty for each emission source included in the FREL, was calculated based on the uncertainty related to the associated AD and EF. Table 4.1 below provides an overview of how uncertainties were determined for each AD and EF.

Table 4.1: 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 + 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[13] 3.1 for multiplication, equation 3.2 for addition and subtraction, and equation 3.2A for combining uncertainties. These are presented below as equations 4.1, 4.2 and 4.3 respectively.

[13] IPCC (2006) Volume 1

Equation 4.1: 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 4.2: Combining uncertainties - Addition and subtraction

$$total = \frac{\sqrt{{}_1{}_1^2 \; {}_i{}_i^2 \; {}_n{}_n^2}}{|{}_1 \; {}_i \; {}_n|}$$

Where:

$total$ = 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 4.3: 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

EF = the percentage uncertainty related to the emission factor

4.3 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 (CO_2). The estimations of the emissions of non-CO_2 gases (nitrous oxide, N_2O, and methane, CH_4) 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 CO_2-equivalents for reporting in the FREL. CH_4 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.

4.4 Deforestation

4.4.1 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 (Table 4.2).

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 (Table 4.2). The first reference map was also based on Landsat data and was made for the year 2000.

Table 4.2: 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 4.4.

Table 4.3: 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.

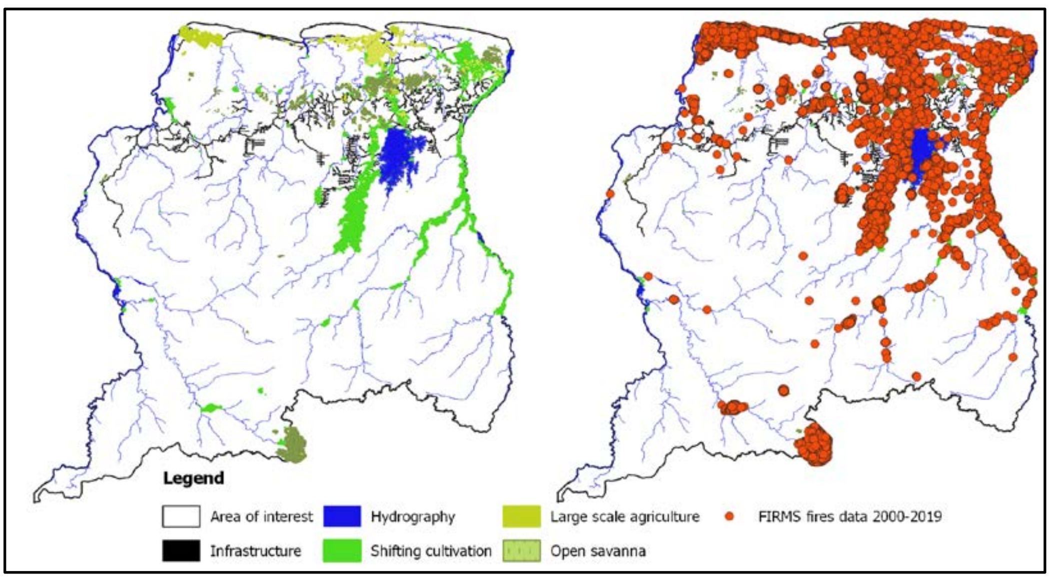


Figure 4.1: FIRMS forest fires data from the MODIS sensor

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 4.2 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)[14]. 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.

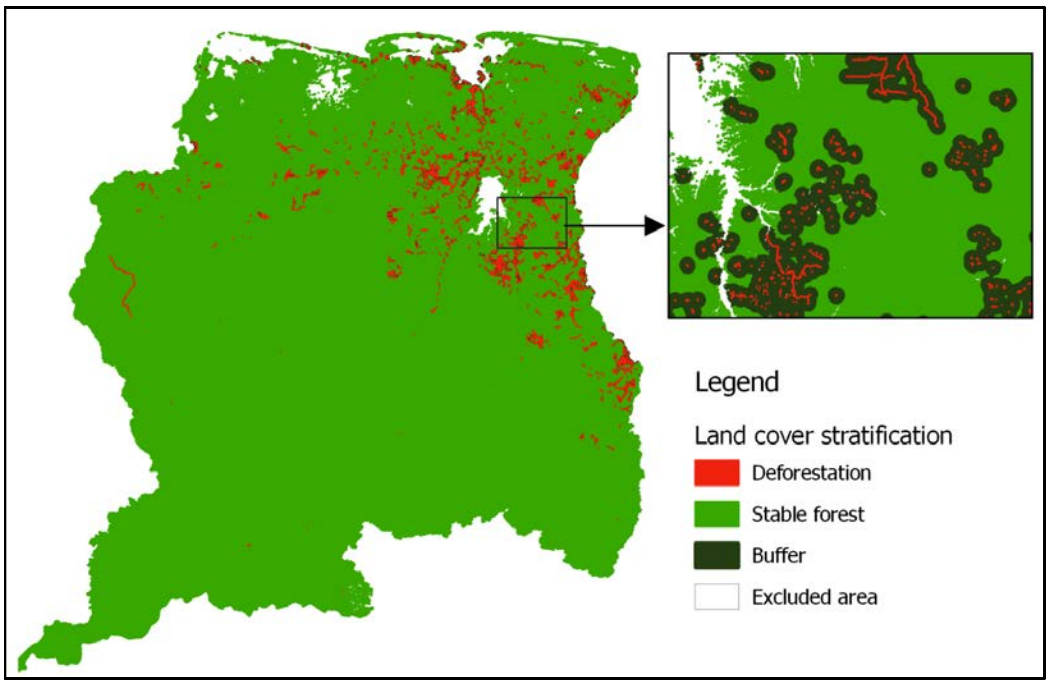


Figure 4.2: Stratification of the land cover classification to be used in the sampling design

[14] Link to report by Kasanpawiro C.pdf

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

Equation 4.4 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.

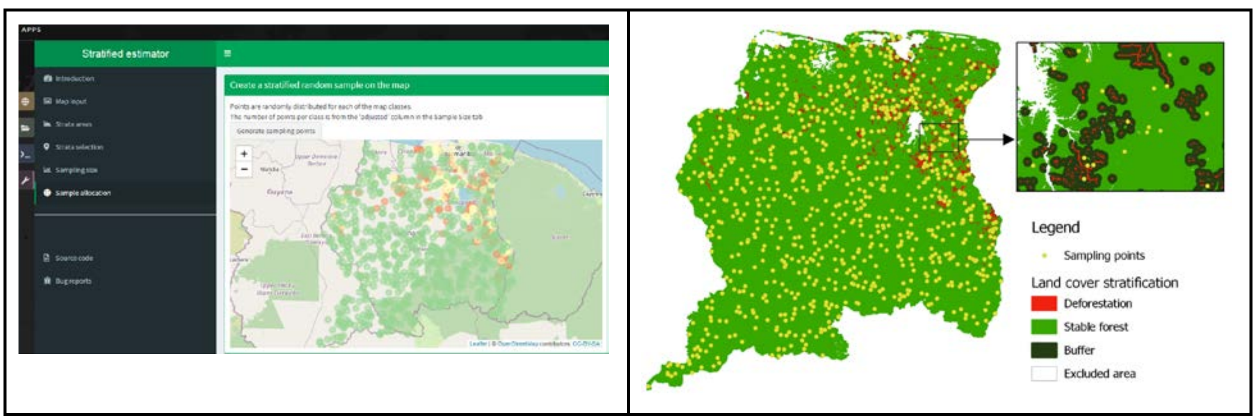


Figure 4.3: Proportionally distributed points, using the stratification as input

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 4.4 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 4.4: 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 4.5 shows the sources of the map and reference classification used for each map period.

Table 4.5: 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 4.6 shows an example of a confusion matrix. This matrix is from the map period 2018-2019.

Table 4.6: Confusion matrix of map period 2018-2019 with the PA and the UA included

Map	Reference						
	***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 4.7 shows the proportional confusion matrix based on table 4.6 and table 4.8 shows the standard error and the 95% confidence interval.

Table 4.7: 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)):

Equation 4.5: Stratified estimator of proportion of area

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

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))

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

Where:

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

A = total map area

Table 4.8: 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.

4.4.2 Deforestation trends and land use

Figure 4.4 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, where after 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[15] is illustrated in figure 4.5. This also shows that after 2019 the gold price increases, which could eventually lead to a high rate of deforestation after 2019.

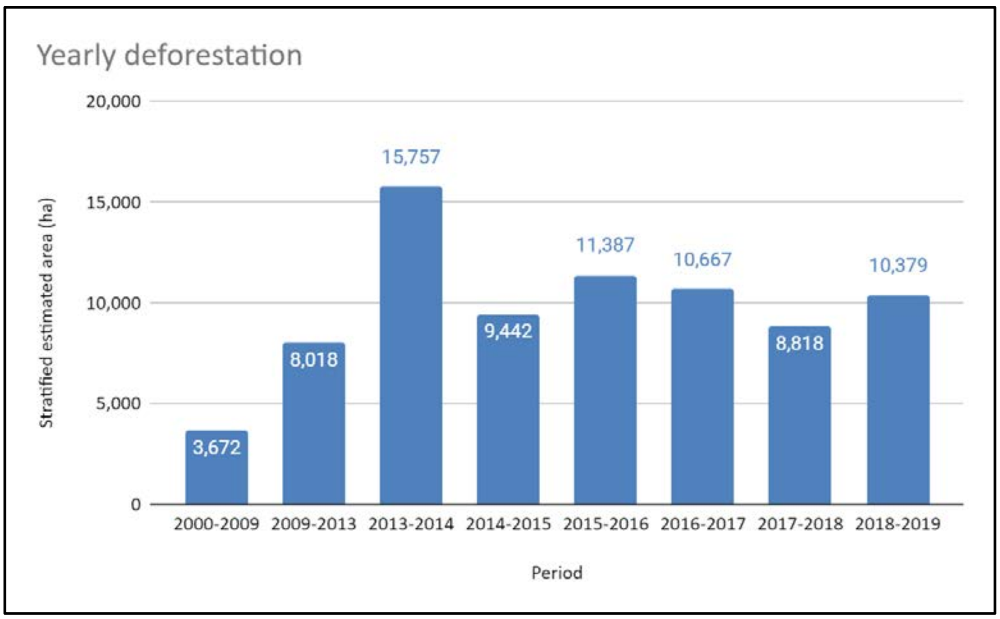


Figure 4.4: Annual average estimated area of deforestation (SBB, 2021)

[15] www.goldprice.org

Figure 4.5: 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 4.6 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[16] *"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 expansion of mining activities. Deforestation or conversion from forested land to other types of land is monitored in Suriname using the IPCC Approach 3.

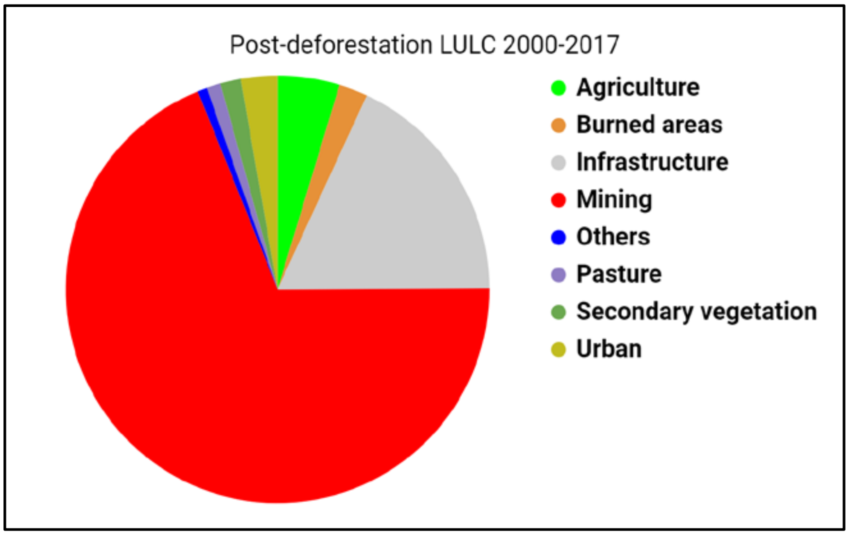


Figure 4.6: Drivers of deforestation areas for the period 2000-2017

4.4.3 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.

[16] FRA 2000

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:

Equation 4.7: Standardization equation

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

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[17] and cross checked with the Taxonomic Name Resolution Service (TNRS)[18] into the most recent scientific name. This allows the tree species to be linked with the wood density values.

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

4.4.4 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.

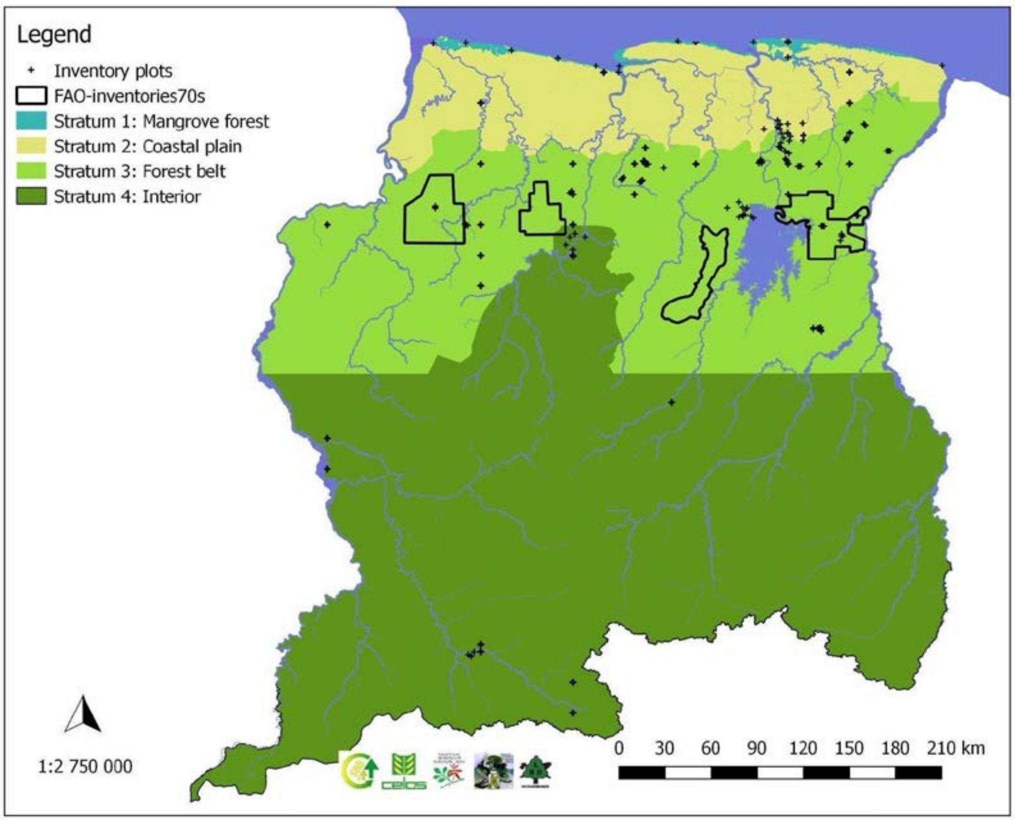


Figure 4.7: Preliminary stratification of Suriname with NFI plot locations

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.

4.4.5 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[19] 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.

[19] 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.

Table 4.9: 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)
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 (Figure 4.7), 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, two mangrove NFI plots had been 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"[20].

Table 4.10: 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
Total		647.05	629.91	748.82	648.50

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

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 4.11: Deforestation emission factors resulting from changes in forest carbon stock

	Forest to non-forest (no forest fires)		Shifting cultivation to non-forest	
Stratum	**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 (Table 4.10), 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.

Equation 4.8: 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 4.12: Non-CO_2 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 4.13: Non-CO_2 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%

4.4.6 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 4.14: 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 annual emissions can be seen in table 4.14). The total emissions from deforestation in the period 2000-2019 were 92,606,292 t CO_2 with an uncertainty of 3.17%.

4.5 Forest degradation

4.5.1 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 4.8 and table 4.14.

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[21]. 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.

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

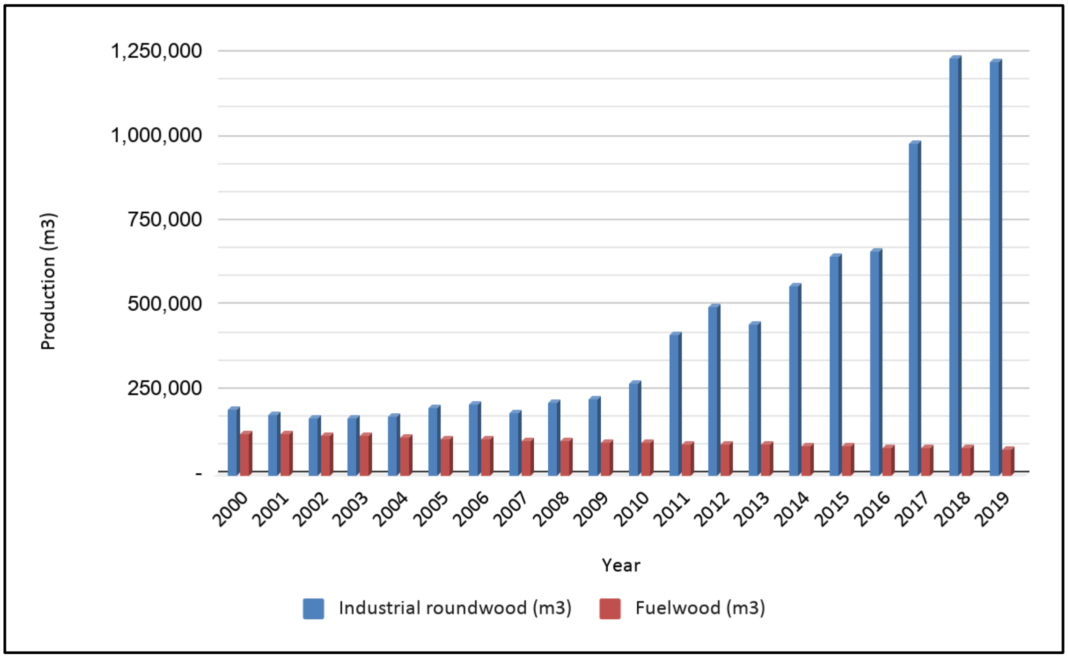


Figure 4.8: Total logging production for the period 2000-2019 (SBB, 2020a)

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 4.15: Logging activity data 2000 - 2019

	Roundwood production in m³		Fuelwood production in m³		Total logging production in m³	
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 4.9 illustrates the monitoring of the expansion of shifting cultivation.

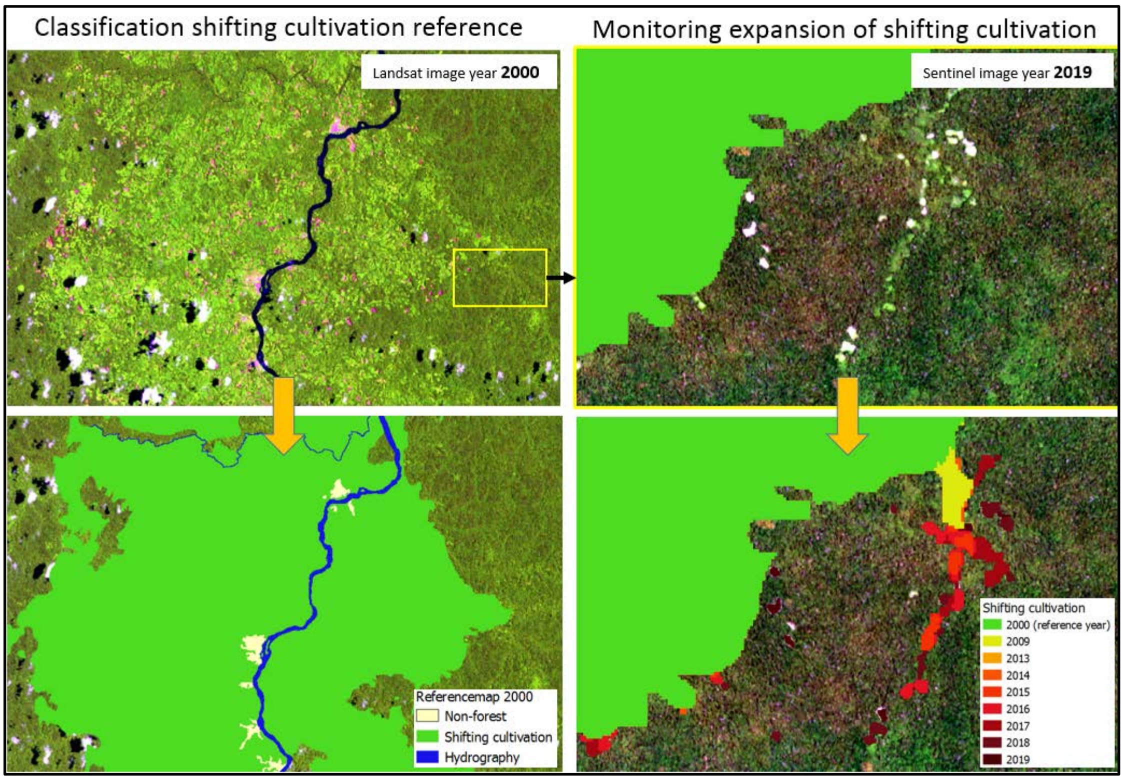


Figure 4.9: Monitoring expansion of shifting cultivation

QA/QC on shifting cultivation

As mentioned before in chapter 4.4.1, 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 4.16. 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 4.16: 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 deforested after 2019	9
	sc19	2,961	Expansion of shifting cultivation in 2019 and deforested after 2019	9
	Total	702,679		1165

As seen in table 4.16, there are two datasets representing two moments that QA/QC assessments were done for the shifting cultivation (sc) maps. The first dataset was produced in 2016, assessing the period 2000-2015. After that, there was a need to execute a QA/QC for each map for consistency and reporting purposes, resulting in the second dataset QaQc being created.

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 4.17.

Table 4.17: Confusion matrix for the forest and shifting cultivation 2013-2015 sampling

	Reference		
Map	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 4.17 a proportional confusion matrix is being created (see table 4.18), followed by an adjusted area confusion matrix (see table 4.19). 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 4.19 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 4.18: 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 4.19: 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 4.20 shows the trend of shifting cultivation and provides the QA/QC results propagated for the different years.

Table 4.20: 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%

4.5.2 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 4.9 (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 4.9: 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[22], 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 (see equation 4.10).

Equation 4.10: Calculation of the ELE

$$\mathbf{ELE = (\Sigma\ (WD \times GAPVol \times CF)\ )\ /\ Volume\ extracted\ from\ cutting\ block}$$

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 4.11, 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.

[22] 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

Equation 4.11: Calculation method for the LDF

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

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 4.12 is used to calculate the final LIF.

Equation 4.12: 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 1.41 t C m^{-3} with an uncertainty of 13.28% (seen in table 4.21). The contributions of the LIF, LDF unextracted wood, LDF collateral damage and ELE to the TEF were respectively 0.22 t C m^{-3}, 0.49 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 4.21: 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 4.22. 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 4.22: Emission factors for shifting cultivation

	CH_4 (CO_2 equivalent)		N_2O (CO_2 equivalent)		CO_2		Total EF	
Stratum	**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%

4.5.3 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 4.23: Forest degradation emissions for period 2000-2019

	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	
Year	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%

4.6. Total historical emissions

The total deforestation and forest degradation emissions (See table 4.24) amount to a total historical emission of 151,534,220 t CO_2 (with annual average of 7,975,485 t CO_2) for the period 2000-2019 with an average uncertainty of ± 8.79%. Deforestation emissions are higher than degradation emissions in the early years due to the low production in the logging sector. Around 2014, the deforestation emissions spiked upwards due to the sudden increase in the gold price, but became lower and more stable in the following years (Figure 4.10). The emissions from forest degradation have become similar to those of deforestation emissions in the last two years (2017-2018), due to the stable and low gold price, and the exponential increase in logging activities.

Suriname's first FREL projection corresponded to the following annual CO_2-Emissions (t CO_2-eq per year):

- 2016: 14,627,465 t CO_2-eq
- 2017: 15,591,284 t CO_2-eq
- 2018: 16,555,103 t CO_2-eq
- 2019: 17,518,922 t CO_2-eq
- 2020: 18,482,741 t CO_2-eq

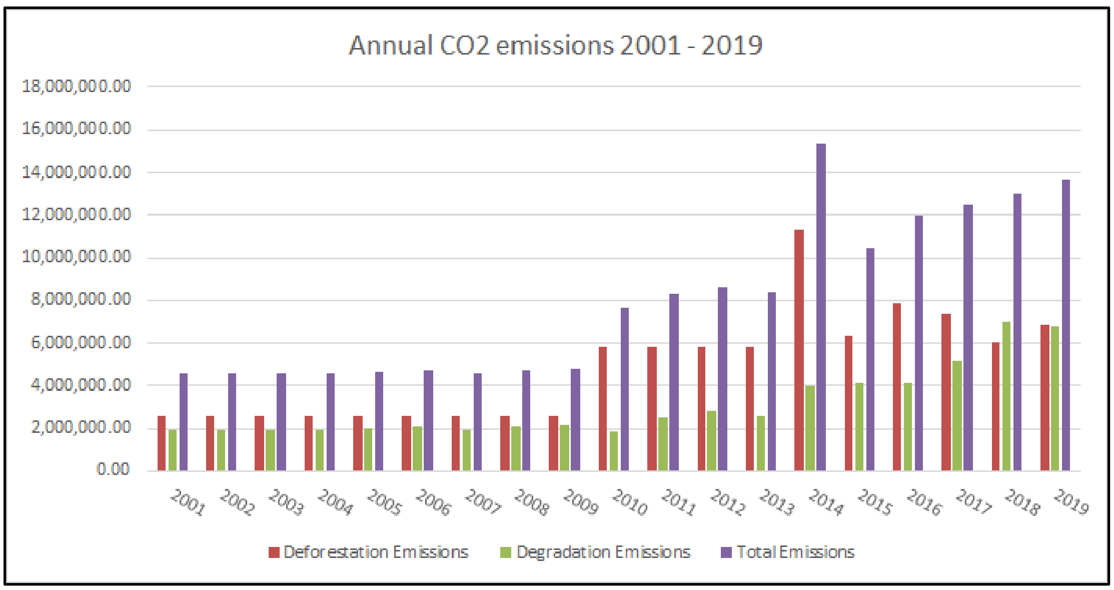


Figure 4.10: Annual emissions from forest deforestation and degradation for the period 2000 - 2019

The previous FREL projected that the emissions for 2016 - 2020 would be much higher than what was actually measured after submission of that FREL. This is caused by various factors of which a main reason is that the current allometric equation (Chave et al, 2014) used for tree carbon stock estimation shows that the allometric equation previously used (Chave et al., 2005) had overestimated the forest carbon stocks and related emission factors. The previous FREL also did not estimate emissions annually for the historical periods 2000-2009 and for 2009-2013, resulting in less historical data points used for the projection. The current FREL has improved on these points, resulting in an improved projection.

Table 4.24: Total CO2 and non-CO2 emissions for the period 2000-2019

Year	CO_2 (t CO_2 yr^{-1})	Uncertainty (%)	CH_4 (t CO_2 yr^{-1})	Uncertainty (%)	N_2O (t CO_2 yr^{-1})	Uncertainty (%)	Total (t CO_2e yr^{-1})	Uncertainty (%)
2001	4,558,271	9.77%	22,588	43.74%	9,807	39.66%	4,590,666	9.71%
2002	4,505,572	9.85%	22,588	43.74%	9,807	39.66%	4,537,967	9.78%
2003	4,505,683	9.85%	22,588	43.74%	9,807	39.66%	4,538,078	9.78%
2004	4,517,935	9.83%	22,588	43.74%	9,807	39.66%	4,550,330	9.77%
2005	4,621,267	9.70%	22,588	43.74%	9,807	39.66%	4,653,661	9.64%
2006	4,676,503	9.64%	22,588	43.74%	9,807	39.66%	4,708,898	9.58%
2007	4,530,472	9.82%	22,588	43.74%	9,807	39.66%	4,562,866	9.76%
2008	4,683,891	9.64%	22,588	43.74%	9,807	39.66%	4,716,286	9.58%
2009	4,726,290	9.60%	22,588	43.74%	9,807	39.66%	4,758,684	9.54%
2010	7,650,084	6.20%	16,918	36.81%	7,345	33.86%	7,674,347	6.18%
2011	8,263,032	6.23%	16,918	36.81%	7,345	33.86%	8,287,294	6.21%
2012	8,618,347	6.30%	16,918	36.81%	7,345	33.86%	8,642,609	6.28%
2013	8,397,090	6.26%	16,918	36.81%	7,345	33.86%	8,421,353	6.24%
2014	15,275,907	9.17%	35,767	26.84%	15,529	20.99%	15,327,204	9.14%
2015	10,403,828	8.86%	30,368	27.43%	13,185	21.44%	10,447,381	8.82%
2016	11,924,570	9.07%	26,734	29.98%	11,607	23.40%	11,962,911	9.04%
2017	12,452,530	15.45%	12,970	27.99%	5,631	21.90%	12,471,132	15.42%
2018	12,970,559	6.51%	37,312	27.14%	16,200	21.26%	13,024,072	6.49%
2019	13,603,375	6.09%	38,424	25.91%	16,683	20.25%	13,658,481	6.07%

4.7 National Circumstances

While Suriname has maintained its mainly primary forest cover up to now, the historical trends presented in the previous sections, the projected future development scenarios and the national circumstances, show that necessarily increasing economic activities for the national sustainable development may pose a risk for the future maintenance of this valuable forest and the ecosystem services this forest provides. Nevertheless, during UNFCCC COP23 the Government of Suriname expressed its intention to maintain the current forest cover of 93% of the land area, contingent upon sufficient technical and financial support from the global community (GOS, 2017a) which was reaffirmed within the submission of the National Determined Contribution. In 2019 Suriname also took the lead by hosting a meeting for other HFLD countries leading to the *Krutu of Paramaribo Joint Declaration on HFLD Climate Finance Mobilization.*

This section provides more insight into the national circumstances, to provide a basis for the establishment of the linear growth adjustment in the next chapter. This is in line with UNFCCC decision 12/CP.17, which invites Parties to provide details on how national circumstances have been taken into account in the construction of their FREL/FRL.

4.7.1 General context

Suriname has a GDP per capita of USD 6,148 in 2019 (ABS, 2020). The main contributor to the GDP is the mining sector, with export of gold and oil accounting for about 90% of the export value and 27% of the government earning[23]. Due to the declined commodities price on the international market in the recent past and the COVID-19 pandemic, there are large macroeconomic imbalances. The high and increasing external and public finance deficits were financed by domestic and foreign borrowing, as well by monetary financing. This led to a substantial increase in public debt and, more importantly, an urgent shortage of foreign currency.[24] Since mid-July 2020, the new government has started to put together an adjustment program to deal with debt sustainability issues and a balance-of payments crisis. Among others, the unification of the exchange rate took place mid-September 2020. The discovery of significant offshore oil reserves may enable consolidation of a stable medium-term growth outlook even though higher oil production will take several years.

[23] https://www.heritage.org/index/country/suriname
[24] http://pubdocs.worldbank.org/en/779281582655261315/mpo-sur.pdf

The recent increasing gold price on the international market may also contribute to macroeconomic stabilization. In the framework of diversification of the economy, the government has started a process to strengthen the forest industry. The policy has been implemented to discourage log export by increasing the export tax. A multi-departmental commission has been installed to study further steps in this context and to determine the strategy for capacity building of the timber processing industry. The aim is to create more value adding of forest production and employment in the forest sector.

A key strategic instrument that guides the development planning in the country is the *National Development Plan*, which has a constitutional base and sets out the State's social economic development for a period of 5 years. The Development Plan 2017-2021 aimed at both strengthening the economic development capacity of the country and achieving sustainable development, by combining economic and social development with the responsible use of the environment. The four pillars that composed the National Development Plan 2017-2021 were (i) the strengthening of developmental capacity, (ii) economic growth and diversification, (iii) social progress, and (iv) the use and protection of the environment. Climate change and the sustainable use of the forests' economic value, including through REDD+, were considered within the last pillar on environmental protection but were also crosscutting. The projects and developments described in the second FREL are for the time being based on the Development Plan 2017-2021 report. The National Planning Office Suriname (SPS) which, according to the Planning Act, has the responsibility for among other activities preparing and drafting the Multi-Annual Development Plan (MOP), will draft the next MOP in close cooperation with the newly elected Government that was established in July 2020.
According to the data on the forest cover of 2019 (SBB, 2021) and the data on the average carbon stock per ha (SBB *et al*., 2017b), Suriname's forest stores at least 12,200 million t CO_2. The sustainability of Suriname's development is highly vulnerable to climatic disasters, especially flooding because of rising sea levels. The removal of mangrove forest for urbanization purposes already leads to high damage costs because of coastal erosion and flooding and these costs will increase when the sea level rises. Inhabited areas in the coastal plain, including the capital Paramaribo, will be flooded following the current trend of sea level rise. Conserving the mangrove forest is therefore a crucial measure within the Suriname National REDD+ Strategy.

Within the National Development Plan 2017-2021, pursuing growth through the extractive economy - based mainly on mining, agriculture, but also on timber harvesting will be the primary solution to diverge from the economic challenges the country is currently experiencing. Activities have been initiated to establish an oil palm plantation in the east of the country. Considering that Suriname is rich in mineral resources and that most of its forests are fit for timber extraction, the opportunity cost of preserving the forest has increased. While the annual deforestation rate has been historically low (0.02%), an increased deforestation rate (average 0.07%) was measured in the period 2015-2019 (SBB, 2021). If this rising trend continues, these pressures might result in an increasing deforestation and forest degradation, which would have a negative impact on the global and local environment.

Through participation in the international REDD+ process, Suriname is exploring the possibility to access financial incentives for alternative development pathways seeking a balance between national, local and global welfare and wellbeing for the current and future generations, resulting in forest based GHG emissions that will remain below an agreed level.

Table 4.25: 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)	**4**2%	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).

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 4.25. 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 CO_2-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).

4.7.2 Forest and mining

Mining has been the largest driver (69%) of deforestation over the period 2000-2017 (SBB, 2021), of which artisanal small-scale gold mining (ASGM) has the largest impact, while in 2017 about 63% of all gold production is produced by industrial mining. Suriname's mineral sector comprises the production of oil, gold, bauxite/alumina, building materials and natural stones, nevertheless 95.5% of mining induced deforestation is caused by gold mining (SBB *et al.*, 2017b).

A recent regional collaborated study carried out by the forest management institutions of the Guyana, Suriname, French Guiana and the Brazilian State of Amapá, indicated an 84% increase of the deforestation rate due to gold mining in Suriname, comparing the period 2000-2008 (19,020 ha) with the period 2008-2015 (35,099 ha) (Rahm *et al.,* 2017). Probably due to a decrease of the gold price after it peaked in 2013, the level of deforestation has remained more or less constant for the years 2016-2019. This is also in line with the recently conducted regional ECOSEO project, where gold mining has been assessed as a driver of deforestation (Rahm *et al.*, 2020). Nevertheless, the sharp rise in the gold price since 2019 combined with the economic depression in the country might lead to a further increase of gold mining activities in the coming period.

Gold and oil are the most important commodities for Suriname's economy, accounting for about 90% of the export value and 27% of the government's earnings and an expected growth of 2.8%. The contribution of the gold sector was 15% and the employment 5,136 in 2018[25]. The bauxite production which has been historically important has stopped since 2014. Corporate income taxes, royalties and dividends applied to gold, bauxite and especially oil are a major source of government revenues (World Bank, 2015). Within the DDFDB+ study (SBB *et al.,* 2017b), a Net Present Value for respectively small and large-scale mining of US\$108,000 ha^{-1} vs. US\$193,364 ha^{-1} was found.
The artisanal and small-scale mining (ASGM) sector provides employment to ca. 10,000 to 12,000 people, including the service sector (Heemskerk, 2016). According to the country's Development Plan 2017-2021, the government intends to regulate small-scale gold mining activities, aiming for improvement of the technology used and for reduction of the impact on the environment, while the national revenues related to large-scale mining will be increased. This includes the intention to reduce the use of gold mining barges in rivers that make use of mercury for gold extraction. Planned new large-scale gold mining projects will support the country's pathway out of the economic difficulties, in particular with the government taking substantial equity stakes in large-scale gold mining projects. It is equally important that the country works towards a more diversified economy, less dependent on mining activities and on the fluctuating prices of the mineral resources.

Artisanal and Small-scale Gold Mining
In the 1990s, artisanal and small-scale gold mining became an attractive income generation activity for Maroons in eastern Suriname, the area that had been hit hardest by the interior war (1986-1993) and hosts much of the country's gold deposits (Heemskerk, 2000, cited from SBB *et al.,* 2017b). Around the same time, increasing numbers of Brazilian miners (garimpeiros), who were confronted with more stringent restrictions on small-scale gold mining in their own country and in French Guiana, moved into Suriname. This caused a multiplicative effect on the deforestation due to gold mining in Suriname and Guyana (Dezécache *et al.,* 2017). Nowadays Brazilian garimpeiros and Maroons dominate the workforce in the artisanal small-scale gold mining (ASGM) sector (Heemskerk *et al.,* 2016).

[25] Stichting Planbureau Suriname. Republiek Suriname Jaarplan Beleid, beleidsprioriteiten en programma's van de Regering voor het Begrotingsjaar 2019.September 2018.

For a large share of households in the interior, gold mining is a primary source of family income. Often in the areas where gold mining takes place, this is one of the only employment alternatives, especially for people with few employable skills (SBB *et al.,* 2017b). It is expected that because of the problems with the economy caused by the economic crisis and the COVID-19 crisis, more people will see the informal artisanal mining sector as a way to generate more income. This will be even more so if the gold price continues to increase, motivating more people to go into the gold mining sector. This is supported by the historical data, where the deforestation due to mining increased exponentially around 2014 when the gold price reached a high peak.

When small-scale miners start their operations, the valuable on-site trees are typically not utilized, but simply felled and burned. The miners have no information on the ecological importance of soil and its possible use for reforestation purposes (SBB *et al.,* 2017b). Small-scale mines are often revisited and re-mined one or several times. Because small-scale gold miners fail to extract an estimated half to two thirds of the gold in the soil, the exploitation of old mining sites is economically viable when mining efficiency improves and the gold price rises (Peterson and Heemskerk, 2001). Yet, the amount of small-scale mining taking place on old sites versus new locations has never been estimated.

Resulting from the 'ad-hoc', unplanned status of ASGM are undesirable factors such as an uncertain legal status for the activity, limited government oversight in the field, and an association of the activity with widespread environmental degradation including deforestation, river siltation, and mercury contamination (SBB *et al.,* 2017b). Research suggests that evaporated Hg (mercury) is transported and, after depositing through precipitation, may affect a much larger area than the mining zones (Ouboter, 2015). In 2016, Social Solutions and the Artisanal Gold Council estimated that ASGM operations in Suriname annually emitted 63.0 t Hg/yr (Heemskerk *et al.,* 2016). Based upon a very rough estimation procedure, Rahm *et al.* (2017) found that 2,197 km of Suriname's waterways were directly affected and 6,806 km were indirectly affected. Table 4.26 shows an overview of policies related to small-scale gold mining.

Table 4.26: Summary of policies and plans relevant for small-scale gold mining

Artisanal and Small-scale gold mining
Regulating policies and laws: Mining Decree (1986), Extractive Industries Transparency Initiative (EITI - member since 2017), Minamata Convention (ratified 2018), and the Environmental Framework Law (2020). **National Development Plan 2017-2021:** Regulate small-scale gold mining activities aiming for improvement of the technology used, limited area for the activities and for reduction of the impact on the environment. **National REDD+ Strategy:** Also in the context of REDD+, the government will focus on regulation and organization of small-scale gold mining activities so that they are carried out in a more controlled way, in a restricted area, with improved technology and with reduced impact on the environment. **Ongoing project:** A Global Environment Facility (GEF) funded project on *'Improving Environmental Management in the Mining Sector of Suriname, with Emphasis on Artisanal and Small-scale Gold Mining'* is being implemented in the period 2018-2025.

Industrial mining

Until 2014 Suralco was mining for bauxite on a large scale, and in recent years on the eastern side of the Suriname River. The current government (Ministry of Natural Resources) has established a commission to rehabilitate these sites. Currently there are only three active industrial mining operations (EITI, 2017). These are:

- Two multinational companies operating under their own Mineral Agreement, Rosebel Gold Mines NV (RGM) which started commercial production in the Brokopondo district in 2004 and Newmont Suriname LCC which started the operations in 2016 in the East
- One State-owned Company Grasshopper Company Suriname NV (Grassalco) under its own authorization act

Table 4.27: Summary of policies and plans relevant for large-scale mining

Industrial mining
Regulating policies and laws: Tailor-made mineral agreements, Mining Decree (1986), Extractive Industries Transparency Initiative (EITI - member since 2017), Minamata Convention (ratified 2018), Environmental Framework Law (2020). **National Development Plan 2017-2021:** Increase national revenues related to large scale mining, through new large-scale gold mining projects planned to be launched shortly. Bauxite mining in new areas is considered as a possibility. **National REDD+ Strategy:** The strategy recognizes that Suriname's economy is dependent on income from the mining sector. The following relevant measures are included in order to improve the efficiency of the mining sector and limit the related deforestation and forest degradation: 1. Streamline concession policies, particularly of the departments responsible for mining and logging concessions/permits; 2. Formulate new land use planning legislation; 3. Review and update the Mining Decree from 1986 and improve mining regulation by incorporating considerations of environmental nature (particularly on land degradation and deforestation) and social considerations in concession and permit requirements; 4. Further support Suriname's decision to participate in the Extractive Industries Transparency Initiative (EITI); 5. Capacity building of institutions in forest monitoring, control and protection (this includes the institutions responsible for the enforcement of the Mining Decree).

To increase income from large-scale mining, two new large-scale mining projects have been initiated: IAMGOLD's Klein Saramacca project and Newmont Suriname in the east. Additionally, there are still potential new bauxite mining projects within the Bakhuys Mountains in the west of Suriname.

The Nassau project is another bauxite mining project that may be executed in the coming 20 years, together with the Grankriki hydropower lake and the infrastructure to access these areas. Table 4.27 shows an overview of policies related to large-scale mining.

4.7.3 Forest and logging

Logging context

Forestry in Suriname has a rich and long history, with first attempts to establish a productive forestry sector dating back to 1903 and the establishment of a state forest service a few years later. In 1947 the second Forest Service (LBB) was established and in the same year the Timber Act was promulgated.
The Nature Conservation Act and the Game Act were promulgated in 1954. In 1992 the Timber Act 1947 was replaced by the Forest Management Act. In the 1980s, the polycyclic CELOS forest management system best suitable for Surinamese forests was developed by CELOS. Key concepts developed under this system, together with those of the CELOS Harvesting System (CHS), were later incorporated into a draft Code of Practice for SFM. The CHS is the oldest Reduced Impact Logging (RIL) system developed in South America (Werger *et al*., 2011). In a process together with the private sector, the draft Code of Practice has to be finalized. After the approval by the government, the Minister of GBB has to make it mandatory and then it will replace the current guidelines for sustainable timber harvesting. The Code of Practice for SFM will become the national manual for sustainable timber harvesting in the country.

In Suriname's context, most forestry practices could be characterized as low impact selective logging based on Reduced Impact Logging (RIL) principles, which aims to mimic natural forest dynamics (Werger *et al.,* 2011), and thus are not associated with significant levels of degradation. Nevertheless, it is expected that these levels of degradation could be higher in recent years, because of the following reasons:

- Fast growing increment of timber production in Suriname in the last years;
- Increasing global demand for tropical timber;
- Insufficient institutional capacity within the forest sector (public and private sector).;
- Comprehensive operational guidelines and procedures need to be improved;
- Limited financial resources in the responsible organizations (public and private sector).

The study of Zalman *et al.* (2019) shows that there is an emission reduction potential of 40% when RIL- or Climate Smart Forestry would be fully implemented. This potential emission reduction can take place by following the already existing rules and regulations. However, capacity strengthening is needed within the public- and private sector to implement it successfully. The SFISS can be a useful instrument/framework to accelerate this process.

Timber cutting licenses are issued in the northern part of the country from the 4th latitude, the so-called Forestry belt, covering ca. 4.5 million ha. South of the forestry belt, the forest has the status of temporary maintained forest, where no timber cutting licenses are issued. Roughly 1.9 million ha of forest was issued as logging concession in 2019, with 819,000 ha as community forests and 168,400 ha as Incidental Cutting Licenses (ICL) (SBB, 2020a). An area of 21,700 ha is certified by the Forest Stewardship Council (FSC) in 2020 (FSC, facts & Figures 2020).

The study of Zalman et al., (2019) showed that logging in FSC certified concessions results in less emissions than in non-certified concessions. Having less certified areas could thus lead to more national emissions from forest degradation. At present, there are no ongoing activities to expand the forest area under (FSC) certification. It should be noted that the rules of FSC related to Intact Forest Landscapes made that some Suriname logging companies no longer had the chance or were not eligible to get certified through FSC. Considerable areas of the Forestry belt (47%) are globally considered as an Intact Forest Landscape.
Therefore, alternative certification mechanisms were explored. Currently 272,728 hectares are certified through Legal Source™. This encompasses 15% of the total area issued as concessions[26]. In the past the main export market of Surinamese timber from certified forests was Europe. Legal Source will create access to this market, as it aims to ensure compliance with EU Timber Regulations.

As can be easily observed on www.gonini.org, forestry licenses and mining licenses overlap extensively. While within the forestry sector there are many planning regulations to comply with (Table 4.28), in the ASGM mining sector there is very limited planning. This causes uncertainty for the logging companies about the land use designation of their concession area in the long term and demotivates them to manage their forestry concessions in a sustainable manner. On the other hand, commercial trees removed to deforest a mining area are often destroyed. To overcome these problems the SBB and the Geological Mining Service started a dialogue on developing protocols for overlapping concessions. Besides this, another bottleneck in the implementation of the sustainable log production is the length of the period for which the concessions are issued. According to the Forest Management Act, long term concessions can be issued for a period of 20 years, mid-term concession for 10 years and short term concessions for 5 years, and these licenses can only be extended one time for the same license holder. To encourage the sustainable utilization of the forest these terms of issuance should be aligned with the rotation cycle of 25 years.

In Suriname the suggested cutting cycle of 25 years and the suggested Annual Allowable Cut (AAC) of 25m^3 is based on the outcome of CELOS silvicultural experiments in the past (Werger *et al.,* 2011). However, due to Suriname's forest composition (i.e. the large diversity in tree species), the harvesting levels from selective logging are still far below the Annual Allowable Cut (AAC) per ha; in practice being only 9.9 m^3 per ha with a range of 8.4 to 10.79 m^3 per ha (SBB, 2019). Based on the rotation cycle, the net productive area within the production forest and the AAC, it is recommended that not more than 1-1.5 million m^3 is harvested on a yearly basis (GOS, 2005).
In order to stimulate economic sustainability of the forestry sector and prevent a depletion of the most commercial species, it is recommended that a higher harvesting level per hectare is attained, focusing on a broader spectrum of species. Some literature on the use of these lesser known species has already been made available (Tropenbos, 2015; Topenbos, 2013). Currently *Dicorynia guianensis* includes more than 30% of the national production (SBB, 2020a).

[26] See https://preferredbynature.org

Forests that have been logged at these modest rates are assumed to be able to recover in due time and to restock and restore the associated carbon stocks. Based on Roopsind *et al.* (2017), there is only 67% probability that timber stocks will recover in 25 years to pre-logging levels after careful harvests of 25 m^3 ha^{-1}. This indicates that the logging cycle might need to be revised in the future.

Table 4.28: Summary of policies and plans relevant for forestry

Forestry and shifting cultivation
Regulating policies and laws: Forest Management Act (1992), National Forest Policy (2005), Strategic Action Plan for the Forest Sector, Code of Practice, Environmental Framework Law (2020). **National Development Plan 2017-2021:** The policy related to forestry in this period is focused on: 1. Increasing the national wood production 2. Increasing the contribution of non-timber forest products (NTFPs) to the national economy 3. Complete the REDD+ readiness phase and move on to REDD+ implementation. **National REDD+ Strategy:** The REDD+ strategy aims to further stimulate the sustainable management of forests. Specifically, the following measures are included: 1. Phasing out extensive management and stimulating Reduced Impact Logging, as already implemented by FSC-certified companies 2. Completing and implementing Practice Guidelines for sustainable logging 3. Revising forestry levies so that sustainable management is stimulated (this can possibly be linked to the financial compensation of the REDD+ program) 4. Increasing the efficiency of local wood processing 5. Streamlining concession policy, especially of the ministries responsible for mining and logging concessions 6. Reviewing the issuance policy of concessions and community forests 7. Revision of the Forest Management Act. **National Determined Contribution (2020)** 1. Conditional contribution to remain a HFLD country with a forest cover of 93% 2. Unconditional contribution to encourage Sustainable Forest Management **Projects to strengthen capacity of the forestry sector to be initiated:** 1) Global Environmental Facility (GEF 7): Sustainable Forest Management Impact Program: Amazon Sustainable Landscapes. 2) Proposed joint Team Europe Initiative for Guyana – Suriname in the area of Forest Governance (EU-project) 3) Pilot project “Climate Smart Forestry” (in collaboration with Conservation international) 4) **Forest Product Value Chain Analysis in Suriname”**

Logging contribution to the economy

Overall, the contribution of the timber industry to the gross domestic product is 2.7% and the sector employs about 6,500 people, including personnel for logging, timber processing, log yards and timber markets (SBB, 2020a). The contribution of timber export to the value of the national export was about 4% (ABS, 2020). The expectation is that the actual contribution of the forest sector to the national economy is higher than registered by the national account. Besides timber, other forest products such as Minor Timber Products and Non-Timber Forest products are extracted that are not or partially registered.

The log production in 2019 was 1,069,000 m^3, of which 315,000 m^3 was exported. It is estimated that of the remaining 745,000 m^3, about 420,000 m^3 was locally processed by the sawmill industry in the country and about 334,000 m^3 was in stock mostly to be exported in the next year (SBB, 2020a). The recovery rate of rough sawn wood in sawmills in Suriname is about 45%. When producing export quality sawn wood, the recovery rate decreases to between 25-30% (Landburg, 2017). Within a period of 10 years from 2010-2019, the roundwood production in the country increased with about 400%, and the sawn wood production increased with about 150%. In the same period, the export of roundwood increased by about 500%. Timber export statistics show that in the past 10 years the assortment of roundwood has contributed more than 80% to the total export volume of timber. Due to foreign investments, mainly from Asian countries, most of the roundwood (about 85%) is exported to this region. The decline of the export to 315,000 m^3 in 2019 compared to 550,000 m^3 in 2018 ha is due to recent development in Asia, especially China and India. In 2019 these two export markets of Surinamese timber took less timber than the previous years. Expectation is that from the second quarter of 2021 the market will recover and the export of roundwood will continue to grow.

The government of Suriname has taken the initiative to encourage local timber processing and to strengthen the timber processing capacity in the country. The first step was to gradually increase on a yearly basis the minimum Free On Board (FOB) value of exported roundwood, which led to an increased export tax on this assortment and semi processed wood (SBB, 2020a). For the export of processed wood no export tax is required.

Additionally, the Ministry of Land Policy and Forest Management (GBB) has recently installed a multi departmental commission of experts to advise the government regarding the process to strengthen the processing industry. This will support the process of discouraging roundwood export and encourage export of processed wood. The aim of this initiative is to achieve increased government income through value added to forest products.

Due to the economic crisis and the COVID--19 pandemic, it is expected that the production data reported for 2020 will be much lower than the previous years. Due to the implementation of the rules by the government to control COVID-19, there was no optimal presence of the SBB in the field to monitor logging production. The possibility is that there will be an under registration of the actual production for this period. However, the expectation is that after 2020, the production trend will recover, even with the intention of the government to discourage the export of roundwood. Within two years, the projected maximum annual production of 1.5 million m^3 roundwood will be achieved.

Recent improvements in forest management

In 2019 a major step was made by enforcing the law in a more strict way requiring harvest plans based on a prior timber stock inventory for all forestry operations as required in the Law. This planning activity is an important tool to check legality of the logs, but also to make sure that logging takes places according to the regulations such as:

- Planned infrastructure to extract the logs with minimum damage (skid trails, roads and log yards)
- Respecting ecological buffer zones
- Reducing felling impact
- Monitor harvest intensities
- Reducing waste in the forest and at the log yards

Before 2019, about 50% of the logging activities were tolerated to take place without this harvest plans (conventional management regime) in predefined harvesting compartments within a timber cutting license. During 2019 a large awareness and training program was started, which was jeopardized in 2020 due to the COVID-19 pandemic. Recently it was reinitiated taking into account the COVID-19 protocols. It should be noted that better harvest planning is a first step to reduce emissions, but an in-depth training program and additional investments in forestry equipment (e.g. winch cables) will be necessary to successfully realize these emission reductions. Another important benefit of planned logging is that it can lead to an increased felling recovery rate.

In June 2019 the Sustainable Forestry Information System Suriname (SFISS) was launched[27]. SFISS is an online platform where data and information about the forestry activities can easily be exchanged between the public and the private sector, including concessionaires and community forest holders. It provides full transparency to its users about process flows and provides an instrument to measure compliance of the rules and regulations on a company scale and on the national scale. This can be a way to support certification processes.

A mobile application has been implemented by the forest guards that allows for an offline tracking of the current status of the logs encountered during field inspections. This makes it easier to detect unregistered timber production. The introduction of SFISS has initiated a process of institutional strengthening within the SBB and a capacity building process within the private sector and the forest communities.

[27] www.sfiss.sbb.sr

The implementation and training phases of SFISS are expected to be finished by the end of 2021. SFISS will provide a framework to estimate the emissions reductions in the forestry sector. Measures to mitigate climate change within the forestry sector can be taken without losing the revenues from this sector. Activities in the forestry sector have been included in the National Determined Contribution submitted to the UNFCCC in 2020 and the National REDD+ Strategy.

Production of fuelwood

Fuelwood production showed a steadily decreasing trend in the last 20 years (40% since 2000). The local traditional communities are the main users of fuel wood because of limited access to electricity and cooking gas. In cases where cooking gas is available for settlements and communities the price is higher related to that in the city and not affordable for them. With the economic developments in 2019, among others the economic recession and the inflation, it is expected that even in urban areas the use of fuel wood will increase now. This development is expected to change the fuel wood production trend compared to the previous years, with the fuelwood production not expected to decrease in the coming years. This prediction is done by SBB's expert judgement, but an extensive fuelwood study is expected to be carried out in 2021 by SBB to validate this trend.

4.7.4 Shifting cultivation

Indigenous and Tribal People rely on the forest for food, fuel and medicine. They are practicing shifting cultivation, which is a type of traditional small-scale farming that involves clearing the land, burning the plant material, planting and harvesting the crops, and then abandoning the land to go fallow. The length of the fallow period is at least 4 years (Fleskens et al., 2010). Shifting cultivation is mainly practiced by vulnerable remote communities, often with limited basic services such as electricity, and at a small-scale for local consumption (food security) and in some cases involving the use of more permanent plots focused on commercial production in order to generate more income.

Food security in the interior is important, yet the impacts of climate change on this farming system are not well understood. One priority area of research is to identify, trial and introduce more permanent agricultural systems such as the integration agroforestry practices to replace traditional shifting cultivation methods, thus strengthening resilience (GOS, 2020b & GOS, 2019a).

4.7.5 National Development Plan, REDD+ priorities and the National Determined Contribution

Within the National Development Plan 2017-2021, climate change is considered within the pillar on environmental protection, but it is also a part of all other pillars. On climate change, the National Development Plan indicates that the country will work on attracting further investments committed to increase reductions of greenhouse gas emissions, using energy and other resources more efficiently, and minimizing the loss of biodiversity and damage to ecosystems. REDD+ is mentioned in the National Development Plan 2017-2021 as a tool for sustainable development.

The plan lays out a detailed set of priorities and actions to address economic and climatic change and it asserts that *“the compensation for conserving Suriname's pristine tropical forest is part of the international climate change programme, under which REDD+ is inserted, and contributes to the growth and development through a programmatic approach for conserving and where necessary restoring Surinamese forest”*.

Both the National Development Plan 2017-2021 (GOS, 2017b, p. 86) and the Suriname National REDD+ Strategy (GOS, 2019a, p. 29) emphasize that even with REDD+ implementation, Suriname will need the extractive industry to boost the economy and development, so that the country can recover from the economic difficulties.

As mentioned in the above section 4.7.2 on forest and mining, new large-scale gold mining projects are planned and the government intends to increase the national revenues related to large-scale mining through participation in these projects. When it comes to small-scale gold mining, the government will focus on regulation and organization of the activities so that they are carried out in a more controlled way, in a restricted area, with improved technology and with reduced impact on the environment. This is part of the National REDD+ Strategy’s strategic line 3.

The restoration of already mined out areas is a priority activity within the National Development Plan 2017-2021 and the National REDD+ Strategy. In addition, the country is currently implementing a Global Environment Facility (GEF) program. The “Amazon Sustainable Landscapes Program”, coordinated by the Ministry of Natural Resources (NH) in close collaboration with the National Institute for Environment and Development in Suriname (NIMOS) *to improve the management of artisanal and small-scale gold mining in Suriname (ASGM) and promote uptake of environmentally responsible mining technologies* to reduce the negative effects on biodiversity, forests, water, and local communities, while also reducing greenhouse gas emissions.

The National Forest Policy (GOS, 2005) includes many elements that are re-emphasized in the Suriname National REDD+ Strategy strategic line 2 on forest governance. By further promoting the application of Reduced Impact Logging (RIL), integrating RIL-C within the draft Code of Practice, and implementing this Code while creating an enabling environment for its implementation through broad capacity strengthening activities and institutional strengthening, this could reduce the emissions from the forestry sector in Suriname with about 40% (Zalman et al., 2019), which is in line with a larger international study by Ellis et al. (2019). Also, special attention is given to the opportunity of adding value to timber for the country and enabling in-country timber processing in a more efficient way, reducing the export of roundwood and increasing the export of processed wood. This will increase the long-term carbon storage in wood products and decrease the pressure on the forest. The reduction of illegal or unplanned logging through strengthening the log tracking system and monitoring capacities is another priority within the Suriname National REDD+ Strategy. The implementation of the SFISS program has already led to increased insights into unplanned logging through improved log tracking tools for forest guards. Additionally it makes information from the flow of roundwood production till the final destination (sawmill or harbour) and the administrative flows more transparent and available. Further expansion of SFISS with modules transport, management reports, inclusion of processed wood and mobile applications parallel with capacity building activities within SBB and the private sector will address the unplanned logging risks related to REDD+.

Equally important is that the country will work towards a more sustainable, inclusive and diversified economy, less dependent on mining. In the current context, employment opportunities in the interior of the country are limited and people from marginalized communities may have no other choice than entering small-scale gold mining for income. Besides a general focus on a broader diversification of the economy, the Suriname National REDD+ Strategy focuses on creating alternative livelihoods related to sustainable use of the forest resource. Specifically, the production of non-timber forest products (NTFPs) and medicinal plants, and the promotion of nature tourism and agroforestry initiatives will be stimulated.

The overarching goal of REDD+ in Suriname is to support Suriname's efforts to continue being a HFLD country while receiving compensation for a more sustainable, inclusive, and diversified economy. The Suriname National REDD+ Strategy will be implemented allowing broad participation of stakeholders from different groups within the society. The REDD+ Readiness phase will be completed in 2021. Suriname has complied with all four key components a country needs to be REDD+ Ready. To summarize, the National REDD+ Strategy was finalized in 2019, the Summary of Information (SOI) was formulated and was submitted to UNFCCC in May 2021, the NFMS is operational and the first FREL was submitted in 2018.

5. Proposed FREL for Suriname

Being the most forested 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 takes into account 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 last 4 years, which would most likely partially be explained by the stable gold price.

Compared to the previous FREL, the yearly historical deforestation emissions have 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 (see annex 6), which took into account 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 last 4 years, 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. 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 would be expected that the recent rise in the gold price since 2019 (reaching its highest peak yet) will likely result in an increase in annual deforestation after 2019.

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

We expect that this trend will continue, which is why a linear projection is used that results in a projected increase of annual deforestation emissions for the coming years (See equation 5.1).

Equation 5.1: Linear trend equation for FREL deforestation emissions based on 2000 - 2019 historical data

$$t\ CO_2\ \text{emissions}\ y^{-1} = (354{,}658.94 * \text{year}) - 707{,}990{,}461.56$$

Roundwood production emissions

Roundwood production shows 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 m^3 of timber. Even with the strong increasing trend, the impact of the COVID-19 crisis in 2020 will not go unnoticed in the coming years, resulting in a downtrend of the production in the year 2020. After that it is 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.

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 5.2: Linear trend for FREL roundwood logging emissions

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

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 shows a slight decreasing trend for 2000-2019. A linear projection is used based on the historical fuelwood logging data since there is no method to determine if there will be a change in the fuel wood production trend. However, the economic crisis has raised the price of living in the city, including cooking gas prices, which will likely result in the use of fuelwood staying stable in the coming years.

Equation 5.3: Linear trend for FREL fuelwood logging emissions

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

Shifting cultivation emissions

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

Equation 5.4: Linear trend for FREL shifting cultivation emissions

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

Total emissions

The projected FREL emission is based on the complete 2000-2019 activity data, applying the linear projection method. The projected total emissions (table 5.1 and figure 5.1) 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 5.1: 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*

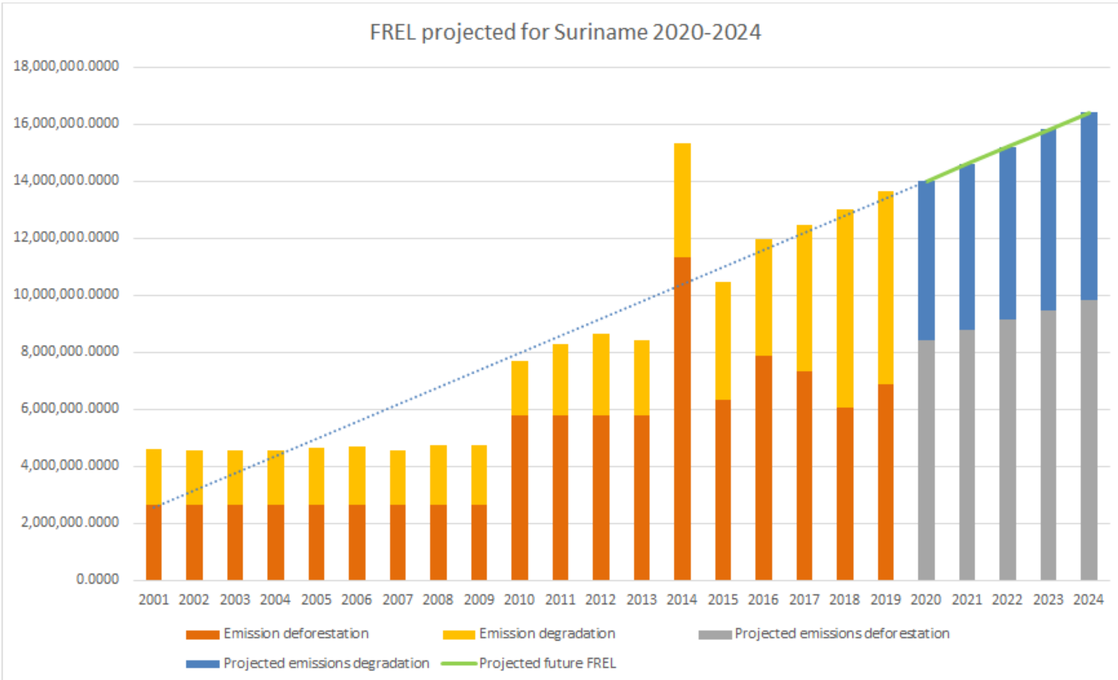


Figure 5.1. FREL projection until 2024 for Suriname

6. Proposed improvements

According to the stepwise approach in setting out the FREL, Suriname submits the current report with the expectation that several aspects of the FREL will require further improvement in the near future once more accurate data is available. This relates to various components of the FREL report.

The improvements that were made to this FREL were activities planned within the NFMS roadmap (SBB, 2017). Except for the Community Based Monitoring and the National Forest Inventory a lot of the planned activities in this NFMS-roadmap are already completed (See annex 7).

6.1 Satellite forest monitoring

Suriname has limited resources and the research and work that comes with satellite forest monitoring cannot be fully covered with the current satellite monitoring team. Therefore the work is focused on keeping on track with the globally or regionally available platforms and instruments so that they can be integrated in the work done on a national or regional scale and making sure the results from these platforms and instruments are suitable for the national conditions and definitions. See below planned improvements:

1. *Enhance the use of cloud computing platforms when producing the annual deforestation maps*

For this FREL, the activity data for deforestation made use of 10m-resolution Sentinel 2A images, which have significantly reduced the uncertainties of the results. This allows for a more efficient monitoring of changes of the forest cover related to the implementation of e.g. the National REDD+ Strategy. While part of the process to generate the deforestation data is already based on automatic algorithms, it is planned that in the coming years, there will be a stronger focus on the use of cloud computing platforms e.g. Google Earth Engine. These platforms might also make it easier to integrate the use of more complex data such as SAR-data such as Sentinel S1A within the deforestation monitoring or the Global Ecosystem Dynamics Investigation (GEDI), a high resolution LIDAR sensor.

2. *Enhance the use of automatic detection algorithms of near real time deforestation or degradation*

While NRTM is currently based upon the manual interpretation of Sentinel 2A images, which are then cross checked with SFISS, we strive towards an automatic detection of selective logging so that larger areas can be covered instantly. Currently two projects are carried out to investigate this potential:

a. Establishment of an Early Warning System in collaboration with WWF and SarVision where an automatic detection algorithm of deforestation selective logging is being developed.
b. Collaboration with Satelligence and Green Growth Suriname to explore the potential of the Satelligence platform which is also detecting forest cover changes automatically on a near real time basis.

3. *Research the dynamics of shifting cultivation in order to get more information on the rotational cycles and related carbon emissions*

Currently, only the expansion of shifting cultivation after the year 2000 is monitored. All areas that have been cultivated before the year 2000 have not been monitored since, and are seen as stable (unchanged) shifting cultivation areas. The intention is to do more research on the dynamics of the forest carbon stock changes within the shifting cultivation areas. This will include doing more field validations and measurements, which can be used for the training samples and the classification process.

4. *Continue to build capacity in measuring, monitoring and statistical reporting*

Capacity building will be done regarding the state of the art measuring, monitoring and statistical reporting techniques that have developed in the recent years. This includes improvements in the SEPAL method that have been developed, and alternate methods that have become available.

6.2 Logging and SFISS

With the implementation of SFISS there is already improved and updated monitoring of the timber production (now including unplanned logging since 2019), the system still has a number of features to improve in order to achieve its full potential. Currently the existing instruments are further being strengthened and reports are being developed. It will be possible to produce standard reports necessary for policy development, management and national & international reporting. This will help to finalize the full flow for the monitoring of the roundwood production and processing. Beside the technical development of SFISS, there is a lot of focus on training the actors in the sector, including public, private and forest communities. In the coming years the following improvements are planned:

1) *Further integration with the satellite monitoring system*

Because SFISS has the location of each tree being harvested, it is possible to use the satellite monitoring, especially the Near Real Time Monitoring (NRTM) components to detect inconsistencies. This is currently done manually using Sentinel 2A images. At the moment there is research ongoing for an automatic detection that can help to get a faster overview of inconsistencies for larger areas.

2) *Integration of compliance appraisal for each forestry operation*

Suriname has the unique situation where each forestry operation is visited by the forest guards, who are not only visiting the log yards, but also inspect the operations in the field. Within one of the applications already developed to inspect the harvesting operations in the field, the forest guard can appraise the quality of the operation looking at the impact of felling, extraction and infrastructure construction. These already existing parameters will be the basis to monitor the reduction of the emissions from the forestry sector. To implement this in a meaningful manner an in-depth training program with the forest guards will be established.

3) Inclusion of processed wood and other forest products

SFISS has been designed to register roundwood, poles and Letterhout (*Brosimum guianensis*). Processed wood, fuel wood and other forest products are not yet included. Nevertheless, the design of the platform allows for an easy expansion to include these products. Collecting more data on fuelwood will give improved estimations of the annual fuelwood production. Processed wood (sawn wood) will be one of the first priorities to be included. Therefore, within the REDD+ Readiness project, a study is being conducted to assess the recovery rate of sawn wood at different processing levels. Based on this recovery rate, a comparison of the input and output in the sawmill will be determined. SBB will determine the legality of the processed wood in the local trade and especially for export. This is important as it is a national objective to reduce the export of roundwood and stimulate local wood processing.

6.3 National Forest Inventory and stratification

The carbon stocks used within this FREL are determined based on fieldwork carried out in 212 plots scattered over the country, where data was collected over different years (1970-2019) during forest inventories established for different objectives. While for now these data provide the best estimates of the country's carbon stocks, these estimations might improve significantly when a National Forest Inventory, based on a solid stratification approach, is carried out. An NFI is a costly activity and requires in-depth planning as well as broad involvement of partner organizations (SBB, 2017). Within the future NFI, information on other carbon pools such as litter and soil organic carbon will be included. Additional parameters, among others on biodiversity, will be collected and can provide insights into the co-benefits of REDD+. Information on the other REDD+ activities, such as the enhancement of carbon stocks and conservation, can also be collected within the NFI.

6.4 Community-Based Monitoring, Reporting and Verification

Community-Based Monitoring (CBM/CMRV) is considered as an integrated component of the NFMS (SBB, 2017). In 2019 two persons from ca. 50 villages with a community forest license were trained in the implementation of SFISS. These village representatives are now actively working in SFISS, and support the traditional authorities in the management of the community forests. The information in SFISS can support the internal governance process of managing the community forest. This has been successful in several of the communities which were involved in the training activities.

When communities want to develop their own monitoring system, the tools developed within the NFMS can be used or modified to be integrated in their CBM. Nevertheless, to fully understand the potential of community forest monitoring within the framework of a sustainable development of the forest-based community, community representatives have indicated that they need more information.

6.5 Capacity building needs

Within the country's process of building capacity for determining the FREL and establishing the NFMS, Suriname has focused strongly on building national expertise within its responsible institutions, supported through South-South technology exchange and collaboration with international backstopping experts. This creates an enabling environment for the sustainability of the NFMS, as a component of a broader environmental monitoring and information system.

Nevertheless, through the formulation of this second FREL for Suriname and earlier experiences within its NFMS, the following areas have been identified as areas for urgent further capacity building:

- Development of a cost-efficient National Forest Inventory design with statistical estimation procedures (including a Carbon Inventory but also information gathering on the co-benefits of REDD+ and for the production sectors);
- Combining Measuring and Reporting systems at different scales (national and community) and building capacity on all those levels;
- Building one harmonized NFMS-database, which provides up-to-date reports of emissions for UNFCCC GHG inventory including solid calculation methods of uncertainties, but also for reporting on criteria and indicators for e.g. CBD, FRA, ITTO. This includes methods to calculate the emission factors related to the conversion from forest land to a land use type with remaining biomass such as agriculture and pasture;
- Research on the carbon stock changes and associated emission factors related to rotational shifting cultivation activities.
- Further strengthening of capacity to report on the emissions caused by forest degradation through field-based measurements but also through spatially explicit methods.

REFERENCES

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.

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 1: List of contributors to this report

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

Annex 2: Multi-stakeholders involved in the LULC mapping and scenario development

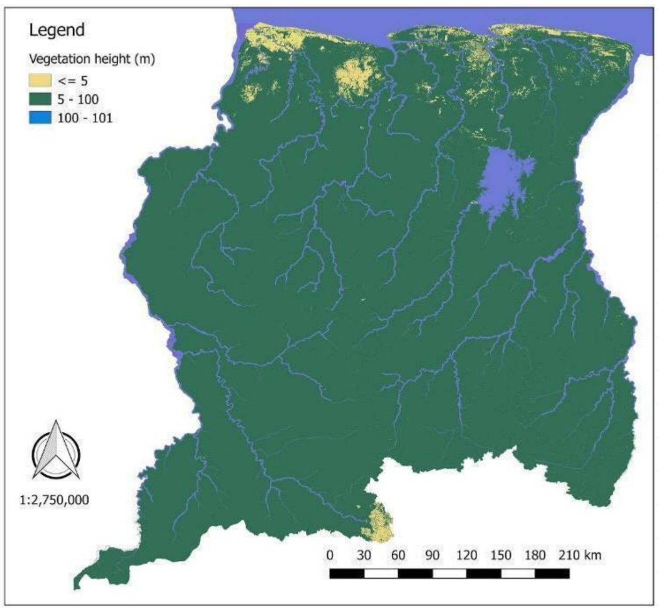
- General Bureau of Statistics
- The National Planning Office (Stichting Planbureau Suriname)
- Ministry of Natural Resources
- Ministry of Public Works
- Ministry of Agriculture, Fisheries and Husbandry
- Ministry of Regional Development
- Ministry of Ministry of Land Policy and Forest Management (previously 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)

Annex 3. Parameters of the national forest definition

The choice of parameters for the national forest definition are based on the following considerations:

a) Minimum canopy height (Vegetation height)

Based on the characteristics of Suriname's forest, which is mainly undisturbed, most trees are higher than 5m. Based on the Detailed Global Tree Height Estimates across the tropics (WHRC, 2015) only 2.2% of the vegetation in Suriname is less than 5m high (See figure x-1). This corresponds with general field observations.



Vegetation height (m)	Area percentage
1	0.14%
2	0.35%
3	0.56%
4	0.60%
5	0.58%
6	0.57%
7	0.56%
8	0.62%
9	0.74%
10	0.91%
11	1.13%
12	1.43%
13	1.90%
14	2.54%
15	3.47%
>16	82.34%

Figure x-1. Indicative vegetation height for Suriname (WHRC, 2015)

b) Minimum tree crown cover

An assessment of Suriname's tree crown cover (table x-1) shows that using a minimum tree crown cover of 10% compared to 30% does not influence the total forest cover area significantly (only 0.2% of the land area has a tree crown cover of between 10% and 30%). 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 x-1. Percentage of land in Suriname in different tree crown cover classes - Data from Hansen et al. (2013)

% Tree cover	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
% land	4.1	0.11	0.09	0.1	0.13	0.23	0.07	0.2	1.68	93.31

c) Minimum area

Because of the abundance of forest in Suriname, most forest patches are larger than 1 ha. This assumption was confirmed by the results of a quick analysis on the global forest cover change data (Hansen *et al.,* 2013). Therefore the minimum area will be the same as the Minimum Mapping Unit (MMU) of 1 ha.

Tree cover from trees, including palm trees planted for agricultural purposes (such as coconut, palm oil, citrus etc.), is <u>excluded</u> from the definition as is indicated by table 4.2 in the IPCC guidelines (2006). When distinguishing between the definition of forest and trees planted for agricultural purposes, the determining factor should be the type of management: forests are subject to extensive management and agricultural crops are the result of intensive management.

Tree cover in areas that are predominantly under urban or agricultural use is <u>excluded</u> from the definition because of its land use designation. An example of this is the Palmentuin palm garden (4 ha) in central Paramaribo.

Annex 4: Overview of the inventory plot database

Table x-2. Forest inventory plots included for carbon stock estimation in Suriname

Forest component	Source or study were data was collected	Sampling Unit areas (size and shape)	Minimum dbh recorded
Trees (n= 104451)	FAO (1975), provided by SBB	9,039 small plots established in 4 areas of the country 0.04 ha circular plots	dbh >= 25 cm
	ACT (2019)	4 plots	dbh>=10cm dbh>=5cm
	National Mangrove NFI (SBB, 2019)	11 plots 1 ha, rectangular plots 0.01ha, rectangular plots	dbh>=10cm dbh>=5cm
	Study by Sofie Ruysschaert (SR) provided by SBB	4 plots 1 ha, rectangular plots 0.01ha, rectangular plots	dbh>=10cm dbh>=5cm
	Pilot National Forest Inventory (NFI) implemented by SBB	31 Sampling Units, area 1.6ha 32 rectangular plots per SU of 0.01 ha 16 rectangular plots per SU of 0.01 ha	dbh>=20cm dbh>=10cm dbh>= 5cm
	Forest carbon stock measurements (FCAM). Pilot Carbon project implemented by SBB	12 transects, 1.5 ha, transect conformed by three rectangular plots (each 0.5 ha) Subplots of 0.375 ha	dbh>= 20cm (1.5ha) dbh>= 5cm (0.375ha)
	Olaf Banki (OB) provided by SBB	39 plots, 1 ha varying shape	dbh >= 10cm
	Bruce Hoffman (BH) provided by SBB	5 plots 1 ha (4 plots) rectangular 0.5 ha (1 plot) rectangular	dbh>=10cm
	Kabo, provided by CELOS	30 plots 1 ha square 100x100m	dbh>= 15cm
	MLA, provided by CELOS	18 rectangular transects 40 m per transect, various area size	dbh >=25 cm
	Nassau, provided by CELOS	1 plot 1 ha square 100x100m	dbh>=15 cm
	TEAM (CSN) managed by CELOS and Conservation International	5 plots 1 ha square 100x100m	dbh >10 cm

	Marchall Kreek (MK) provided by CELOS	6 plots 1 ha (3 plots), each 1 ha plot consist of 16 squares of 25m X 25 m 0.2 ha (3 plots), each 0.2 ha plot consist of 5 squares of 25m X 25 m	dbh>=20 cm dbh 5-20 cm
Lianas (n= 2266)	Forest carbon stock measurements (FCAM). Pilot Carbon project implemented by SBB	12 plots 0.375 ha, transect, unknown shape	dbh>= 1cm dbh>= 2 cm
	Pilot National Forest Inventory (NFI) implemented by SBB	33 SU with 8 plots each 0.32 ha, 4 square subplots of 0.01 ha, per plot	dbh>= 5 cm
	Bruce Hoffman (BH) provided by SBB	4 plots 1 ha (4 plots) rectangular	dbh >10 cm
	TEAM (CSN) managed by CELOS and Conservation International	5 plots 1 ha 100x100m	dbh >10cm
Palms (n=2650)	Forest carbon stock measurements (FCAM). Pilot Carbon project implemented by SBB	6 transects 0.375 ha, measures in 2 square subplots of 0.125 ha each 0.5 ha 6 transects, measures in all plots 0.375 ha, 5 transects, measures in 2 square subplots of 0.125 ha	dbh 5-20cm dbh >= 20cm Stem H >= 1.3 m
	Pilot National Forest Inventory (NFI) implemented by SBB	31 plots (clusters) 0.01 ha rectangular plots, 4 subplots in each cluster	stem H ≥ 1.3m
	Olaf Banki (OB) provided by SBB	20 plots 1 ha, varying shape	dbh >= 10cm
	Bruce Hoffman (BH) provided by SBB	1 ha (2 plots) rectangular 0.5 ha (1 plot) rectangular	dbh >= 10cm
	Study by Sofie Ruysschaert (SR) provided by SBB	4 plots 1 ha, unknown shape 1 ha 1 subplots, unknown shape	dbh >= 10cm dbh 0-10 cm
Standing dead wood (n=3244)	Forest carbon stock measurements (FCAM). Pilot Carbon project implemented by SBB	12 plots 0.5 ha, rectangular plots	dbh >= 5cm
	Pilot National Forest Inventory (NFI) implemented by SBB	31 plots 0.02 ha, square plots	dbh >= 10cm
Lying dead wood (n=608)	Pilot National Forest Inventory (NFI) implemented by SBB	29 plots 0.01 ha, square subplots	dbh >= 10cm

Annex 5: FREL streamlined with GHG inventory

Table x-3. FREL activities streamlined with the GHG inventory

REDD+ Activities	**Activity in FREL**	**Gases**	**Carbon pools**	**Stratification**				**National GHGI Categories**
(1) Deforestation	(1.a) Conversion Forest to Non-forest (without Forest fire) in area ha	CO_2	AGB (trees, palms & lianas) + BGB(trees & palms) + DW (lying & standing)	(1) Mangrove forest	(2) Coastal plain	(3) Forest belt	(4) Interior	Forest land converted to Cropland/ Grassland/ Wetland/ Settlements/ Other land
	(1.b) Conversion Shifting cultivation to Non-forest (without Forest fire) in area ha	CO_2		(1) Mangrove forest	(2) Coastal plain	(3) Forest belt	(4) Interior	
	(1.c) Conversion Forest to Non-forest through Forest fire in area ha	CO_2		(1) Mangrove forest	(2) Coastal plain	(3) Forest belt	(4) Interior	
		Non-CO_2 (CH_4+N_2O)	AGB (trees, palms & lianas) + DW (lying & standing)					
(2) Degradation	(2.a) Roundwood production in m^3 volume	CO_2	AGB (trees & palms) + BGB (trees) + DW (lying & standing)	National				Forest land remaining Forest land

	(2.b) Fuelwood production in m^3 volume	CO_2		National				
	(2.c) Conversion Forest to Shifting cultivation through Forest fire in area ha	CO_2	AGB (trees, palms & lianas) + BGB(trees & palms) + DW (lying & standing)	(1) Mangrove forest	(2) Coastal plain	(3) Forest belt	(4) Interior	
		Non-CO_2 (CH_4+N_2O)	AGB (trees, palms & lianas) + DW (lying & standing)	(1) Mangrove forest	(2) Coastal plain	(3) Forest belt	(4) Interior	

Annex 6: Background information on existing future scenarios for deforestation and forest degradation

1. Modeling scenarios for future deforestation

Suriname is currently in the REDD+ preparation phase, in which the institutional frameworks are strengthened and the National REDD+ Strategy is developed. An important part of this phase is the development of spatial explicit scenarios. This activity was carried out as a multi departmental approach, where the expected impact of the National Development Plan 2017-2021 on the forest cover has been discussed. As the same National Development Plan is still applicable for the first and second FREL, these modelling scenarios are the same as in the first FREL.

The results of the spatial explicit for scenarios of future deforestation are relevant for the development of the National REDD+ Strategy and should be comparable with the Forest Reference Emissions Level (FREL). Projects regarding reforestation have not been taken into account, as the focus was to predict future deforestation.

A land use change model was developed within Dinamica EGO (Soares-Filho et al., 2002) to simulate scenarios (See tabel x-4). The three scenarios that were identified are:

1. Business As Usual (BAU) scenario: the assumption in the BAU scenario is that there will be no major differences in economic, technological and political development. The deforestation rate will remain stable and there will be no REDD+ implementation;
2. Development scenario: the assumption here is that the development projects which are included in the Development Plan 2017-2021 will be carried out, except the projects with reforestation activities;
3. Development with REDD+ scenario: the assumption in this scenario is that the development projects which are included in the Development Plan 2017-2021 will be carried out, but considering the implementation of the REDD+ National Strategy.

Table x-4. Overview of the development projects included in the projected development scenario and the development with REDD+ scenario

Category	Sub-category	Assumptions	
		Projected development scenario	**Development with REDD+ scenario**
Mining	Gold mining	All the gold mining concessions in Suriname are used.	Only the gold mining concessions within the Greenstone belt are used
		The large and small-scale gold mining concessions are expanded.	The large-scale gold mining Concessions are expanded, but small-scale gold mining concessions will not expand.
		Give the same weight of evidence of the exploitation concessions to the exploration concessions after 5 years.	Idem
	Oil exploration	The oil exploration will shift between the Gangaram Panday weg and Weg naar Zee, leading to new infrastructure in this area.	Idem
	Bauxite mining	The Bakhuys project will be executed, but without the construction of the Kabalebo hydro power dam.	Idem
		Only the bauxite-laterite areas within the borders of the Bakhuys project will be deforested.	Idem
		Nassau mining concession with the Grankriki hydro power dam will be executed.	Nassau mining concession without the Grankriki hydropower dam will be executed.
Agriculture	Oilpalm	All the planned oilpalm projects will be executed.	Consider only the existing China Zhong Heng Tai (CZHT) oilpalm project.
Mangrove		Deforestation may occur in the mangrove forest.	There will be no deforestation in the mangrove forest.

Infrastructure		Tapajai project will be carried out	Tapajai project will not be carried out
		Consider planned roads : Roads to Nassau, road to hydropower Grankriki, road to Tapajai project	Consider planned roads: Road to Nassau
		Roads to Tapajaiproject has a width of 20meters	---
Urban area		The four development areas with a buffer of 5km are considered: Apoera, Atjoni, Stoelmanseiland and Snesikondre.	Idem
Protected areas		Deforestation may occur in the (existing and proposed) protected areas.	It is is assumed that deforestation will not occur in the (existing and proposed) protected areas.
General info		The deforestation rate used is the highest rate, estimated from the historical period (2000-2015).	The deforestation rate used is the mean rate, estimated from the historical period (2000-2015).
		The first 5 years (2015-2020) use the BAU trend. After 2020 the Development considerations impact the occurrence of deforestation.	The first 5 years (2015-2020) use the BAU trend. After 2020 the REDD+ considerations impact the occurrence of deforestation.

The scenarios were simulated from 2015 till 2035, with an interval of 5 years in between. The reason for setting this projected period until the 2035 projection was because at the moment the scenarios were developed, the Suriname Planning Office intended to create a Development Plan document until 2035. It should be noted that the BAU scenario and the REDD+ scenario have comparable results (Table x-5 and figure x-2). This can be explained because of the historically low deforestation rate. Nevertheless, currently there is an ongoing increase in the mining and logging sector and a number of large land conversion projects have been initiated. This indicates that the expected future projection if no REDD+ activities are carried out, will be closer to the development scenario than to the BAU scenario.

Table x-5. Results of the modeling of the future deforestation models

	BAU	Development	REDD+
Deforestation 2015-2035 (ha)	407,772	656,290	415,425
Average annual deforestation based on scenarios (ha per year)	20,388	32,814	20,771

We expect the deforestation to increase gradually, and therefore, the projected average annual deforestation rate for the Development scenario for the period 2015-2035 will not be reached during the FREL-period 2015-2020.

Table x-6 shows the projected increase in deforestation based on the country's FREL. Rehabilitation of deforested areas has not been included in the REDD+ scenario, but might become necessary to maintain the country's 93% forest cover.

Table x-6. Results of the projected deforested area (ha) based on the FREL

Year	Emissions deforestation ($t\ CO_2$)	Projected deforested area (ha) based on FREL
2016	10,424,074	13,773
2017	11,109,668	14,680
2018	11,795,262	15,588
2019	12,480,855	16,495
2020	13,166,449	17,403

Business As Usual scenario	REDD+ scenario	Development scenario

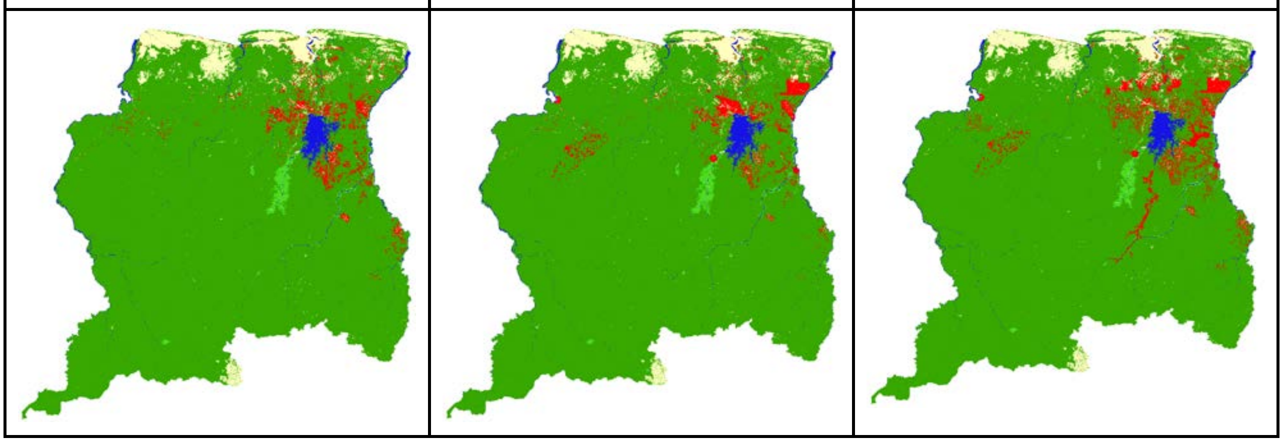


Figure x-2. Overview of the three scenarios for the period 2015-2035

2. Modeling future scenarios for forest degradation due to timber logging

While no spatial explicit scenarios for future forest degradation prediction are available, the projected FREL can be compared with the emissions based on the projected timber production which are part of the yearly analysis of the forest sector reports (reports can be found on: http://sbbsur.com/bosbouw-economische-diensten/statistieken/).

The timber production in the past 10 years, from 2010 to 2019 showed a steady increasing trend. With an average annual increase of 19% this reached up to 1,074,000 m^3 in 2019, excluding unregistered logs and fuelwood. Based on the potential of the source, the accessible forest area where timber cutting licenses are issued, and national & international development, the expectation is that the production will increase up to 1,500,000 m^3 in 2025 and stabilize. However due to COVID-19 the production is expected to decrease to 650,000 m^3 in 2020. Looking at the progress in the health- and medical sector internationally regarding the COVID-19, the expectation is that the activities within the forest sector will normalize in 2021 and the timber production trend will recover (Table x-7). This was estimated by the FREL technical working group based on expert estimations.

Table x-7. Predicted logging production 2020-2025

Year	Annual prediction logging production (m^3)
2020	650,000
2021	850,000
2022	1,000,000
2023	1,200,000
2024	1,440,000
2025	**1,500,000**

Annex 7: Realizations from the NFMS roadmap

Table x-8. Current state of NFMS roadmap activities

	Status	
Cross Cutting activities		
Reach agreement on forest-related definitions		FREL with definitions was submitted to UNFCCC with validated definitions
Institutional arrangements for the NFMS		NFMS became part of SBB's institutional structure and is also institutionalized within the 3rd National Communication on GHG
Store NFMS data in a centralized manner		More work to be done
Share NFMS data with Broader public		www.gonini.org and sfiss.sbb.sr are the two online platforms with information. These platforms are constantly being improved
Develop and implement research program		Regular communication with CELOS to streamline activities
Stimulate research scholarship opportunities for NFMS related-topics		The broad network built throughout the NFMS implementation has led to scholarship opportunities. Additionally many students (about 10 students since 2018) have done their thesis projects on NFMS related topics
Support financial sustainability of the NFMS		We need a better structure and longer term perspectives for the experts involved within the NFMS.
SLMS		
Deforestation monitoring		Deforestation maps were produced for 2015, 2016, 2017, 2018, and 2019. Since 2018, Sentinel 2 images are being used
Forest degradation monitoring		Some aspects of forest degradation have been measured or are included in the SLMS
Accuracy assessment		All data from the SLMS is accompanied with a QA/QC
Spatially explicit LULC monitoring		3 LULC maps were finalized in a multi stakeholders process: 2000, 2015, 2019
Agreement on national cartographic standards		More work is needed to establish structures of e.g. the Suriname Environmental Information Network (SMIN)

and production of national data layers		
National Forest Inventory		
Best estimates for forest carbon stocks and emission factors related to logging		This report was completed in collaboration with CATIE
Evaluation of pilot NFI protocol		Preparations were made to include this in the regional project within the Guiana Shield. This project was not implemented yet due to a lack of financial support
Develop National Forest Inventory for Suriname		Improvements were done and implemented during the Mangrove Inventory
Harmonize NFI with other forest inventory procedures		Nothing has been done but we need to evaluate the relevance
Build capacity on Tree species identification Field measurement		This is urgent as there is currently a lack of tree spotters
Validate pantropical allometric equations		Completed by CELOS
Monitoring the EF of logging using the gain-loss method		
Assess the EF related to logging		Report was finished (Zalman et al 2019) and (Ellis et al, 2019)
Embed monitoring EF in the SFM operational procedures		A whole new forestry information system was built and implemented (SFISS)
Other monitoring functions		
Create awareness and strengthen capacity on C-MRV		A number of training were implemented especially also on the role of communities in SFISS. But more awareness and capacity is needed
Work on methodologies		A study carried out by ACT brought together information on

to carry out C-MRV		community based monitoring
Test the possibilities of using satellite images for NRTM		Completed. This is in operation for 3 years now
Implement an NRTM system		Already implemented, but now we are working on ways to automate the detections.
Keep track of the fire alerts to monitor the general trends		Ongoing
Create a platform to share information on mangrove forest		All information collected on mangroves can be found back on www.gonini.org
Monitoring the extent of the mangrove forest and/or land use changes in the coastal area		Completed and will be further continued
Execution of the National Forest Inventory in the mangrove forest		Completed and will be further improved
Include mangrove forests in the NRTM		Ongoing but not always systematically
Reporting		
FREL		1st FREL was submitted in January 2018 and is currently updated for a 2nd submission in January 2021
REDD+ reporting/ LULUCF data for GHG inventory		NFMS is embedded now in the structures for the 3rd National Communication on GHG-inventory
Other international reporting (FRA and similar)		Input was delivered for FRA 2020, CBD reporting and Amazon report
National reporting		Regularly input for the NFMS is used for all national report with information on the forest sector

Annex 8. Background information on analyzing forest degradation due to mining

Mining activities lead to deforestation, but may also cause forest degradation in its vicinity. An analysis was carried out to know if the emissions from forest degradation due to mining are significant to be considered in the second Forest Reference Emission Level (FREL) report.

Method

The data that has been used for the analyses is:

- Forest loss data of 2000 to 2019 from Hansen
- Goldmining data from FCMU/SBB
- Greenstone belt
- Hydrography data
- Infrastructure data

The next steps have been executed:

1. The forest loss data from Hansen has been clipped with the Greenstone belt in Suriname. Gold deposits are concentrated in large parts of the Greenstone belt. Most of the deforestation within this area is therefore assumed to be due to goldmining activities.
2. Comparing the goldmining data from FCMU/SBB and forest loss data from Hansen, it seems that some areas have been missed. To cover all the goldmining areas, the goldmining data from FCMU/SBB has been merged with the forest loss data from Hansen.
3. To identify forest degradation due to goldmining, all the forest loss patches smaller than 1ha have been extracted. The definition of forest specifies the minimum mapping unit to be 1ha. According to this definition, forest loss patches equal or larger than 1ha are then mapped as deforestation. Deforested patches smaller than 1ha are therefore seen as forest degradation.
4. All the deforested patches smaller than 1ha that intersect with the hydrography, infrastructure and shifting cultivation data, is removed to avoid false forest degradation patches.
5. Around the goldmining areas a buffer of 1300m was drawn. The distance of 1300m was estimated in a previous study, which has shown that this was the maximum distance to identify a deforested patch from a previous deforested area.

All the deforested patches smaller than 1ha within the buffer were identified as forest degradation. The total area of these small patches is 2644 ha., which was about 1% of the total emissions for 2000-2019. According to this result, the emissions of forest degradation due to mining is not taken into account in the second FREL report.

Annex 9: QA/QC results of Deforestation data

Table x-9 QA/QC results

Period	Stratified estimated area (ha)	95% confidence interval (ha)
Deforestation 2000-2009	33051	5361
Deforestation 2009-2013	32071	2388
Deforestation 2013-2014	15757	2082
Deforestation 2014-2015	9442	1620
Deforestation 2015-2016	11387	1886
Deforestation 2016-2017	10667	3162
Deforestation 2017-2018	8818	315
Deforestation 2018-2019	10379	0