FOREST REFERENCE EMISSION LEVEL

FOR SURINAME's REDD+ PROGRAMME

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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 to estimate emission factors and produce activity data and has formulated a national strategy for REDD+ implementation. This Forest Reference Emission Level (FREL) has been written in-country by a national team, bringing together the most robust national forest related data available, with policy goals for the country's future. The purpose of the FREL is to enable result-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.

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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
BFAST	Break detection For Additive Seasonal Trends
BGB	Below-Ground Biomass
C	Carbon
CATIE	Tropical Agricultural Research and Higher Education Center
CBD	Convention on Biological Diversity
CBM	Community-based monitoring
CELOS	Centre for Agricultural Research in Suriname
CH4	Methane
CHS	CELOS Harvesting System
CI	Confidence Interval
CI	Conservation International
cm	Centimeter
CMRV	Community Measurement, Reporting and Verification
CO2	Carbon dioxide
COP	Conference of the Parties (UNFCCC)
CSNR	Central Suriname Nature Reserve
D	Diameter (lianas)
dbh	Diameter in breast height
DDFDB+	Drivers of Deforestation, Forest Degradation and Barriers to REDD+ activities
DOM	Dead Organic Matter
DW	Dead Wood
E	Emission
EF	Emission Factors
EITI	Extractive Industries Transparency Initiative
ELE	Extracted Log Emissions
eq	Equivalent
et al.	And others (et alia)
FAO	Food and Agriculture Organization of the United Nations
FCMU	Forest Cover Monitoring Unit
FCPF	Forest Carbon Partnership Facility
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
FSC	Forest Stewardship Council
g	Gram
GCCA+	Global Climate Change Alliance

GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFOI	Global Forest Observation Initiative
GHG	Greenhouse gas
GIS	Geographic Information System
GMD	Geological Mining Department
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GOS	Government of Suriname
GPG	Good Practice Guidance
ha	Hectare
HFLD	High Forest Low Deforestation
Hg	Mercury
ibid	In the same source as above
ICL	Incidental Cutting License
IDB	Inter-American Development Bank
INDC	Intended Nationally Determined Contribution
INPE	National Institute for Space Research in Brazil
IPCC	Intergovernmental Panel for Climate Change
km	Kilometre
LBB	Lands Bos Beheer / State Forest Service
LDF	Logging Damage Factor
LDW	Lying Dead Wood
LIF	Logging Infrastructure Factor
LULC	Land Use Land Cover
LULUCF	Land Use, Land Use Change and Forestry
m	Metre
Mg	Megagram (= ton)
MI-GLIS	Management Institute for Land Registration and Land Information System
MMU	Minimum Mapping Unit
MRV	Measurement, Reporting and Verification
MTP	Minor Timber Products
MW	MegaWatt
N	North (latitude)
N2O	Nitrous oxide
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NH (Min)	Ministry of Natural Resources
NIMOS	National Institute for Environment and Development in Suriname
NRTM	Near Real Time Monitoring
NSC	Norwegian Space Centre
NTFP	Non-Timber Forest Products
NZCS	National Zoological Collection Suriname
ONF	French Governmental Forestry Service
ONFI	ONF International
PMU	Project Management Unit
QA/QC	Quality Assurance/Quality Control

QGIS	A free and open source GIS software
R2	R square (statistics)
RAC	REDD+ Assistants Collective
REDD+	Reduced Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
RIL	Reduced Impact Logging
RIL-C	Reduced Impact Logging Certification
RO (Min)	Ministry of Regional Development
R-PP	Readiness Preparation Proposal
SA	Skid Trail
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	Skid Trail Factor
SFM	Sustainable Forest Management
SIS	Safeguards Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SPS	Stichting Planbureau Suriname / National Planning Office
SRD	Surinamese Dollar
SU	Sampling Unit
TBI	Tropenbos International
TEF	Total Emission Factor
TNC	The Nature Conservancy
TNRS	Taxonomic Name Resolution Service
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 first 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.

The Suriname National REDD+ Strategy (being finalized) outlines the vision of REDD+ in Suriname 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 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, Suriname's REDD+ program including 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 (2003) 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.

The current FREL submission is based on best available data, mostly generated by the National Forest Monitoring System (NFMS), with a transparent analysis of uncertainty and remaining gaps. This corresponds to Decision 12/CP.17 Paragraph 1. Suriname will update its FREL periodically, based on 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 (73%) (of which Artisanal Small Scale Gold Mining (ASGM) covering ca. 59% of the total deforestation), Infrastructure (15%), Urbanization (4%), Agriculture (3%), Pasture (1%), Burned area (3%) and other deforestation (1%) (see annex 5);

[1] See folder with FREL Suriname background information openly available online: https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing; Geoportal: http://www.gonini.org/portal/

- Inclusion of forest degradation caused by logging (ca. 25% of the total emissions);
- 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 Organic Matter (DOM). 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 gets available;
- Carbon dioxide (CO_2) is the only GHG that has been included in this FREL;
- 'Historical period' calculations are based on the fifteen-year timespan from 2000-2015, and the FREL is established for a period of five years (2016-2020). 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 0.02-0.05%) and forest degradation, resulting in an effective forest cover of 93% of the land area (SBB, 2017c) and historical emissions of **97,566,122** Mg CO_2 (with annual average of 6,557,411 Mg CO_2 for the period 2000-2015). The 95% CI is **± 6,819,188** Mg CO_2 or ±6.99% of the mean.

Nevertheless, pressure on Suriname's forests has steadily increased in recent years, primarily due to strong incentives for the growth of economic activities from mining, especially artisanal small-scale gold mining (ASGM). 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, but on the other hand a large area (25%) of the logging concessions is under a voluntary certification scheme, where companies commit to work in a sustainable way. The forestry sector could provide many opportunities 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 (2-3% of the deforestation in the period 2000-2015), but a rapid expansion is expected in the near future due to various projects (e.g., oil palm plantations) planned to boost Suriname's development. The Development scenario, that is part of the scenario modeling process executed in the framework of the Suriname National REDD+ Strategy, was also used to support the projection of the FREL. The Development scenario considers all the main planned projects, based on the National Development Plan of 2017-2021 and stakeholder involvement, indicating the future deforestation that can possibly occur.

Due to this expected increased growth, Suriname is presenting a FREL with a linear growth projection as an adjustment in calculating its historical emissions. This corresponds with the results found through the scenario modeling process executed in the framework of the Suriname National REDD+ Strategy. The Development scenario considers all the main planned development projects, based on the National Development Plan of 2017-2021 and in-depth dialogue with partner institutions and stakeholders, indicating that future deforestation is likely to continue increasing. Also the timber production is expected to continue increasing, at least until it would reach 1,000,000 m^3 in 2022 (SBB, 2017d).

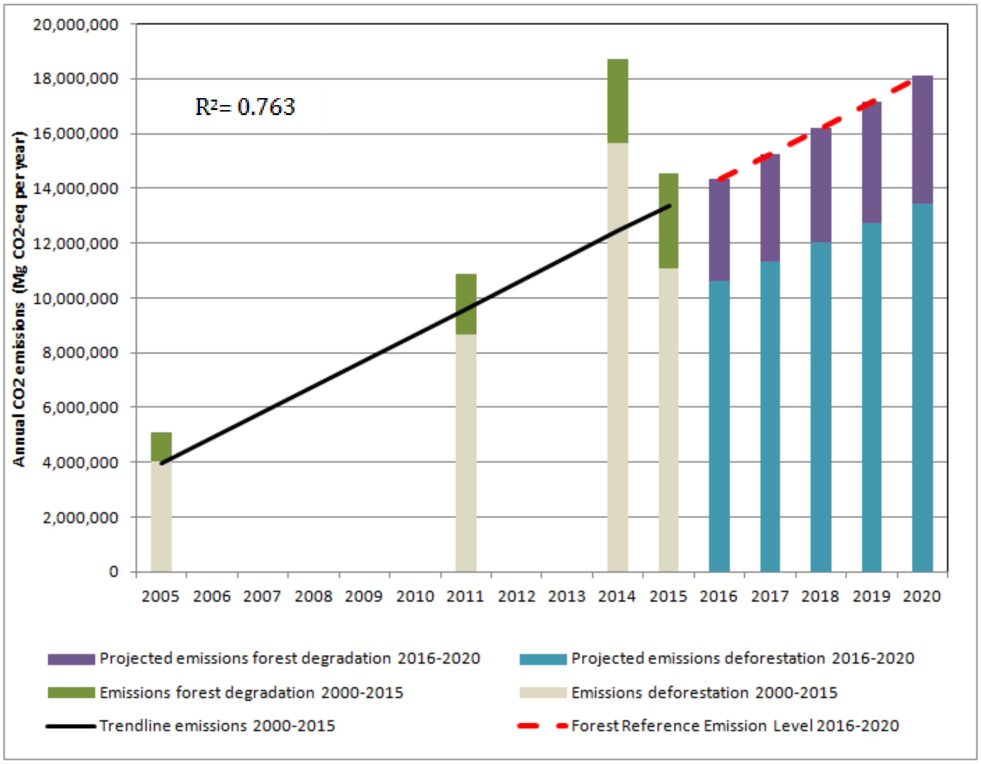

Figure. FREL projection for Suriname - For the period 2000-2009 the year 2005 has been used and for the period 2009-2013 the year 2011

Suriname's FREL corresponds to the following annual CO_2-Emissions (Mg CO_2-eq per year):

- 2016: 14,441,113 Mg CO_2-eq
- 2017: 15,390,853 Mg CO_2-eq
- 2018: 16,340,593 Mg CO_2-eq
- 2019: 17,290,333 Mg CO_2-eq
- 2020: 18,240,073 Mg CO_2-eq

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 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

Suriname welcomes the opportunity to submit a Forest Reference Emission Level (FREL) for 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). The submission of this first FREL for Suriname is part of the overall REDD+ readiness process of Suriname and this FREL is consistent with the Suriname National REDD+ Strategy (finalized soon). 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.

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

> *Suriname's tropical forest continues and improves its contribution to the national and community growth, welfare and wellbeing of current and future generations through planning, research, effective protected areas management and sustainable forest management, resulting in an efficient use of the forest and natural resources, ecosystem services and the preservation of biodiversity, while continuing to offer a substantial contribution to the global environment, enabling the conditions for an adequate compensation for this global service.*

Suriname aims to implement REDD+ as a tool for 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. With the UNDP as Delivery Partner, this grant is used for 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. 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 being finalized and a Safeguards Information System (SIS) is under development. The Foundation for Forest Management and Production Control (SBB) serves as the REDD+ Technical Partner responsible for preparation of the FREL and the National Forest Monitoring System (NFMS).

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

In accordance with UNFCCC decision 4/CP.15, this document shows transparently how the FREL for Suriname has been established, taking into account historical data with adjustment for 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.

Formal submission of the FREL is done through the Office of the President's Coordination Environment of the Republic of Suriname as the National Focal Point to the UNFCCC, via NIMOS and SBB. Before its submission, the FREL went through an extensive consultation process with national stakeholders. This process included the raising of awareness about the FREL and building capacity of stakeholders to better understand its concept. Technical stakeholders provided substantive feedback that helped improve 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 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 first 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; Hammond, 2005; Bart de Dijn *et al.*, 2018). The country is rather small with an official reported land surface of 163,800 km^2 (FAO 2014). 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 decretion (See figure 1). Suriname's 15.2 million hectares of forest (SBB, 2017c) represent around 0.9% of the total tropical forest (1.71 billion hectare) in the world (FAO, 2015).

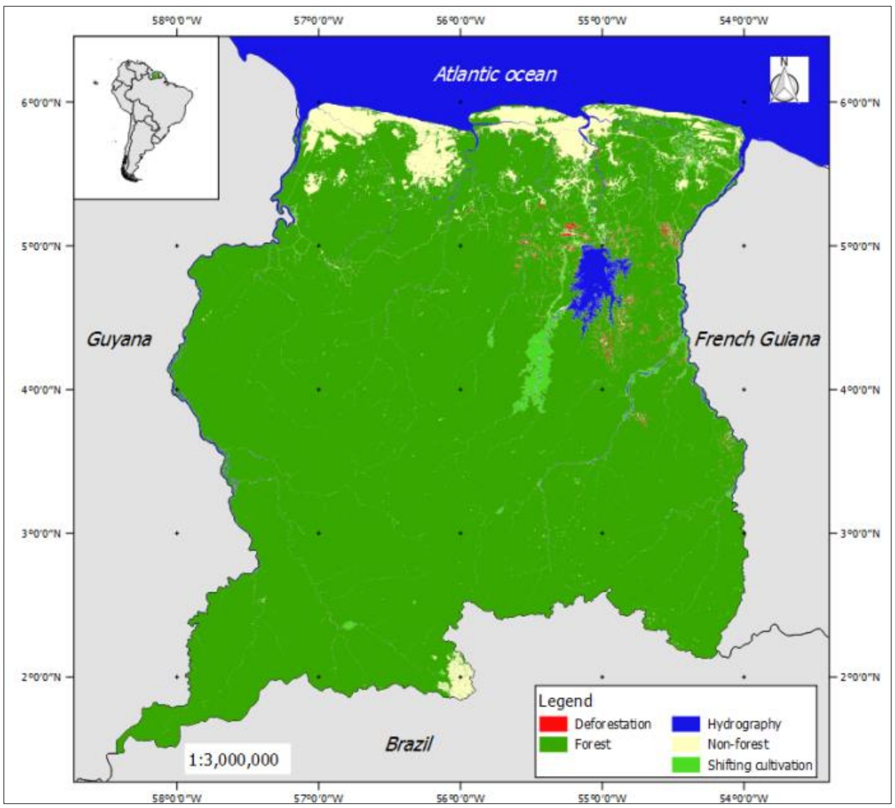

Figure 1. Situation map of Suriname

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 2020. 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 Labour, Technological Development and Environment, 2013), the National Forest Policy (2005) and the draft 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 rate increased from 0.02% to 0.05% in average in the period 2009-2015, and is expected to continue increasing (SBB, 2017c).

The current main driver of deforestation is mining (mainly for gold), especially Artisanal Small Scale Gold Mining (ASGM) (ca. 80% of all mining activities) (SBB, 2017c). 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. The intention to conditionally remain a HFLD country was also mentioned in the Intended Nationally Determined Contribution (INDC)[4] and is in line with the draft 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. The vegetation of Suriname can be classified into three main types: Hydrophytic, Xerophytic and Mesophytic. The Mesophytic vegetation, mainly consisting of high tropical lowland forest with a diverse species mix, is considered the most valuable from a commercial perspective (Van der Hout, 2008). Commercial logging is taking place only north of the 4° N latitude within the forest belt, covering an area of 4.5 million hectares, of which ca. 2.5 million ha are currently issued under logging licenses (www.sbbsur.com, August 2017). 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). This yet needs to be finalized and enforced (National Forest Policy, 2005; draft Suriname National REDD+ Strategy). Applying these guidelines enables maintenance of other forest functions such as protection of water and soil, maintenance of biodiversity, carbon sequestration and erosion control (Werger *et al.,* 2011; Putz *et al.,* 2012).

[3] https://www.cbd.int/sp/targets/default.shtml#GoalC, accessed on 27-11-2017
[4] Accessible at: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Suriname/1/INDC-2-Suriname%20300915.pdf

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. This section presents and motivates decisions made on the scope and scale for this first FREL submission for Suriname.

3.1 Scale (geographic area)

Suriname is submitting a national FREL, because the government structure of the country is centralized and most data is available on the national level.

3.2 Historical time period

The historical reference period used for the first FREL in Suriname is 2000-2015. For this period, robust and locally produced information is available in terms of Activity Data (AD) linked to deforestation as well as to logging related forest degradation. This period was separated in four time intervals based on the availability of deforestation data: 2000-2009, 2009-2013, 2013-2014 and 2014-2015. These time intervals are of a different duration because the national deforestation maps were made as a contribution to regional Amazon deforestation maps[5]. Activity data (AD) for forest degradation due to logging (timber production) are available on an annual basis, but this data has been aggregated in the time intervals mentioned above.

3.3 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* (DDFDB+ study, SBB *et al.*, 2017b), the main ones being:

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

All these drivers are included and reported upon in the total deforestation assessed in the *Technical report: Forest cover monitoring in Suriname using remote sensing techniques for the period 2000-2015* (SBB, 2017c). This FREL is based upon these reports.

[5] Within the project of the Amazon Cooperation Treaty Organization (ACTO): "Monitoring the forest cover of the Amazon region"

Forest degradation

As presented in the DDFDB+ study (SBB *et al.*, 2017b), the drivers of forest degradation in Suriname are:

1. Mining (mining itself is deforestation, but degradation takes place in its vicinity);
2. Logging activities;
3. Shifting cultivation;
4. Fire.

A natural cause of forest degradation is windbreaks, but because of their natural character, they are not included here.

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 as a source of forest degradation in its first FREL. Methodologies are currently being developed to quantitatively assess the emissions due to the other drivers of forest degradation, to be included in a future submission.

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 draft Suriname National REDD+ Strategy. The removals resulting from carbon stock enhancement has not been included in this first FREL, because there are limited historical activities that can be used to determine these removals. It is part of the description of national circumstances and the aim is to include these in the next FREL/FRL submission.

4. Information used to construct the FREL

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

The NFMS includes a Measuring, Reporting and Verification (MRV) function and other monitoring functions. Suriname's NFMS is composed of an operational Satellite Land Monitoring System (SLMS)[6], a National Forest Inventory (NFI), a Sustainable Forest Management monitoring component (SFM), a Near Real Time Monitoring system (NRTM) and several cross-cutting activities (e.g. mangrove monitoring), with broad participation of other institutions and stakeholders. The NFMS will also include community based monitoring (CBM/CMRV), to ensure that national and local initiatives are supporting each other. Guiding principles for the NFMS in Suriname include national ownership,

[6] 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.

open data accessibility and transparency, cost efficiency, and adaptation to context (e.g. different contexts require a different monitoring approach) (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[7].

4.1 Definitions and information used to construct the FREL

Forest definition for Suriname

While Suriname has a forest definition in its Forest Management Act (1992), this definition is meant for administrative purposes. Therefore Suriname has chosen to monitor forest based on nationally appropriate criteria chosen in line with the Marrakesh Accords (UNFCCC, 2001)[8]:

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. *Tree cover from trees, including palm trees, planted for agricultural purposes (such as coconut, citrus, 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, as long as it is done in a traditional way so that the forest gets the chance to grow back after harvest.

The administrative definition in the Forest Management Act (1992) will need to be adjusted and improved based on the above mentioned criteria. For reporting done within the FAO Forest Resource Assessment 2015, the above-mentioned criteria to define forest is applied. This will also be implemented for the next Greenhouse Gas Inventory.

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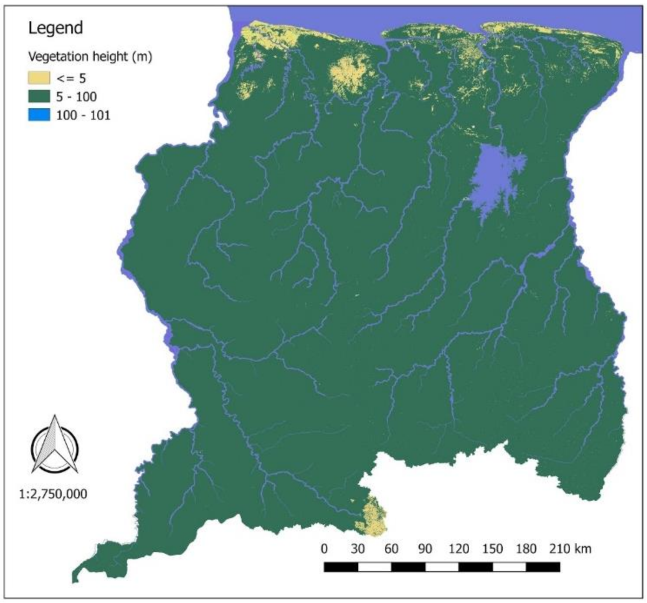
[7] For more information, see the *NFMS Roadmap - Status and Plans for Suriname's National Forest Monitoring System* (SBB, 2017). Available data can be found on the Geoportal http://www.gonini.org and in published reports.

[8] 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.

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 2). 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 2. Indicative vegetation height for Suriname (WHRC, 2015)

b) Minimum tree crown cover

An assessment of Suriname's tree crown cover (table 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 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 excluded 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 excluded from the definition because of its land use designation. An example of this is the Palmentuin palm garden (4 ha) in central Paramaribo.

Shifting cultivation is included in the national definition of forest, but conversion of primary forest to shifting cultivation is seen as forest degradation (forest land remaining forest land). Shifting cultivation is a type of 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. In the Surinamese situation, shifting cultivation plots are traditionally cultivated for 1 to 3 years and fallow periods vary from 3 to 15 years, letting the forest regenerate on the abandoned land (Helstone and Playfair, 2014). According to Ribeiro Filho *et al.* (2013), in most cases shifting cultivation can be seen as a sustainable activity without long-term negative impact on the soil and where fallow periods, which are long enough, mimic forest ecosystems. The forest dependent indigenous and tribal communities clearly indicate that shifting cultivation is a traditional and sustainable use of the forest (Gomes-Poma and Kaus, 1992; AAE and Tropenbos International Suriname 2017). Analysis conducted by SBB, using multi-year forest loss data (Hansen *et al.*, 2013) has shown that most shifting cultivation patches (>90%) are smaller than the minimum mapping unit of 1 hectare. It should be noted that in Suriname's 2nd National Communication to the UNFCCC on GHG inventory, the conversion of primary forest land to shifting cultivation was classified as the conversion from forest land to cropland. This will be updated and streamlined when submitting the 3rd National Communication.

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 2003 Good Practice Guidance for Land Use, Land-use Change and Forestry (GPG-LULUCF) and the IPCC 2006 Guidelines for National Greenhouse Gas Inventories: Agriculture, Forestry and Other Land use (AFOLU) 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 online[9]. All spatially explicit information on forest cover change is available through the open-access geoportal www.gonini.org. 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 Factor (EF), Timber production and Forest Inventory data are published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the website of the SBB (www.sbbsur.com).
- **Accuracy:** Area estimations based on remote sensing are generated following the good practices recommended by Olofsson *et al.* (2014) and GFOI (2016) and the tools developed by FAO (2016). When new data on emission factors and carbon stocks were collected, field protocols were developed and implemented in the field. 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.
- **Completeness:** All methodologies used, intermediate results and decisions made are presented and documented so that is possible to reconstruct the FREL (in agreement with decision 13/CP.19).
- **Consistency:** The FREL and the Suriname GHG national inventories are not consistent yet, but they will be in the future**.** Suriname's 1st National Communication was formally submitted to the UNFCCC on 27 March 2006 and the 2nd (based on 2008 data for the GHG inventory) was submitted on 15 March 2016[10]. This FREL does not fully coincide with the National Communications GHG inventory. Because the forest related emissions within the GHG inventory were determined before the NFMS was established, these emissions were estimated based on expert knowledge and research. Since the NFMS became operational, regular numbers are 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 that the national forest definition has been updated in the FREL. The new forest definition will be used in a consistent manner for the 3rd National Communication 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.

[9] https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing
[10] http://unfccc.int/resource/docs/natc/surnc2.pdf

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, 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 by:

- Annual wall-to-wall monitoring of the Activity Data (AD) using Landsat imagery, following a standard protocol and applying the methodology recommended by Olofsson *et al.* (2014) for land-use and land-use change area estimations. This is according to Approach 3.
- Activity data are disaggregated by drivers of deforestation for three periods. 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, 2017c). This is according to Approach 3 (the resulting land use change matrices are presented in annex 5).
- While no National Forest Inventory (NFI) has been carried out covering the the whole country, the forest carbon stocks have been assessed by assembling a national database bringing together data from 208 forest inventory plots scattered over the country. Within this database, above-ground biomass and dead wood were assessed according to Tier 2, based on national data, but using pantropical allometric estimates. Belowground biomass was assessed using Tier 1.
- 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. These emission factors are considered Tier 2.

Suriname will take steps for gradual improvement towards a combination of Tier 2 and Tier 3 (see chapter 6).

4.3 Pools / Gases

For **deforestation**, 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 (BGB);
- Dead Wood (DW).

Litter

Based on Crabbe *et al.* (2012), litter contributes ca. 2-6% to the total carbon stock. This includes 1-5% lying dead wood (with diameter larger than 5 cm), which is included within the FREL (Table 4). This means that the remaining litter component contributes less than 5% to the total emissions.

Because of no reliable complete national dataset, as well as the presented estimations 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 national forest inventory will be carried out.

Soil Organic Carbon
Based on Crabbe *et al.* (2012) Soil Organic Carbon (depth 0-30 cm) contributes ca. 14% to the total carbon stock. 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 **forest degradation** the following pools are included in the FREL:

- Above-Ground Biomass of trees and palms(AGB);
- Below-Ground Biomass of trees (BGB);
- Dead Wood (DW).

For forest remaining forest land, the Tier 1 approach assumes that Soil Organic Carbon and litter are in equilibrium. Changes in carbon stock are assumed to be zero.

Gases
The only GHG that is included in this FREL is carbon dioxide (CO_2). While some of the drivers of deforestation and forest degradation may also result in the emissions of N_2O and CH_4, insufficient national data is available for these gases to be included. CH_4 will be especially released when swamp area or mangrove forest are deforested. Nevertheless the swamp area being deforested is approximately less than 1% of the total deforestation.

4.4 Deforestation

4.4.1 Activity data

Activity data (AD) for deforestation are estimated from the forest basemap of year 2000 and the historical assessments of deforestation for the periods 2000-2009, 2009-2013, 2013-2014 and 2014-2015. These maps were developed by the Forest Cover Monitoring Unit (FCMU), located in SBB, through support of the Amazon Cooperation Treaty Organization (ACTO) project "*Monitoring the Forest Cover of the Amazon region*", in collaboration with international experts (INPE, UN-REDD, ONFI and CI) and national stakeholders. The periods were adapted based on the input to be provided for the regional Amazon maps.

For the wall-to-wall mapping and monitoring of the basemap 2000 and all deforestation maps, Landsat satellite images with a resolution of 30m were used (Landsat 5, 7, 8). The method used to produce the maps is 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 (SBB, 2017c).

Using Landsat satellite images for the monitoring of the forest cover is a challenge, due to the fluctuation in cloud coverage on these images leading to possible underestimation of the deforestation. In order to minimize this underestimation, a method was established to fill the cloudy areas with more available data.

All methodological details regarding map construction and analysis of satellite imagery are described in the technical report "*Forest cover monitoring in Suriname using remote sensing techniques for the period 2000-2015*" (SBB, 2017c). Figure 3 shows an overview of the deforestation per district over the periods 2000-2009 and 2009-2015. This data can also be viewed on the website www.gonini.org, having the ability to zoom in and out for a better view of the data and separating the periods 2000-2009, 2009-2013, 2013-2014 and 2014-2015.

The areas of deforestation were determined based on the results of the map accuracy assessment, as suggested by Olofsson *et al.* (2014), Global Forest Observation Initiative (GFOI), Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) and Norwegian Space Centre (NSC) (Proceedings of workshop, 2017).

The accuracy assessment was carried out with support of the UN-REDD program using the manual developed by the FAO (2016). 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. These "Good Practice" recommendations address the three major components: sampling design, response design and analysis using an on-screen review with remote sensing imagery (Olofsson *et al.,* 2014). The process is broken down into Quality Assessment/Quality Control (QA/QC) of four major components: (i) Final map, (ii) the sampling design, (iii) the response design and (iv) the analysis.

The accuracy assessments of the forest cover change data for the periods 2000-2009, 2009-2013, 2013-2014 and 2014-2015 took place with guidance from UN-REDD/FAO, and in close collaboration with SBB and the Centre for Agricultural Research in Suriname (CELOS). The OpenForis tools such as Collect Earth, Stratified Area Estimator Design and Analysis, were used to carry out the accuracy assessment. Also the System for Earth observations, data access, Processing & Analysis for Land monitoring (SEPAL), an on-the-cloud processing system, was used to adjust scripts for the analyses. The results show an overall accuracy of 99%. The stratified estimated areas will be used in further calculations (See table 2).

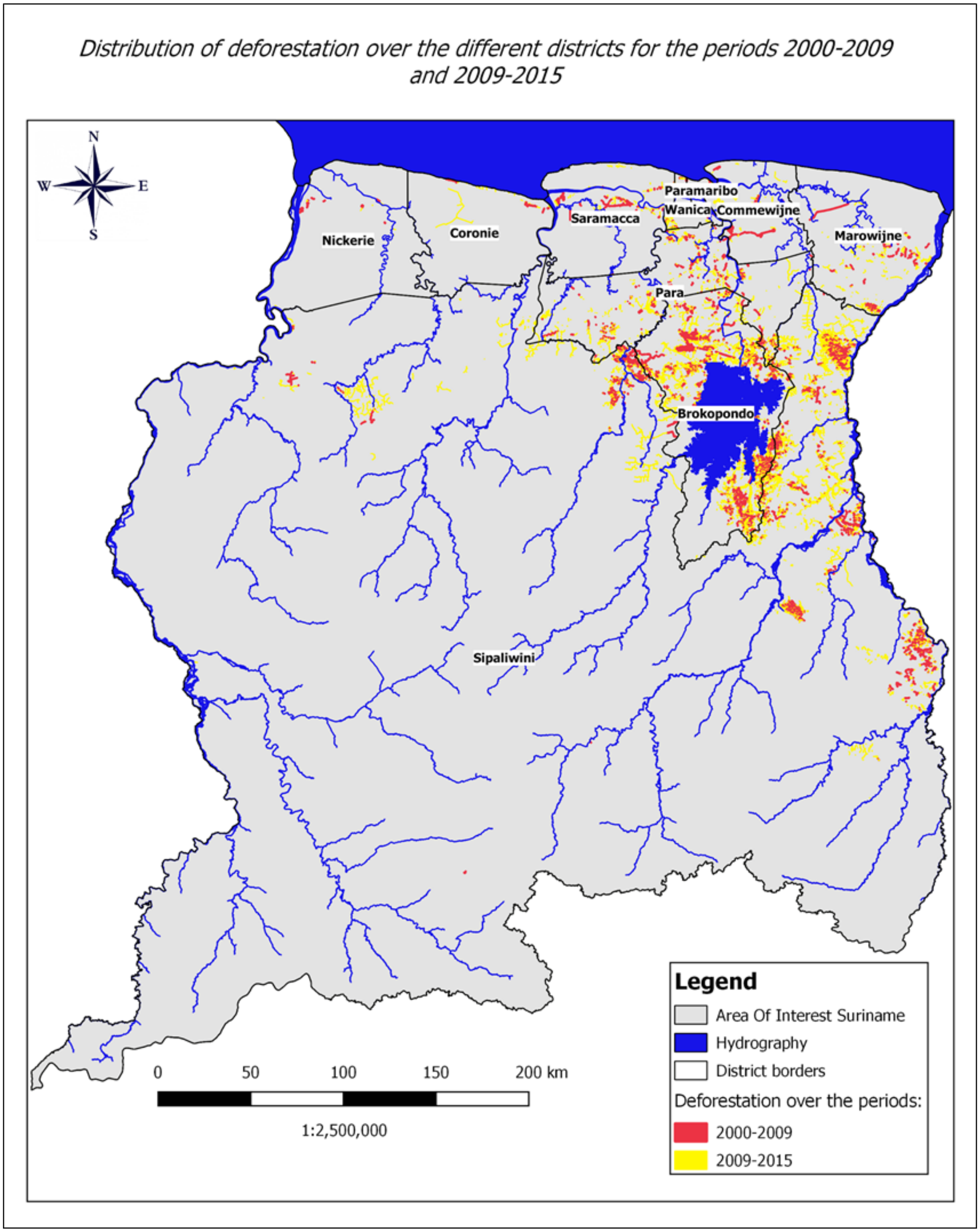


Figure 3. Overview of the deforestation per district in Suriname over the periods 2000-2009 and 2009-2015

Table 2. Stratified estimated areas and confidence intervals (SBB, 2017c)

	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

For the years 2009, 2013 and 2015, Post-deforestation Land Use Land Cover (LULC) maps have been created where the LULC classes (see annex 5) were determined through multi-sectoral collaboration. The main driver of deforestation is mining (mainly gold mining). Gold mining covers about 71% of the deforestation for the period 2000-2015 (SBB, 2017c). 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). Based on a general assessment, 80% of the gold mining areas are artisanal small scale gold mining (ASGM). The other two main drivers of deforestation for the period 2000-2015 are infrastructure (15%) and urbanization (4%) (SBB, 2017c). Land use change matrices have been created for the period 2009-2013 and 2013-2015, indicating the transformation of the forest and the LULC classes between the given years with the amount of area in ha (see annex 5).
Deforestation or conversion from forested land to other types of land is monitored in Suriname using the IPCC Approach 3 (See annex 5 - Overview of the classes in the Deforestation maps and Post-deforestation LULC maps).

4.4.2 Source and compilation of data for carbon stocks

Within the country's REDD+ readiness phase, a study was carried out bringing together data from eleven different forest inventory programs as shown in figure 4 (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), completed with the data collected in 12 field transects established during the *Forest Carbon Assessment and Monitoring* project (SBB., 2012) and the data collected in 31 Sampling Units (SU) throughout the pilot NFI project in 2013-2014.

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 of 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 has 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:

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

Equation 1. Standardization equation

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[11] and cross checked with the Taxonomic Name Resolution Service (TNRS)[12] into the most recent scientific name. This allows the tree species to be linked with the wood density values.

First an assessment of the carbon stock per forest type was carried out (see annex 3), but because no nationally approved area estimations for all these forest types are available, this classification was not further considered and an approach using four more general strata was used for now. 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 an average national forest carbon stock, based on this compiled database.

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

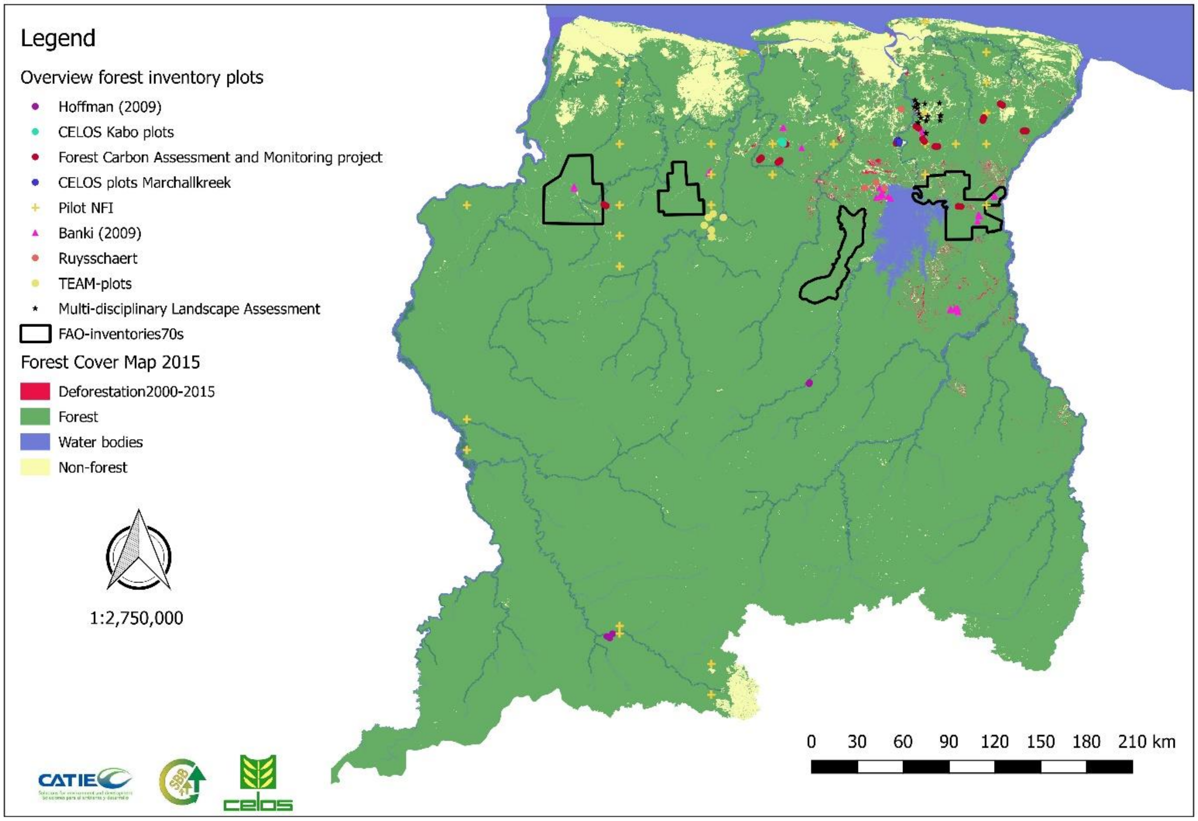


Figure 4. Overview of the forest inventory plots in Suriname (SBB et al., 2017a)

4.4.3 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. For this FREL, a first stratification of the country (figure 5) 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 strata currently included are:

- Stratum 1 Mangrove forest;
- Stratum 2 Coastal plain: From the mangrove forest to forest belt;
- Stratum 3 Forest belt: Includes the area where most logging activities occur, bordered in the South by the 4° North latitude and the Central Suriname Nature Reserve (CSNR);
- Stratum 4 Forest in the interior: The CSNR and the area south of the forest belt.

The emission factors for deforestation (equal to average carbon stocks) used for the different strata are displayed in table 4.

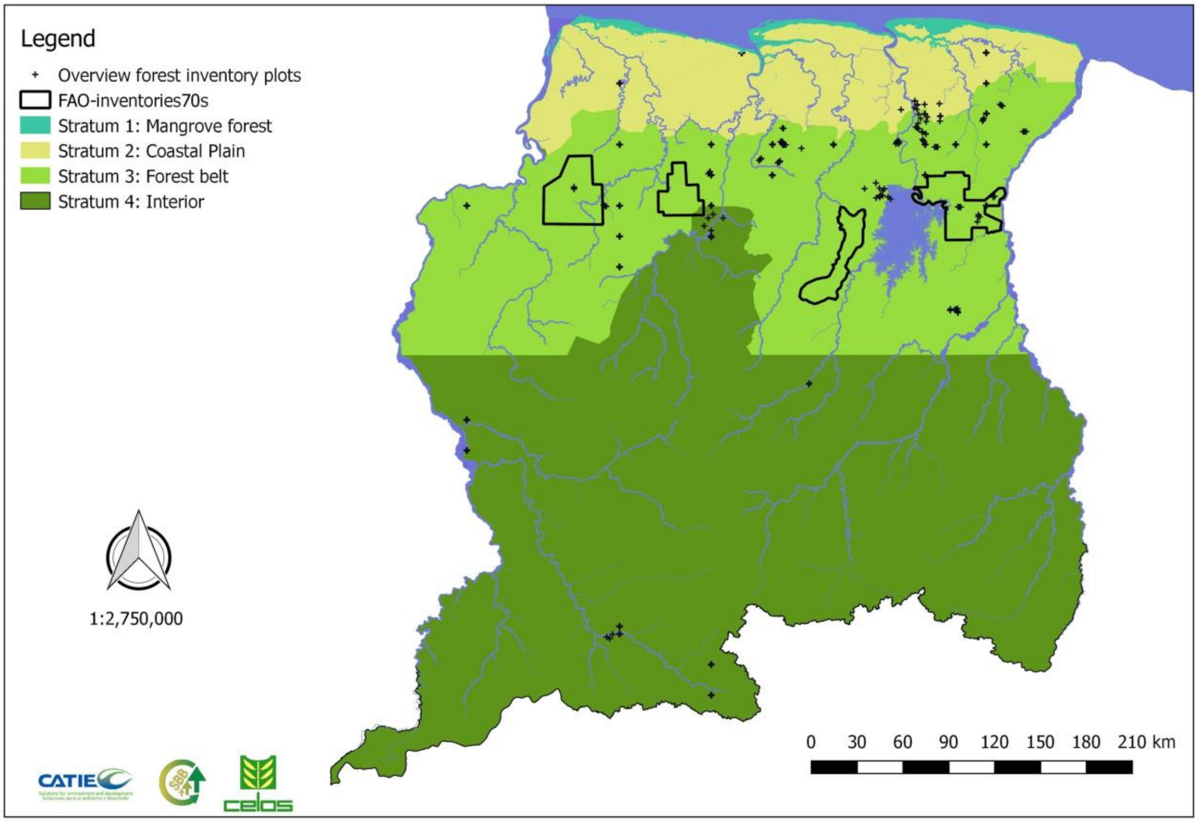


Figure 5. Preliminary stratification of Suriname

Currently other stratification approaches are being tested, such as the method developed by Guitet *et al.* (2013) in French Guiana. In this process geomorphological landscapes and climate zones are taken into consideration.

4.4.4 Method used to estimate carbon stocks

The Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF) of the IPCC 2003 provides definitions for five carbon pools: Above-Ground Biomass, Below-Ground Biomass, dead wood, litter and soils. Based on the available data in the database described in section 4.4.2, Suriname will include the carbon pools[13] within this FREL as indicated in table 3. More details can be found in *Technical Report State-of-the-art study: Best estimates for emission factors and carbon stocks for Suriname* prepared by SBB in collaboration with CATIE, CELOS and AdeKUS (SBB *et al.*, 2017a).

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

Table 3. 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 established by Chave *et al.* (2005) was used. This equation will be evaluated by CELOS in the coming period. The selected equations used dbh values in cm and wood density values (ρ) in g cm^{-3}. The wood densities were obtained from the Global Wood Density Database (Zanne *et al.*, 2009). An community weighted mean of 0.68 g cm^{-3} was found for the wood density in this dataset and used for unknown species. **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, AGB values were multiplied by the 0.24 factor for tropical rainforests (Cairns *et al.*, 1997), 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).
Standing Dead Wood (SDW)
Biomass in standing dead trees was estimated using the Chave *et al.* (2005) equation developed for estimating biomass in living trees. After this, 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).

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 the average carbon stocks in Mg C per hectare per pool per forest stratum are shown.

It is remarkable that the forest belt, where logging takes place, has a higher average carbon stock than the interior where only very limited anthropogenic activities are carried out. This could be explained by the limited number of plots in the interior (Figure 5) which is difficult to access, or by a sparser tree cover because of the mountainous landscape and or savanna. Also for the mangrove forest, the carbon stock estimates are very low, because of the limited number of plots. The information will be improved when more field data is collected during the coming years.

Table 4. Carbon stocks (Mg C ha-1) in the selected pools in each stratum (SBB et al., 2017a)

Carbon Pools		**Carbon stock (Mg C ha^{-1})**			
		Mangrove forest	**Coastal plain**	**Forest belt**	**Interior**
Number of sampling units		2	21	170	15
Above-Ground Biomass	Live trees (dbh > 5cm)	44.41	149.62	176.10	164.99
	Palms	0.00	5.08	1.06	2.26
	Lianas	0.00	0.64	2.83	2.38
Below-Ground Biomass	Roots	10.66	35.91	42.26	39.60
Dead Organic Matter	LDW	0.79	3.23	11.54	4.50
	SDW	2.11	1.31	3.14	1.92
Total		**57.97**	**195.78**	**236.93**	**215.65**

The total carbon stock for the whole country is calculated (see table 5) by first, multiplying the total carbon stocks of each stratum by the area of the stratum and then, taking the sum of the results and dividing it by the area of the whole country. The average carbon stock for Suriname is equal to **218.73 Mg C ha^{-1}** with an uncertainty of 5.82%. To convert to its CO_2-equivalent the factor 44/12 is used, with as result an average value of **802.01 Mg CO_2 ha^{-1}** with an uncertainty of 5.82%.

Table 5. Carbon stocks in the selected pools in each stratum

Stratum	**Area (ha)**	**Carbon stock (Mg C)**	**Uncertainty (%)**
Mangrove forest	112,261	6,507,753	387.0%
Young coastal plain	1,981,396	387,922,087	17.2%
Forest belt	5,057,477	1,198,264,826	3.6%
Interior	9,236,498	1,991,835,373	9.6%
Whole country	**16,387,632**	**3,584,530,039**	**5.82%**

Compared to the neighboring countries the average carbon stock found in Suriname is relatively low. 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 Mg C ha^{-1}, while ter Steege (2001) found carbon stocks in Guyana between 111.5 and 146.5 Mg C ha^{-1}. Furthermore, Arets *et al.* (2011) reports that AGB carbon stocks in Suriname range from 121 to 265 Mg C ha^{-1}.

Activities are planned to improve these estimations, especially the implementation of a full multipurpose National Forest Inventory. In 2018 more data will be collected especially from the mangrove forest, for which information for the current estimation was limited to two plots.

4.4.5 Historical emission due to deforestation

Emissions caused by deforestation will be determined with the IPCC 2006 basic equation (see equation 2), by multiplying the AD with the EF for gross deforestation (the average carbon stock of the forest in Mg C per ha). While more detailed carbon stocks for other land use types need to be determined, it was assumed that the carbon stock immediately after deforestation is zero. This can be supported, knowing that most of the deforestation was caused by mining (73%), infrastructure (15%) and urbanization (4%) (annex 5) (SBB *et al.,* 2017c), which all are land use classes corresponding to a zero carbon stock.

$$\mathbf{E = AD \times EF}$$

Where:

E = Emissions in Mg C yr^{-1}

AD = Activity data in ha yr^{-1}

EF = Emission factors in Mg C ha^{-1}

Equation 2. IPCC equation for the estimation of emissions

The historical emissions for the period 2000-2015 are calculated based on activity data (deforested area) and emission factors. The total deforestation of the period was divided by the number of years and multiplied with the emission factors. Therefore the total emissions from deforestation in the period 2000-2015 were **72,440,370 million Mg CO_2** (see table 6). Using the error propagation method proposed by IPCC 2003, the uncertainty is **±5,916,444 million Mg CO_2** or **± 8.17%** of the mean calculated according to IPCC guidelines (2003 GPG) on error propagation using approach 1 (for more details, see Total Emissions Tab in the excel file Suriname FREL Final Historical emission tool[14]).

[14] Online: https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing

Table 6. Emissions due to deforestation for the period 2000-2015

Period (years)	Historical activity data (deforestation)			Emissions due to deforestation*		Total deforestation emissions
	Area (ha)	Area (ha) yr^{-1}	Uncertainty (%)	Mg CO_2 yr^{-1}	Uncertainty (%)	Mg CO_2
2000-2009	33,051	3672	16.22%	2,945,300	17.23%	26,507,701
2009-2013	32,071	8018	7.45%	6,430,439	9.45%	25,721,757
2013-2014	15,757	15757	13.21%	12,637,888	14.44%	12,637,888
2014-2015	9,442	9442	17.16%	7,573,025	18.12%	7,573,025
Total period 2000-2015	90,322	6021	7.12%	4,829,358	8.17%	72,440,370

*Note: * the same emission factor of 802.01 Mg CO_2 ha^{-1} was used for all years*

4.5 Forest degradation due to logging

4.5.1 Activity data

Activity data due to the construction of haul roads for logging and log yards are included within the deforestation LULC class 'infrastructure' (see annex 5). Additional activity data linked to logging are determined by the annual timber production, extracted from SBB's records and published on an annual basis. These records are based on the registration that takes place on cutting registers where all legal logs, and when confiscated also the illegal logs, are recorded. SBB started registering produced logs after the year 2000, using a log tracking system (LogPro) that was developed in house with the technical assistance of FAO in 1999. Before 2000, the production was recorded by the State Forest Service (LBB).

The total timber production from 2000-2015 is presented in the graphic shown in figure 6, indicating that the timber production has been relatively constant up to 2008, but has been steadily been increasing over the last years. All timber production statistics can be found on the SBB website (www.sbbsur.com). In terms of area harvested, from the ca. 2.5 million ha of forest area issued for timber harvesting purposes, ca. 50,000 ha are harvested on a yearly basis (SBB, 2016).

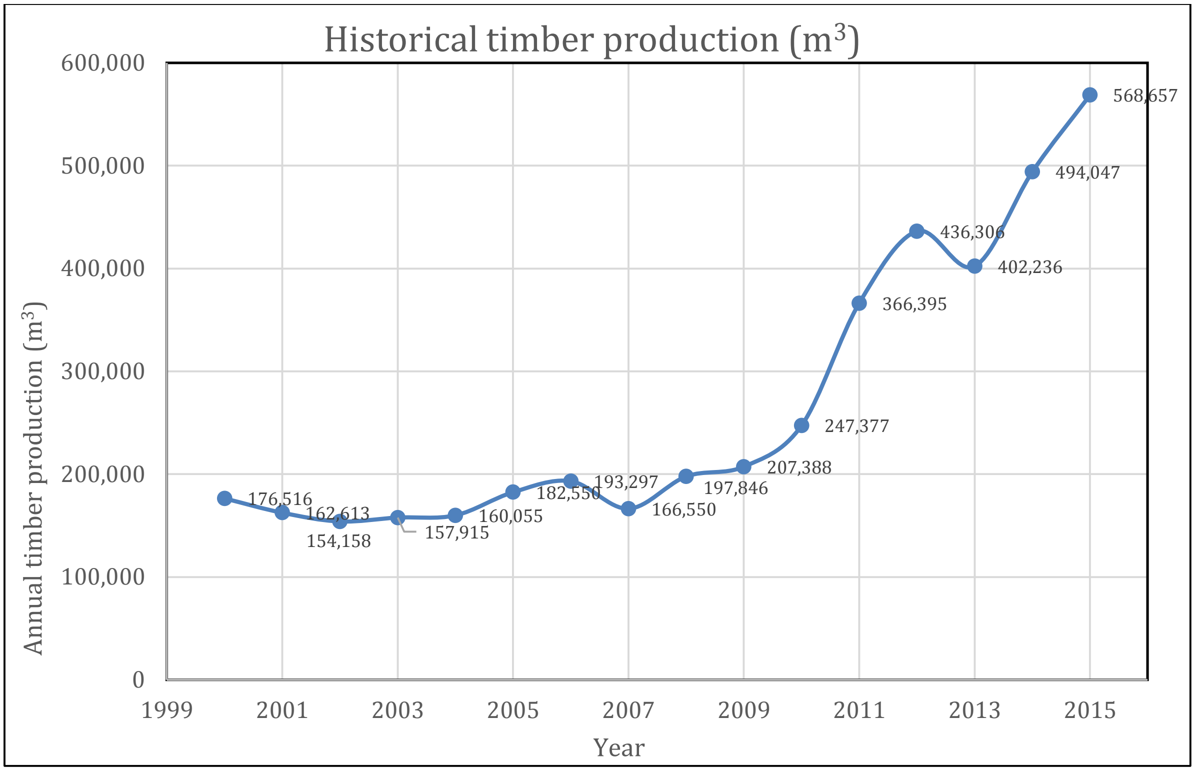


Figure 6. Timber production for the period 2000-2015 (SBB, 2016)

Illegal logging has not been included within this FREL submission, because no recent updated information exists on it. Earlier reports have shown an average proportion of illegal logging of 20%, including timber that was transported to Guyana (Playfair, 2007). This percentage also includes the illegal logs that are confiscated and registered. Therefore this estimation cannot be used in the FREL, because it could lead to double accounting of illegal logs that might be registered after having been confiscated. This approach corresponds to the IPCC guidance related to being conservative.

4.5.2 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 (in Mg carbon per m^3) of produced timber were established. The approach used is a gain-loss approach and focuses on the direct losses in live biomass, namely the extracted logs, incidental logging damage to other trees caused by tree felling, and the skid trail establishment (Pearson *et al.,* 2014). The field methods used are similar to the field methods used by Griscom *et al.* (2014). The work was carried out in Suriname in the first part of 2017 by SBB, with support of The Nature Conservancy, the University of Florida and CELOS. Since the IPCC guidelines (2003, 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 Chave *et al.* (2005), using tree height where available.
- 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 the physical conditions of the terrain, a random stratified sampling approach was conducted over the whole range of active logging concessions (including community forest)[15].

Emission calculation

The Total Emission Factor (TEF) in Mg of carbon emitted per m^3 timber extracted from selective logging is estimated using equation 3 (Pearson *et al.*, 2014).

$$TEF = ELE + LDF + LIF$$

Where:

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

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

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

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

Equation 3. Calculation method for the Total Emission Factor (TEF)

Extracted Log Emissions (ELE)

The ELE are 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[16], 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 wood block volume (see equation 4). For this calculation, the SBB log tracking database was used to determine the timber production per logging unit.

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[15] In total four intensive/controlled, four extensive/conventional and two FSC certified sampling units (corresponding to the logging units) were randomly selected.

[16] 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

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

Where:

ELE= Extracted log emissions ($Mg\ C\ m^{-3}$)

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)

Equation 4. Calculation method for the ELE

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 and tree mortality scenarios used in the Griscom *et al.* (2014) study. For this study the medium mortality scenario was used (see table 7), since this was also used to determine the emissions in the Griscom *et al.* (2014) study.

Table 7. Proportion of trees killed based on the damage type from the medium mortality scenario (Griscom et al., 2014)

Damage type	**Proportion killed trees (%)**	**Description of damage type**
Grounded	100	Completely pushed over to the ground, either uprooted or snapped below 1.3 meters height
Snapped	100	Snapped above 1.3 meters and below first major branch
Crown	20	50% or more of tree canopy removed or destroyed

A total of 258 felled trees were sampled. The AGB of the total tree is estimated by using the equations from Chave *et al.* (2005) and the AGB for palms was calculated using the equations from Goodman *et al.* (2013). The BGB was calculated using an equation proposed by Cairns *et al.* (1997). 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, snapped and crown damaged trees in the felling gaps and calculating the emitted carbon for those trees using the same Chave *et al.* (2005) and Goodman *et al.* (2013) equations. As seen in equation 5, the carbon emission for each gap per m^3 was calculated by dividing the emitted carbon in the gap by the volume extracted from that gap.

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

Where:

DW or LDF=	Dead wood carbon stock in Mg C m^{-3} or logging damage factor (LDF)
f (dbh, h, WD)=	Allometric function for calculating tree biomass in carbon in Mg 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 Mg gap^{-1}
Number of gaps=	Total number of gaps inventoried

Equation 5. Calculation method for the LDF

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.

To calculate the LIF, it is necessary to estimate the SF (Skid Trail Factor) in Mg 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. The trees damaged on the skid trails in sample plots were measured based on the medium mortality scenario (table 7). All trees greater than 20 cm dbh were measured in the plots to determine how much carbon was emitted by skidding. Field observations showed that heavy logging machinery (excavators, skidders or bulldozers) could destroy or pulverize damaged trees (10 - 20 cm dbh) on the skid trails, but evidence of damage to these smaller trees was often obscured by excavation or other larger damaged trees. This made it impossible to ensure a complete sample of these smaller trees and could result in an underestimation of skid trail damage. To determine how much biomass is lost by damaging trees with sizes between 10 and 20 cm dbh, skid trail plot data was not used, but biomass reference data (Mg carbon per ha) is extracted from other biomass studies done in the forest belt (SBB *et al.,* 2017a).

The total area (in ha) of skid trails (SA) for each sample unit was calculated by multiplying the average measured width of the skid trails multiplied by the total length of the skid trails in the sampling unit.

The LIF is calculated by dividing the total skid trail emissions (SA * SF) within a sampling unit by the extracted volume from that sampling unit. The extracted volume in the sampling unit is calculated by multiplying the number of stumps counted in the sampling unit with the average volume per log for the logging unit. The average volume data is extracted from the SBB LogTracking database. To calculate the LIF (see equation 6), the skid trail area (ha) is used, which was calculated by multiplying the skid trail total length with the average skid trail width.

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

Where:

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

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

SA= Area of skid trails in ha

Equation 6. Calculation method for the LIF

Resulting EF for forest degradation

The total emission factor (EF or TEF) for forest degradation due to logging was estimated to be 1.67 Mg C m^{-3} with an uncertainty of 15.37% (seen in table 8).

Table 8. Emission factors for logging

	Emission Factor (Mg C m^{-3})	S.D.	C.I. 95%	Uncertainty (%)
LIF	0.40	0.26	0.16	40.25%
ELE	0.30	0.02	0.01	4.04%
LDF	0.97	0.32	0.20	20.62%
TEF	1.67	0.57	0.36	15.37%

4.5.3 Historical emissions due to forest degradation from logging

The historical emissions for the period 2000-2015 (see table 9) are calculated with the activity data and emission factors. The total timber production of that period was multiplied with the emission factors, resulting in a total emission of **25,125,752** Mg CO_2. Using the error propagation method proposed by IPCC (2003 GPG), the 95% CI is **± 3,381,600** Mg CO_2 or ±13.46% of the mean (for more details, see Total Emissions Tab in the excel file Suriname FREL Final Historical emission tool[17]).

[17] Online: https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing

Table 9. Emissions due to degradation for period 2000-2015

Period	Historical activity data		Emissions due to degradation from logging	
	Production(m^3)	Production(m^3 yr^{-1})	Mg C yr^{-1}	Mg CO_2 yr^{-1}
2000-2009	1,582,372	175,819	294,040	1,078,147
2009-2013	1,452,314	363,079	607,213	2,226,447
2013-2014	494,047	494,047	826,245	3,029,563
2014-2015	568,657	568,657	951,022	3,487,082

4.6. Total historical emissions

The total deforestation due to the conversion of forest to non-forest and forest degradation due to logging accounts to a total historical emission of **97,566,122** Mg CO_2 (with annual average of 6,557,411 Mg CO_2 for the period 2000-2015). The 95% CI is **± 6,819,188** Mg CO_2 or ±6.99% of the mean (see Total Emissions Tab, Suriname FREL Final Historical emission tool[18]) (See figure 7)

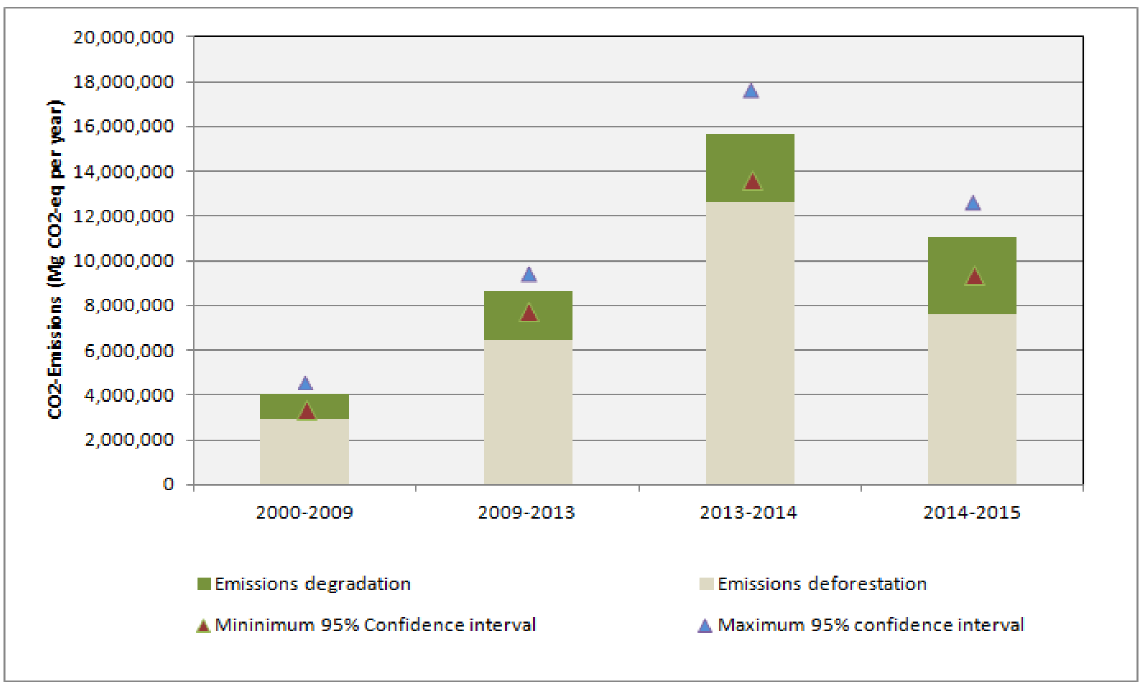

Figure 7. Emissions from forest degradation due to selective logging and emissions from deforestation over the different periods

[18] Online: https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing

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 increasing economic activities 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, 2017).

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 is a small country with a GDP per capita of SRD 34,245 at the end of 2016. Like other developing countries, Suriname is also facing challenges in its economic development. The country's economy is highly dependent on the extractive (gold, oil, and bauxite) and agriculture industries, which play an important role in driving growth, employment and government revenues. Therefore the sharp decline of international gold and oil prices, which resulted in the international financial crisis, affected Suriname's economic performance. The cessation of the alumina production also had an impact on the country's economy. As a consequence this has caused external and fiscal deficits and as well a loss of parts of the international reserves. To address these issues, the government is giving high priority to promoting economic diversification through private sector development, strengthening social services and addressing the effects of climate change (in line with national policy and the Financial Strategy of the draft Suriname National REDD+ Strategy).

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 (current version Development Plan 2017-2021). The current Plan aims 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 compose the National Development Plan 2017-2021 are (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+, are considered within the last pillar on environmental protection but are also crosscutting.

According to the data on the forest cover of 2015 (SBB, 2017c) and the data on the average carbon stock per ha (SBB *et al*., 2017b), Suriname's forest stores at least 12,200 Mg of CO_2. The sustainability of Suriname's development is highly vulnerable to climatic disasters, especially flooding because of rising sea levels. Removing mangrove forest already leads to high 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. Conserving the mangrove forest is therefore a crucial measure within the draft 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 0.05%) was measured in the period 2009-2015 (SBB, 2017c). If this trend accelerates, these pressures might result in an increasing deforestation and forest degradation, which would have 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 for 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.

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 in 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.,* 2016b). 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.

Another challenge Suriname is facing is the potentially high climate change adaptation costs, to protect the low lying coastal areas where most of the population is living and most economic activities are taking place, but also to deal with the lower electricity supply because of lower water levels in the Brokopondo hydropower lake (caused by climate change). The lower electricity supply caused by climate change and the projected increasing energy demand of 500 MW until 2020 (GOS, 2015) are a major concern during the current FREL period. The Grankriki project, which is another hydropower project in the planning, has the aim to strengthen the Brokopondo hydropower lake and increase the electricity supply. Related to this project, infrastructure activities will also be executed. To enable the government to maintain the current living conditions for the population, the financial means to meet these costs might be generated through unsustainable use of the natural resources. This shows again the importance of providing an economic incentive to protect the forest.

4.7.2 Forest and mining

Mining has been the largest driver (73%) of deforestation over the period 2000-2015 (SBB, 2017c), of which artisanal small-scale gold mining (ASGM) has the largest impact. 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 study carried out as a regional collaboration between the forest monitoring teams of the Guyana, Suriname, French Guiana and the State of Amapá, indicated a 84% increase in the rate of deforestation due to gold mining in Suriname comparing 2000-2008 (19,020 ha) with the period 2008-2015 (35,099 ha) (Rahm *et al.,* 2017). It should also be mentioned that some of the main access roads towards the interior (e.g. Afobaka road), which are an underlying cause of deforestation and forest degradation, were constructed because of mining activities.

Gold, oil and bauxite, which are the most important commodities for Suriname's economy, accounted for 90% of exports, 95% of the national revenues and 30% of the GDP in 2013. Since 2014 the bauxite production has stopped and the contribution of bauxite to the GDP became zero. 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 108,000 USD ha^{-1} vs. 193,364 USD ha^{-1} was found. The small scale mining sector provides employment to ca. 10,000 to 12,000 people, including the service sector (Heemskerk, 2016).

Within the country's Development Plan 2017-2021 (SPS, 2017), the government intends to regulate the 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. 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.

Small Scale Gold Mining

In the 1990s, 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 (ibid.). 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). 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).

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). Existing 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 Mg 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.

Large scale mining

During the period 2000-2015, two large scale gold mining operations and one large scale bauxite mining operation took place. Rosebel Gold Mines in the Brokopondo district started their commercial production in 2004 and Newmont Mining Corporation in the east of the country started their operation in 2016 (with deforestation related to the mine construction phase starting in 2015). Suralco established three bauxite mines on the Eastern side of the Suriname river.

The government's intention to increase income from large scale mining has already started with two new large scale mining projects planned to be launched shortly: IAMGOLD's Kleine Saramacca project and Newmont Suriname in the east. Additionally, negotiations were re-initiated with ALCOA for a bauxite mining project 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.

4.7.3 Forest and logging

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 was established and in that 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, a forest management system best suitable for Surinamese forests was developed by CELOS, the polycyclic CELOS Management System. 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).

Overall, the contribution of the timber industry to the gross domestic product is 1.7% and the sector employs about 5,500 people. In addition, the recorded harvesting of Minor Timber Products (MTP) is small and their contribution to the overall timber taxation is just about 0.5% (van Dijk 2011, cited by SBB *et al.,* 2017b). However, the actual harvesting levels are suspected to be much higher than existing official records, as many MTPs are harvested for subsistence purposes. The collection and use of non-timber forest products (NTFP) is also estimated to be significant, but there are no data records to serve as proof. CELOS market research (2017) indicated a sharp increase in the number of NTFP processing industries (8 in 2008 to 33 in 2016).

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 law enforcement;
- Comprehensive operational guidelines and procedures need to be improved;
- Limited resources in the responsible organisations; and

A clear indicator for the potential emission reduction is the proportion of logging units under a conventional management regime (known as extensive management). While the annual timber production and the managed area has increased, the number of compartments under the conventional logging regime has remained within the same range (ca. 50%). In conventionally managed forests, timber can be harvested without prior timber stock inventories and without demarcation and planning of roads and skid trails (controlled logging or intensive management). Commercial logging is permitted, provided that the logging compartments are demarcated and logged according to the SBB regulations (such as respecting buffer zones and adhering to a maximum harvesting intensity). These minimum requirements are the basis for SBB production control (SBB *et al.,* 2017b). Better harvesting planning and implementation of this planning could reduce the emissions from the forestry sector.

With the increase in the gold mining activities especially in the period 2009-2015, logging companies claim that there is little certainty about the land use designation of their concession area on the long term. This stimulates companies to ask for exemptions and instead of applying the required controlled logging, they apply for extensive management with conventional logging.

Timber production increased significantly in the past decade, amongst others caused by Asian investments in the timber industry. Nevertheless actual harvesting levels remain far below the annual allowable cut of 25 m^3 per hectare. In 2003, SBB presented its ambition to increase the annual timber production to 500,000 m^3 per year by 2008 (FAO, 2003). As the conditions were subsequently put into place, this objective was first reached in 2015.

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 per ha; in practice being only 7.4 m^3 per ha with a range of 4.8 to 10.7 m^3 per ha (SBB, 2016). This can be higher in cases where the logging compartments are entered multiple times within the cutting cycle. In Suriname the suggested cutting cycle of 25 years is based on the outcome of CELOS silvicultural experiments in the past (Werger *et al.,* 2011). This implies that for a concession, the Annual Allowable Cut (AAC) in m^3 equals the total net productive area in hectares divided by 25 years, multiplied by 25m^3 ha^{-1}. This net productive area is far less that the gross area as mentioned in the concession license and is estimated to ca. 80% of the gross productive area, because of ecological buffer zones and unproductive vegetation types (vicinity of creeks, rivers, steep slopes, swamps).

Concession operators practicing controlled logging may seek third party certification to demonstrate their commitment to SFM. Roughly 1.6 million ha have been issued as logging concessions and other forestry production titles, 737,500 ha as community forest and 168,400 ha as Incidental Cutting Licenses (ICL) (SBB, 2016). Of the total area, 396,090 ha (25%) was FSC certified in late 2015 (ibid). At present, there are no ongoing activities to expand the forest area under (FSC) certification (SBB *et al.,* 2017b). When calculating the EF of forest degradation, the results suggested that the FSC and controlled management systems have significantly lower emissions than the conventional management systems. More data will be collected to assess this difference.

Controlled logging results in higher production levels (SBB, 2016), closer to the AAC. The timber extraction rate may thus not be reason for concern in the view of forest degradation. Forest that has 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 or the AAC might need to be revised.

In 2016 the total roundwood production in Suriname was 573,000 m^3, of which 265,000 m^3 was exported and 308,000 m^3 was locally processed by the sawmill industry in the country. The recovery rate of rough sawn wood in sawmills in Suriname is 45%. When producing export quality sawn wood, the recovery rate decreases to between 25-30%. Within a period of 17 years from 2000-2016, the roundwood production in the country increased with about 300%, and the sawn wood production increased with about 200%. In the same period, the export of roundwood increased with about 1,400%. Timber export statistics show that in the past 10 years the assortment roundwood contributes more than 80% of the timber export volumes. Due to foreign investments, mainly Asian, most of the roundwood (about 85%) is exported to Asia. The expectation is that in the coming 5 years the timber production will increase steadily.

While infrastructure is included as a driver of deforestation, it should be mentioned that in the past and the present a number of main access roads were constructed primarily for logging purposes. A recent example is the 50 km long road, which was constructed in the period 2016-2017 to the village Pusugrunu.

4.7.4 National Development Plan and REDD+ priorities

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 and the draft Suriname National REDD+ Strategy make clear 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 4.6.2 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 draft National REDD+ Strategy's strategic line 3, and specifically the following related measures are included:

- Streamline concession policies, particularly of the departments responsible for mining and logging concessions/permits;
- Map and publish areas designated for small-scale gold mining;
- Formulate new land use planning legislation;
- 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;
- Further support Suriname's decision to participate in the Extractive Industries Transparency Initiative (EITI);
- Capacity building of institutions in forest monitoring, control and protection (this includes the institutions responsible for the enforcement of the Mining Decree).

The restoration of already mined out areas is a priority activity within the National Development Plan 2017-2021 and the draft Suriname National REDD+ Strategy. In addition, the country is currently initiating a Global Environment Facility (GEF) 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 (2005) includes many elements that are re-emphasized in the draft 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, could reduce the emissions due to logging with 30-50% (Griscom *et al.,* 2014). However, this still needs to be assessed for Suriname's context. 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 draft Suriname National REDD+ Strategy.

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 draft 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. This modality is presented within the REDD+ implementation framework (draft Suriname National REDD+ Strategy).

5. Proposed FREL for Suriname

Being the most forested country, Suriname has a history of very low emissions related to deforestation and forest degradation. Nevertheless these emissions have increased significantly over the last six years. This can be explained by an increase in deforestation, mostly due to gold mining (SBB, 2017c) (artisanal small scale gold mining is responsible for ca. 80% of the deforestation) and an increased forest degradation due to the increasing timber production.

As part of the scenario modeling process carried out in order to support the Suriname National REDD+ Strategy, different scenarios were identified, providing an indication of the possible amount of deforestation in the future. One of these scenarios was the Development scenario, where future planned projects have been taken into account. During the process of creating the scenarios, all the main projects that have the probability to be carried out were considered. The National Development Plan of 2017-2021 was used as a guide, but especially in-depth dialogues were carried out with different stakeholders (see annex 2), such as the Suriname Planning Office and the Ministry of Natural Resources, who were involved in order to have a broad view on the expected development. Two new bauxite mines, two new gold mines, some planned infrastructure, four development areas and several planned oil palm plantations are projects that were taken into account in the Development scenario model. At the moment the scenarios are still under construction, as part of the finalization of the Suriname National REDD+ Strategy. However, the preliminary results of the Development scenario indicating the deforestation of all the planned projects, provided results which are very similar to the linear projection used to establish the FREL. Also the timber production is expected to continue increasing, at least until it would reach 1,000,000 m3 in 2022 (SBB, 2017d).

Mg CO_2 emission year^{-1} = 942,389 * year - 1,885,527,721 (Equation 7)

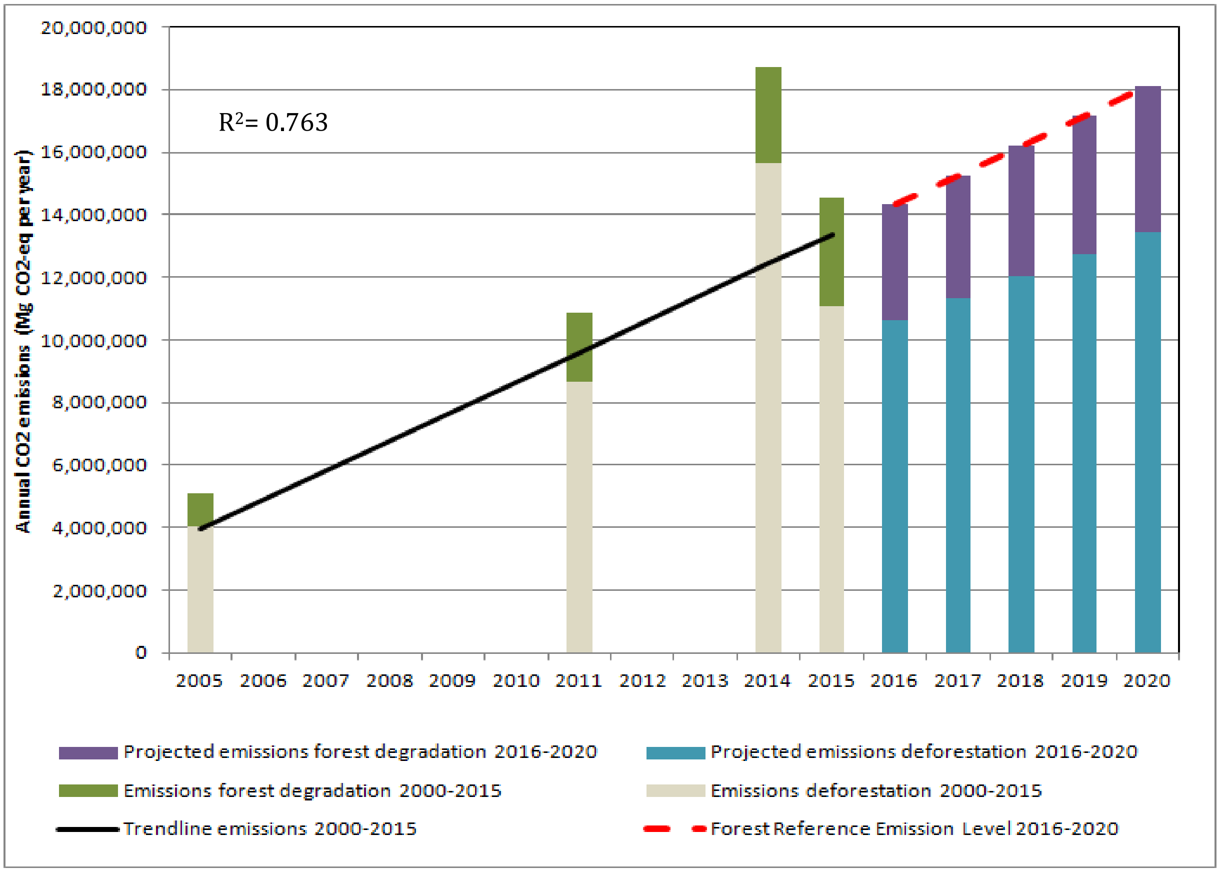

Figure 8. FREL projection for Suriname - For the period 2000-2009 the year 2005 has been used and for the period 2009-2013, the year 2011

Table 10. FREL for Suriname, expressed in yearly CO2-emissions

Year	**Annual CO_2-Emissions (Mg CO_2-eq per year)**
2016	14,328,503
2017	15,270,892
2018	16,213,281
2019	17,155,670
2020	18,098,059
Total 2016-2020	**81,066,405**

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 will be made to this FREL in the next submission are closely related to the activities planned within the NFMS roadmap (SBB, 2017):

A) Forest degradation

A.1 Mining

While deforestation due to gold mining is the main source of CO_2 emissions in the AFOLU sector for Suriname, no data are yet available to assess the degradation related to mining. Forest degradation due to mining is caused by two components: 1) deforestation due to gold mining smaller than 1 hectare, and 2) higher tree mortality in the buffer zone around the deforested areas.

In a study within the Guiana Shield, Rahm *et al.* (2017) found that mining areas between 0.5 and 1 ha contribute in average only 0.5% to the total deforested area within the period 2001-2014. Therefore, including gold mining areas smaller than 1 hectare will probably have a limited impact on the FREL. Hence during the coming period, studies are carried out to assess forest degradation in the buffer zone around deforested areas, using three methodologies:

- Assessment of the state of fragmentation of the landscape (Haddad *et al.,* 2015) related to small scale gold mining, which is often following the creek patterns (SBB *et al.*, 2017b);
- Assessment of long time series of satellite observations to track forest disturbance using the Break detection For Additive Seasonal Trends (BFAST) (Verbesselt *et al.,* 2010);
- The methodology developed by Brown and Mahmood (2016) in Guyana, assessing tree mortality in a buffer area zone around deforested areas.

Based on the results of these studies and further expert consultation, a national methodology to assess forest degradation related to mining will be developed, especially if these emissions contribute more than 10% to the total emissions. Emissions contributing less than 10% are considered to be insignificant, according to the World Bank's Carbon Fund, and do not need to be accounted for.

A.2 Logging

i) Legal logging

Estimations for emissions related to legal logging within this document are based on a field research carried out in 2017, in collaboration with The Nature Conservancy (TNC). While this research provides a statistically sound estimate of the total emissions, for monitoring purposes more detailed information will be needed. During 2018 a project will be carried out with support from IDB and CATIE as part of the regional project *Mechanisms and Networks for Technology Transfer Related to Climate Change in Latin America and the Caribbean*. Within this project, impact indicators that are easy to measure will be added to the daily control that the SBB forest guards are carrying out. This will provide more information on the difference in impact between different management types (Reduced Impact Logging, controlled logging and conventional logging), and will be used as a day-to-day instrument to guide the sector towards sustainable forest management. This new information can also improve the estimations provided in the FREL. The LogTracking database of the SBB will be strengthened through the same project, which will result in a lower uncertainty related to timber extraction.

ii) Illegal logging

While it is estimated that illegal logging could contribute up to 20% to the total timber production in Suriname (Playfair, 2007), it was not included in this FREL, because after confiscation this timber might be registered as legal logs, which could lead to double accounting. Therefore a more conservative approach was followed. Within the IDB/CATIE project mentioned above, measures will be taken to avoid this double accounting and improve registration of illegal logging. The newly developed Near Real Time Monitoring (NRTM) component of the NFMS provides independent area estimates of illegal logging based on Sentinel 2A satellite images. Combining the results of both sources will make it possible to add an estimate to an improved version of the FREL.

A.3 Shifting cultivation

The increase in area subjected to shifting cultivation (pioneer shifting cultivation) was measured while monitoring the changes in forest cover, but high uncertainty of the data indicates that this class needs a more detailed study (SBB, 2017c). Within the NFMS an additional study will be carried out to assess the net emissions related to the conversion of primary forest to shifting cultivation. Combining a multi-temporal spatial analysis with field measurements linked to socio-geographic characteristics could provide concrete examples for land use measures, combining the advantages of both traditional and modern knowledge.

B) National Forest Inventory

The carbon stocks used within this FREL are determined based on fieldwork carried out in 208 plots scattered over the country, where data was collected over different years (1970-2015) 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 (SBB, 2017c). An NFI is a costly activity and requires in-depth planning as well as broad involvement of partner organizations (SBB, 2017). Within the Global Climate Change Alliance (GCCA+) project, a network of plots within the mangrove forests will be established during 2018. Within the 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 in 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.

C) Validation of pantropical allometric equations

One of the potential sources of error in the carbon stocks and emission factors, is the use of an allometric equation that is not appropriate for the geographical area, the forest type or the tree species. Within this FREL, the equation from Chave *et al.* (2005) was used, as this equation includes data from the region, and was validated in Guyana. During 2018, a study coordinated by CELOS will be carried out to evaluate the performance of the different pantropical allometric equations, using the methodology proposed by Alvarez *et al.* (2012). During this study we will for example validate the more recent allometric equations Chave *et al.* (2014). Based on our findings, our carbon stock and emission factor estimates might need to be updated.

D) Stratification

Currently other stratification approaches are being designed, such as the method developed by Guitet *et al.* (2013) in French Guiana, where geomorphological landscapes are considered explanatory for the forest composition (Guitet *et al.*, 2015), the floristic diversity (Richard-Hansen *et al.*, 2015) and also for modeling ecosystem services such as carbon sequestration. Suriname is currently applying the FOTO method developed by Couteron, Barbier and Gautier (2006), which delineates landscapes based on elevation data. The results will go through a national validation process, whereafter the carbon stocks would be recalculated for these landscapes. This stratification approach will also be important for practical forestry planning processes.

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ANNEXES

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

- Presentation of FREL/FRL ideas to the Suriname REDD+ Project Board 2017-08-11
- Presentation for Directors of different Ministries, Anaula 2017-09-06
- Presentation for the REDD+ Assistants Collective (RAC) 2017-10-04
- Presentation of FREL draft 2 for NIMOS and REDD+ PMU 2017-11-30
- In-depth technical FREL session for national stakeholders 2017-12-05
- Presentation for Office of the President 2017-12-12
- National FREL validation workshop (111 participants) 2017-12-15
- Consultation meeting with Maureen Playfair, CELOS 2017-12-21
- Consultation meeting with Conservation International Suriname 2017-12-22

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Annex 3: Above-Ground carbon by forest type

Table. Above-Ground carbon (trees >5 cm dbh, Mg C ha^{-1}) by forest type in Suriname.

Forest Type	Mean	S.E.	LL(95%)	UL(95%)	Uncertainties
All forest	157.38	3.23	151.03	163.72	4.03
Creek forest	139.51	7.37	124.78	154.23	10.55
Dry montane forest	202.26	0.00	-	-	-
Forest plantation	210.12	77.87	-	-	-
High Savanna forest	159.05	12.39	133.67	184.43	15.96
High swamp forest	109.93	9.42	83.77	136.08	23.79
Low Savanna forest	117.52	34.82	32.31	202.72	72.50
Low swamp forest	122.29	12.12	70.16	174.42	42.63
Mangrove	44.41	17.15	-	-	-
Moist Evergreen forest	161.75	4.57	152.71	170.78	5.59
Montane forest	198.11	15.53	164.27	231.96	17.08
Periodic swamp forest	165.47	13.15	134.38	196.55	18.79
Riparian forest	112.88	0.00	-	-	-
Savanna forest	210.87	17.24	173.32	248.43	17.81
Secondary forest	113.81	33.94	30.76	196.87	72.97
Swamp forest	127.47	31.33	50.81	204.14	60.14
Unknown	167.43	6.40	154.52	180.34	7.71

Table. Above-Ground carbon (Mg C ha^{-1}) by carbon pool in forest type in Suriname.

Type of forest	Palms	Lianas	Lying wood	Standing dead wood
Creek forest	3.53	3.01	6.29	1.35
Dry Montane forest	0.11	4.56	3.02	1.65
High savanna forest	0.03	1.06	14.91	4.65
Low Savanna forest	0.00	0.00	0.00	0.99
Low Swamp forest	2.30	8.30	3.40	2.17
Mangrove	0.00	0.00	0.79	2.11
Moist evergreen forest	1.05	2.99	9.81	2.97
Periodic swamp forest	7.35	3.59	6.29	2.77
Riparian forest	0.58	0.00	3.70	2.04
Secondary forest	0.59	3.67	22.89	4.09
Swamp forest	0.01	1.62	4.81	1.13
High swamp forest	7.63	2.66	0.00	1.90
Montane forest	0.05	1.57	0.00	0.00

Annex 4: Overview of the inventory plot database

Table. 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
	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

Forest component	Source or study were data was collected	Sampling Unit areas (size and shape)	Minimum dbh recorded
	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

Forest component	Source or study were data was collected	Sampling Unit areas (size and shape)	Minimum dbh recorded
	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: Overview of the classes in the Deforestation maps and Post-deforestation LULC maps

Deforestation classes	LULC classes	Definition
Deforestation	Secondary vegetation	Areas that, after the complete removal of forest vegetation, are in advanced process of regeneration of shrub and/or tree vegetation.
	Agriculture	Extensive areas with a predominance of annual cycle crops, such as grains, banana, vegetables, etc., with use of high technological standards, such as use of certified seeds, inputs, pesticides and mechanization, among others.
	Pasture	Pasture areas in current production process with a predominance of herbaceous vegetation, and between 90% and 100% coverage of grass species.
	Urban area	Urban patterns formed by population concentration, villages, towns or cities with differentiated infrastructure from rural areas, with density of streets, houses, buildings and other public facilities.
	Infrastructure	All roads excluding roads within another LULC class and man-made waterways such as irrigation canals, access ways to oil wells, etc.
	Mining area	Mining areas in current production process of gold mining (industrial and artisanal mining), sand mining, house material mining, bauxite mining, oil mining and gravel mining.
	Burned area	Areas that have recently been burned.
	Other	These areas that do not fall under any of all LULC classes, with different coverage pattern such as savannas and others.

Land Use Change matrix between 2009 and 2013 based on map areas

	Land Use Change matrix between 2009 and 2013								
	LULC 2013								
LULC 2009	AGRICULTURE	BURNED AREA	INFRA STRUCTURE	MINING	OTHERS	PASTURE	SECONDARY VEGETATION	URBAN	Grand Total
AGRICULTURE	706.06	0.00	10.26	2.07	0.00	0.00	124.65	29.70	872.74
BURNED AREA	0.00	238.21	0.00	0.00	0.00	0.00	4.41	0.00	242.62
FOREST	549.36	1759.61	4807.47	22232.52	88.04	28.35	143.96	522.91	15025713.16
INFRA STRUCTURE	2.25	0.00	2417.83	228.81	0.00	0.00	173.07	7.29	2829.25
MINING	2.88	0.00	77.40	18962.21	1.26	0.00	457.70	20.70	19522.15
OTHERS	0.00	52.83	100.08	3.96	4.68	0.00	6.75	0.90	169.20
PASTURE	0.00	0.00	2.25	0.00	0.00	147.33	0.36	0.00	149.94
URBAN	5.58	2.16	41.76	14.04	0.00	0.63	38.34	923.37	1025.88
Grand Total	1270.89	2052.81	7544.47	41808.38	100.55	230.31	953.12	1717.18	16366825.17

Land Use Change matrix between 2013 and 2015 based on map areas

	Land Use Change matrix between 2013 and 2015								
	LULC 2015								
LULC 2013	AGRICULTURE	BURNED AREA	INFRA STRUCTURE	MINING	OTHERS	PASTURE	SECONDARY VEGETATION	URBAN	Grand Total
AGRICULTURE	1270.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1270.89
BURNED AREA		2052.81	0.00	0.00	0.00	0.00	0.00	0.00	2052.81
FOREST	676.24	452.06	5615.98	19957.10	101.67	70.02	261.56	1011.51	14993812.05
INFRASTRUCTURE	7.30	0.00	7322.21	18.96	91.53		69.83	34.65	7544.47
MINING	0.00	0.00	17.79	41746.87	0.34		43.39		41808.38
OTHERS	0.00	0.00	0.27		85.88			14.40	100.55
PASTURE	0.00	0.00	0.00	0.00	0.00	228.33	1.98	0.00	230.31
SECONDARY VEGETATION	0.00		11.79	76.33	0.00	0.00	861.40	3.60	953.12
URBAN	0.00	0.00	0.00	0.00		0.00	10.00	1707.18	1717.18
Grand Total	2196.94	2504.88	13199.98	62242.05	288.23	455.49	1249.59	3467.55	16366825.17