The Republic of Suriname

1st REDD+ TECHNICAL ANNEX

to first Biennial Update Report of Results achieved by Suriname from Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation for REDD+ Results-based Payments 2016 -2019.

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[1] https://www.globalgiving.org/projects/sanctuary-helps-surinames-sloths-to-jungle/reports/?subid=60438

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- Coalition for Rainforest Nations

[2] https://pejegotours.com/blog/experience-the-culture-of-the-maroons-and-the-amerindians/

LIST OF ABBREVIATIONS AND ACRONYMS

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

[3] https://www.nationsonline.org/oneworld/suriname.htm

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

HFLD	High Forest Low Deforestation
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	Skidtrail Area
SBB	Foundation for Forest Management and Production Control
SDW	Standing Dead Wood
SEPAL	System for Earth observations, data access, Processing & Analysis for Land monitoring
SF	Skidtrail Factor
SFM	Sustainable Forest Management
SIS	Safeguards Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SPS	Stichting Planbureau Suriname / National Planning Office
SRD	Surinamese Dollar
SU	Sampling Unit
TBI	Tropenbos International
TEF	Total Emission Factor for forest degradation
TNC	The Nature Conservancy
TNRS	Taxonomic Name Resolution Service
t	Tonnes
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations REDD Programme

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

CHAPTER 1. INTRODUCTION

1.1 Background

The Conference of the Parties has encouraged developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities: reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks (decision 1/CP.16, paragraph 70).

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

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

Considering all these Decisions and Considerations of the process agreed under the Paris Agreement, Suriname has the honor to present its REDD+ Technical Annex to the First Biennial Update Report, where the results achieved in 2016-2019, after the successful implementation of REDD+ activities at the national level, are reported.

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

This submission was developed by the Suriname's government with technical support from the Coalition for Rainforest Nations. This document presents the results achieved in reducing emissions and enhancing removals in the context of REDD+ in the country of Suriname during the 2016-2019 period, and also the progress made in capacity building and generation of more robust data and information to continuously improve Suriname's submission. The country has made its best effort to present all its data and information used in the estimation of anthropogenic forest-related emissions by sources and removals by sinks, forest carbon stocks, and forest carbon stock and forest-area changes, in a transparent, accurate, complete, comparable, and consistent manner,

[4] https://wallpapercrafter.com

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

1.2 National Circumstances

The forests of Suriname are part of the Amazon and the Guiana Shield region, included in one of the largest blocks of primary tropical rainforest worldwide and marked by high biodiversity levels. These forests provide ecosystem services important on global and local levels, including climate change mitigation, biodiversity preservation, cultural values, livelihoods and food security for communities, while they also contribute to national incomes of countries in the region (Loftus *et al.,* 2013; de Dijn, B., 2018). The country is rather small with an official reported land surface of 163,800 km^2. Suriname is located on the north-eastern coast of South America, between 2° and 6° North latitude and 54° and 58° West longitude. It borders French Guiana to the east with the Marowijne river and the Lawa river, Brazil to the south, Guyana to the west with the Corantijn river, and the Atlantic Ocean to the north with a very dynamic coastline resulting in land accretion and 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).

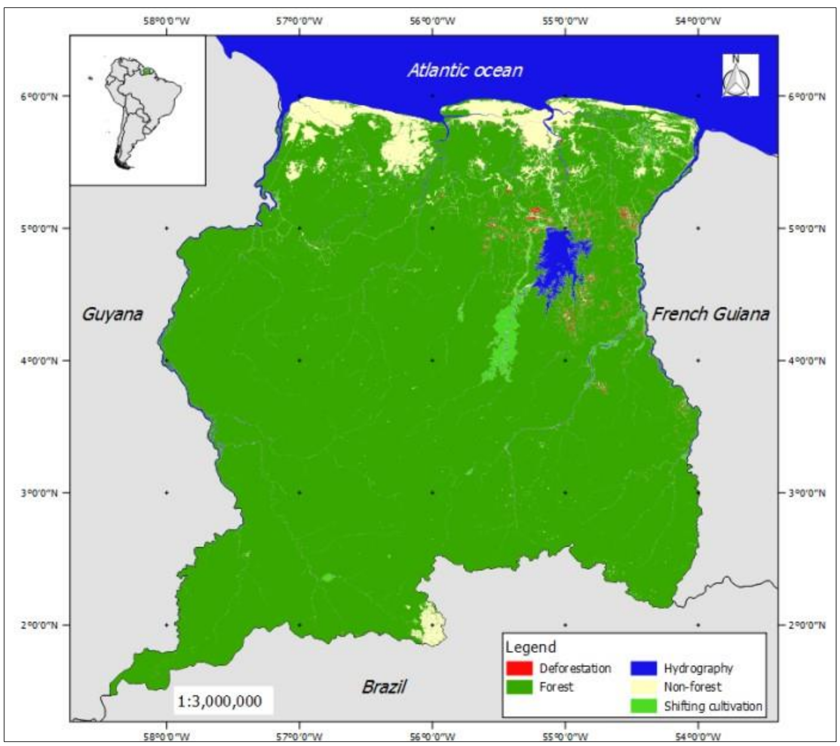

Figure 1. Situation map of Suriname (SBB)

In terms of conservation, 13.5% of the country's surface is within protected areas (GOS, 2009). Suriname has drafted a new Nature Conservation Law in a participatory process, to enable improved management of its protected areas. This has already been submitted to the parliament with the intention of placing this proposed act on the agenda for the process of approval. This law will replace the Nature Conservation Act of 1954. In line with the UN Convention on Biological Diversity (CBD) Aichi targets[5], 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

[5] https://www.cbd.int/sp/targets/default.shtml#GoalC, accessed on 27-11-2017

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 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 0.07% in average in the period 2009-2019, and is expected to continue increasing

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. However, these plans have not been carried out yet and is not getting much attention at the moment. The intention to conditionally remain a High Forest Low Deforestation (HFLD) country was also mentioned in the Nationally Determined Contribution report of 2020 (GOS, 2020a) and is in line with the Suriname National REDD+ Strategy. For this to be possible without hampering national development, adequate compensation for the global climate mitigation service is necessary.

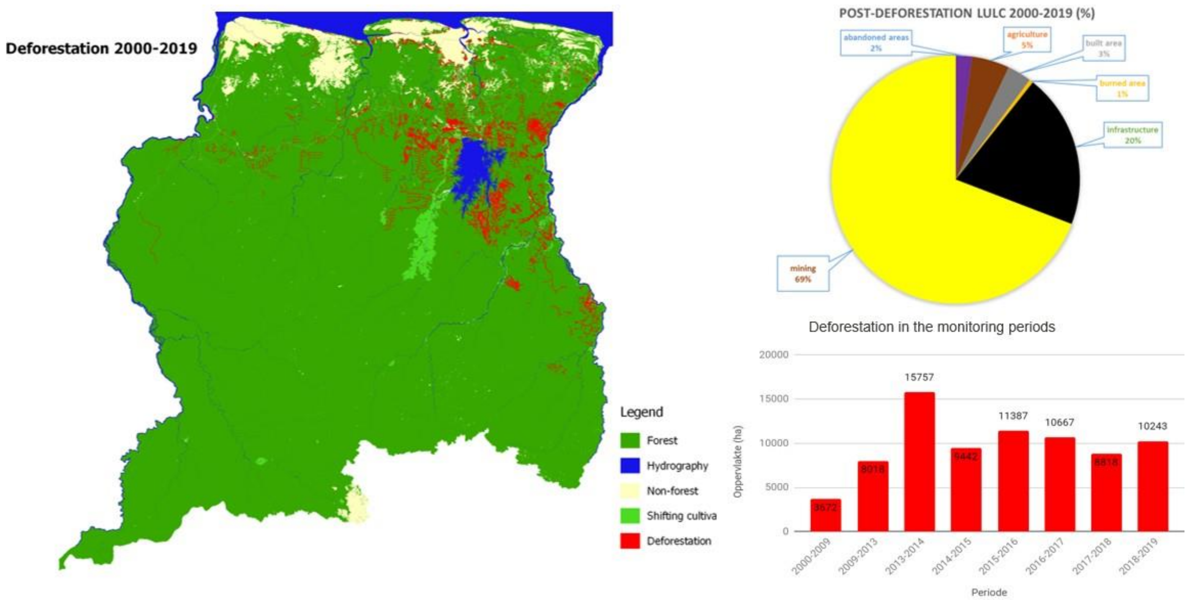

Figure 2. Trend of the drivers of deforestation in Suriname for the period 2000-2019

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 (LBB, 1990 in Mitchell, 1996). 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 further enforced (National Forest Policy, 2005; 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).

1.3 Objectives for submitting the REDD+ results

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

This technical annex presents the REDD+ results (results measured against First Suriname's technically assessed Forest Reference Level) achieved by Suriname between 2016 and 2019 which was 9,178,978.09 $tCO2_e$. The REDD+ activities that were accounted for in the period 2016 to 2019 include reducing deforestation and reducing forest degradation. The results are derived mainly from actions to enforce forest protection regulations to halt unplanned logging, illegal deforestation, the protection of forest through the identification of new protected areas, monitoring the forest fires, formulating a regional strategy to monitor forest fires, and protection and maintenance of natural regeneration processes in degraded areas.

1.4 Progress with REDD+ Strategy and Actions

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

Table 1 shows an overview of the strategic lines and the progress that was made during the last three years.

Table 1. Overview of the strategic lines and the progress

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

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

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

REDD+ TECHNICAL ANNEX

2.1 The assessed forest reference level

Being the most forested tropical country (92.77% forest cover) (FCmU-SBB), Suriname has a history of very low emissions related to deforestation and forest degradation. Nevertheless, these emissions increased significantly over the period 2009-2019This was explained by an increase in deforestation, mostly due to gold mining (SBB, 2017c) and an increased forest degradation due to the increasing timber production. Considering the foreign investments in both sectors, this trend was expected to continue and even accelerate. Therefore, Suriname proposed a linear growth FREL projection.

The deforestation rate for the period 2000-2009 was 0.02%, which increased to 0.08% for the period 2009-2015. For 2015 the forest cover was 93.02% (SBB, https://kopi.sbb.sr/).

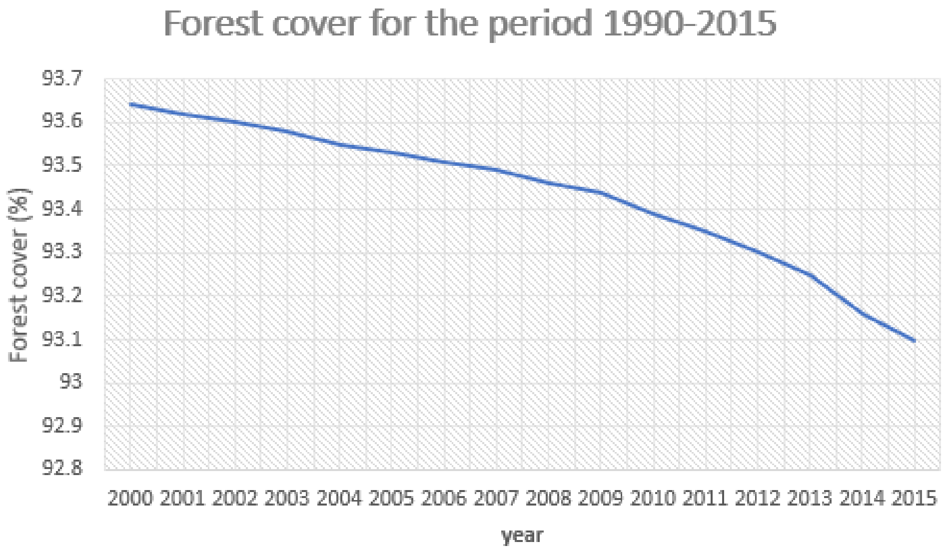

Figure 3. Forest cover trend over the period 2000-2015 (SBB, Kopi)

[6] Photo: https://es.globalvoices.org/

Regarding forest degradation, the forestry sector shows an increase when it comes to roundwood production. The production data for 2000 was 194,107.00 m^3, which gradually increased to 649,615.00 m^3 for the year 2015.

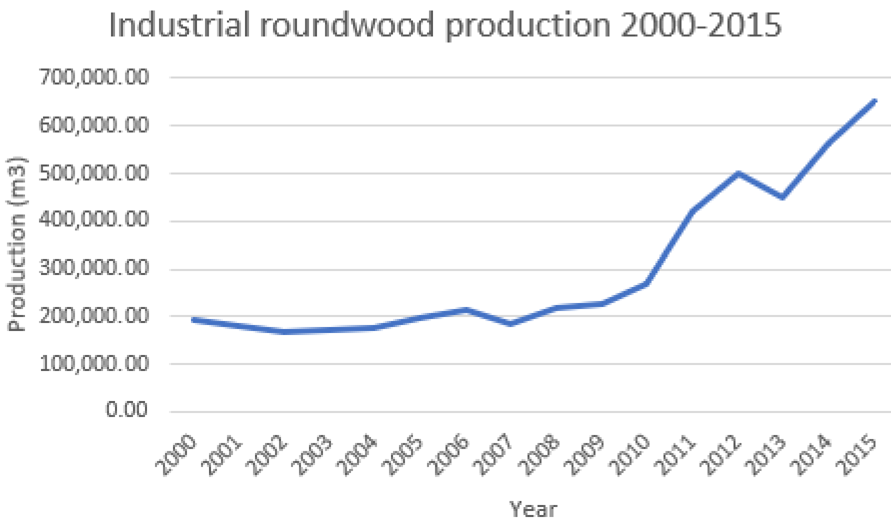

Figure 4. Trend industrial roundwood production for the period 2000-2015 (SBB, Kopi)

As part of the scenario modeling process carried out in order to support the Suriname National REDD+ Strategy, different future scenarios and their impact on the forest cover 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 had 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, 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. This was part of the finalization of the Suriname National REDD+ Strategy. The preliminary results of the Development scenario indicating the deforestation of all the planned projects, provide results which are very similar to the linear projection used to establish the FREL.

To estimate the projected emissions for the period 2016-2020, an equation has been used,which was formulated based on the trendline of the historical emissions.

$$\text{t } CO_2 \text{ emission year}^{-1} = 963{,}819 \times \text{year} - 1{,}928{,}432{,}063$$

Equation 1 Linear trend for FREL

Figure 5 shows the FREL with a linear projection. The linear projection is based on the historical trend and also on the National Development Plan and the REDD+ National Strategy. These national documents indicate the future developments that are likely to occur in order to have some economic stability in the country. The historical period that has been used is 2000-2015, where the annual emissions at year 2005 and 2011 respectively represent the time periods 2000 - 2009 and 2009 - 2013.

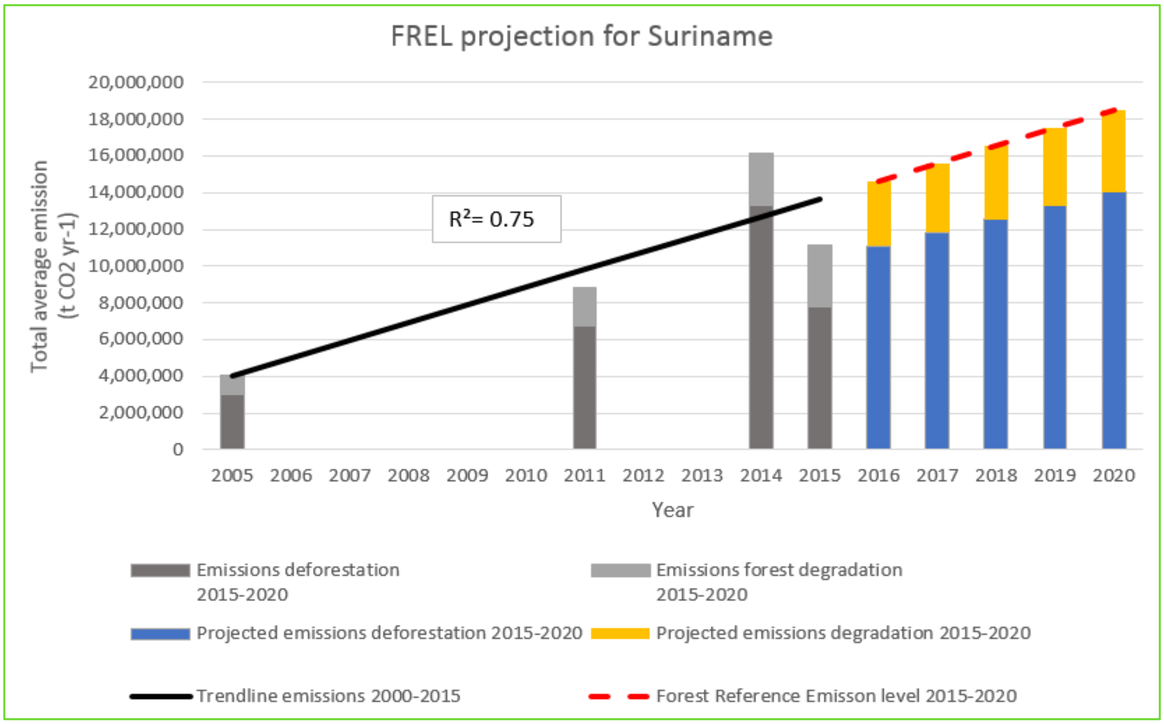

Figure 5. FREL for Suriname 2016-2020

Table 2 gives an overview of the projected future emissions from deforestation and forest degradation for the period 2016-2020. These results will be used to verify the results-based payments.

Table 2. FREL for Suriname, expressed in yearly CO2 emissions

Year	Projected future emissions from deforestation and degradation	Projected emissions from deforestation	Projected emissions from degradation
2016	14,627,465	11,099,636	3,527,828
2017	15,591,284	11,831,003	3,760,281
2018	16,555,103	12,562,370	3,992,733
2019	17,518,922	13,293,737	4,225,185
2020	18,482,741	14,025,104	4,457,638
Total	82,775,515	62,811,850	19,963,665

2.2 Activities included in the forest reference level

Deforestation

In the context of the 1st FREL submission, deforestation was defined as *"the direct and/or induced conversion of forest cover to another type of land cover in a given timeframe"*.

Explanatory notes

This excluded areas that underwent a temporarily loss of the forest cover, such as:

- **Shifting cultivation (included in the definition of forest):** The patches that were deforested were mostly smaller than the minimum area of forest and the Minimum Mapping Unit of our deforestation maps. There was a remaining tree cover, and the area was expected to recover after it was left to regenerate. The conversion from natural forest to shifting cultivation was seen as forest degradation.
- **Natural deforestation** where the forest cover was expected recover naturally such as small areas where wind break or unplanned fires took place.

There were 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 were 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 was based upon these reports.

Forest degradation

Forest degradation was for the 1st FREL submission defined as *"human-induced or natural loss of the goods and services, provided by the forest land, in particular the forest carbon stocks, not qualifying as deforestation, over a determined period of time"*.

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

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 was windbreaks, but because of their natural character, they were not included in the FREL.

Taking into account the available data , as well as the estimated contribution of different sources of degradation to the overall CO_2 emissions, Suriname only included logging as a source of forest degradation in its first FREL.

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 were included in the first FREL*, because there were limited historical activities that can be used to determine these removals.

2.3 The territorial forest area covered

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

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

The FREL was submitted on 8 January 2018 and the final technical assessment report was published on 23 November 2018.

2.5 The period of the assessed forest reference level

The FREL used the reference period of 2000-2015.

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

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

The FREL proposed by Suriname covered the activities "reducing emissions from deforestation" and "reducing emissions from forest degradation", which were among the activities included in decision 1/CP.16, paragraph 70. For its submission, Suriname developed a national FREL. The FREL presented in the original submission, for the reference period 2016–2020, corresponded to 14,441,113, 15,390,853, 16,340,593, 17,290,333 and 18,240,073 tonnes of carbon dioxide equivalent (t CO2 eq) for the respective years. As a result of the facilitative process during the technical assessment, the FREL was modified to **14,627,465**, **15,591,284**, **16,555,103**, **17,518,922** and **18,482,741** t CO_2 eq/year for 2016–2020, respectively. The assessment team noted that the data and information used by Suriname in constructing its FREL were transparent, complete and in overall accordance with the guidelines contained in the annex to decision 12/CP.17.

As a result of the facilitative interactions with the AT during the TA, Suriname provided a modified version of its submission on 2 June 2018, which took into consideration the technical inputs of the AT. The modifications improved the clarity, accuracy, completeness, consistency and transparency of the submitted FREL. This TA report was prepared in the context of the modified FREL submission.

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

REDD+ TECHNICAL ANNEX

3.1 Trend in emissions and removals in Suriname 2016-2019

During the reference period (2000-2015), it was identified that the main driver of ***deforestation*** was mining (mainly gold mining). Gold mining covered about 71% of the deforestation for the period 2000-2015 (SBB, 2017c). The other drivers of deforestation for the period 2000-2015 were infrastructure (15%), urbanization (4%), agriculture (3%), pasture (1%), burned area (3%) and other deforestation (1%) (SBB, 2017c). Land use change matrices were created for the period 2000-2009, 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.

Table 3. Emissions due to deforestation for the period 2000-2015

Period (years)	**Historical activity data (deforestation)**			**Annual deforestation emissions**		**Total deforestation emissions**
	Area (ha)	**Area (ha) yr^{-1}**	**Uncertainty (%)**	**t CO_2 yr^{-1}**	**Uncertainty (%)**	**t CO_2**
2000-2009	33,051	3672	16.22%	3,034,882	13.09%	27,313,938
2009-2013	32,071	8018	7.45%	6,757,268	7.25%	27,029,071
2013-2014	15,757	15757	13.21%	13,282,026	11.81%	13,282,026
2014-2015	9,442	9442	17.16%	7,815,882	14.45%	7,815,882
Total period 2000-2015	90,322	6021	7.12%	**5,029,395**	**5.98%**	75,440,919

*Note: * The emission factor of 219.79 was used for deforestation emissions, excluding forest fire deforestation where IPCC (2006) was used for calculating the emissions factors from CO_2, CH_4 and N_2O.*

[7] https://worlddayofprayer.net/suriname-2018.html

During the results period (2016-2019), it was identified that the main driver of ***deforestation*** was still goldmining. Every two years post-deforestation Land Use Land Cover data is being produced, indicating the main drivers of deforestation for the specific periods. Based on these results it can be concluded that mining activities remained the main driver of deforestation. The results can also be viewed at the KOPI statsistical portal at kopi.sbb.sr.

Table 3 shows the historical deforestation in each strata. The uncertainties in 2018 and 2019 are very low due to the use of Sentinel 2 data, which shows more detail resulting in more accurate data.

Table 4 Activity data: Historical deforestation (ha yr-1)

Forest stratum	**2016**	**Uncertainty (%)**	**2017**	**Uncertainty (%)**	**2018**	**Uncertainty (%)**	**2019**	**Uncerta inty (%)**
Mangrove forest	7.69	16.56	56	29.64	31	3.58	20	0.00%
Coastal plain*	2358	16.56	707	29.64	804	3.58	1589	0.00%
Forest belt*	8207	16.56	8905	29.64	7142	3.58	7512	0.00%
Interior	813	16.56	998	29.64	841	3.58	1122	0.00%
Sum	*11,387*		*10,667*		*8,818*		*10,243*	

Table 4 shows an overview of the historical deforestation caused by forest fires. Forest fires mainly occur in the coastal plain and the forest belt. This can be explained by the agriculture activities such as rice plantations and the shifting cultivation method used by local communities, where fires are being started.

Table 5 Activity data: Historical deforestation caused by forest fire (ha yr-1)

Forest stratum	**2016**	**Uncertai nty (%)**	**2017**	**Uncertain ty (%)**	**2018**	**Uncertainty (%)**	**2019**	**Uncertaint y (%)**
Coastal plain	73	16.57%	48	29.64%	189	3.58%	373	0.00%
Forest belt	100	16.57%	15	29.64%	107	3.58%	223	0.00%

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

During the reference period (2000-2015), the main driver of ***forest degradation*** was 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%. The first FREL only took into account logging activities as forest degradation. Therefore, the assumption is that during the results period (2016-2019) the main driver was also logging.

Table 6 shows the average annual production of logging, indicating an increasing trend over the years. This can be explained by the growing demand of wood worldwide.

Table 6. Table Average annual production in m^3 and uncertainty in %

Period	**Average annual production (m^3)**	**Uncertainty[8]**
2000-2009	175,819.11	20%
2009-2013	363,078.50	20%
2013-2014	494,047.00	20%
2014-2015	568,657.00	20%

[8] The uncertainty for 2015-2019 have been updated based on field observations.

2015-2016	583,376.00	5%
2016-2017	862,907.00	5%
2017-2018	1,083,350.00	5%
2018-2019	1,074,710.00	5%

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

Table 7 Summary of policies and plans relevant for different drivers

Drivers of projected emissions level	Percentage of contribution to reference level	Regulating policies and planned development relevant for the Forest Reference Emission Level (FREL)
Forestry (degradation)	About 25% of the total emissions	Forest Management Act (1992), National Forest Policy (2006), Strategic Action Plan for the Forest Sector, Code of Practice, National Development Plan 2017-2021, Draft National REDD+ Strategy.
Mining (deforestation)	55% of the total emissions from which 44% is contributed by Artisanal Small Scale gold mining (ASGM)	Mining Decree (1986), Extractive Industries Transparency Initiative (EITI - member since 2017), Minamata Convention (ratified 2018), National Development Plan 2017-2021, Draft National REDD+ Strategy.
Infrastructure (deforestation)	11% of the total emissions	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, Draft National REDD+ Strategy.
Urbanization (deforestation)	3% of the total emissions	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, Draft National REDD+ Strategy.
Agriculture and pasture (deforestation)	Agriculture 2%, pasture 1% of the total emissions	Environmental and Social Impact Assessment (ESIA), National Development Plan 2017-2021, Draft National REDD+ Strategy.

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

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

Table 8. Total Average emissions due to Deforestation and degradation

Period	Deforestation emissions (t CO2 yr-1)	Degradation emissions (t CO2 yr-1)	Total emissions (t CO2 yr-1)	Uncertainty for total emissions	Confidence interval lower limit	Confidence interval upper limit
2000-2009	3,039,038.98	1,021,721	4,060,760	11.71%	3,585,280	4,536,240
2009-2013	6,757,267.93	2,109,923	8,867,191	8.22%	8,138,167	9,596,216
2013-2014	13,282,026.40	2,871,008	16,153,034	10.72%	14,421,036	17,885,033
2014-2015	7,815,882.32	3,304,582	11,120,464	12.69%	9,709,531	12,531,398
2015-2016	9,418,074.65	3,390,117	12,808,192	10.81%	11,422,993	14,193,390
2016-2017	9,050,210.10	5,014,529	14,064,739	17.59%	11,590,909	16,538,569
2017-2018	7,356,427.62	6,295,568	13,651,996	8.08%	12,549,527	14,754,465
2018-2019	8,343,509.26	6,245,359	14,588,869	7.42%	13,505,848	15,671,889

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

According to the FREL submitted, the expected emissions for 2016, 2017, 2018 and 2019 were 14,627,465, 15,591,284, 16,555,103 and 17,518,922 respectively. The total emissions estimated for these years for Suriname were 12,808,192, 14,064,739, 13,651,996, 14,588,869, having emission reduction results.

Table 9. Total average emissions (Deforestation and Degradation). Reference period and results period

Year	Total average emissions (Deforestation and Degradation) (t CO2 yr-1)	Projected future FREL (Deforestation and Degradation)	Estimated total emissions (Deforestation and Degradation)	Estimated total REDD+ results (Deforestation and Degradation)
2005	4,056,603			
2006	4,056,603			
2007	4,056,603			
2008	4,056,603			
2009	4,056,603			
2010	4,056,603			
2011	8,867,191			
2012	8,867,191			
2013	8,867,191			
2014	16,153,034			
2015	11,120,464			
2016		14,627,465	12,808,192	1,819,273
2017		15,591,284	14,064,739	1,526,545

2018		16,555,103	13,651,996	2,903,107
2019		17,518,922	14,588,869	2,930,053

As mentioned in the previous section, although there are general results for total emissions, a significant decrease is observed for deforestation, but there is still an increase in degradation activities.

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

Forest degradation has kept on increasing, because it was mainly driven by the export of round logs. To reduce the emissions, we should use two approaches: 1) focus on improved practices on the ground (better logging practices like RIL-C) 2) Reduce the export of round logs and strengthen the wood processing sector. Of course it is also important to strengthen the country's national institutions. There are already ongoing programs related to improve this, but to successfully tackle degradation, the country still needs a lot of technical and financial support.

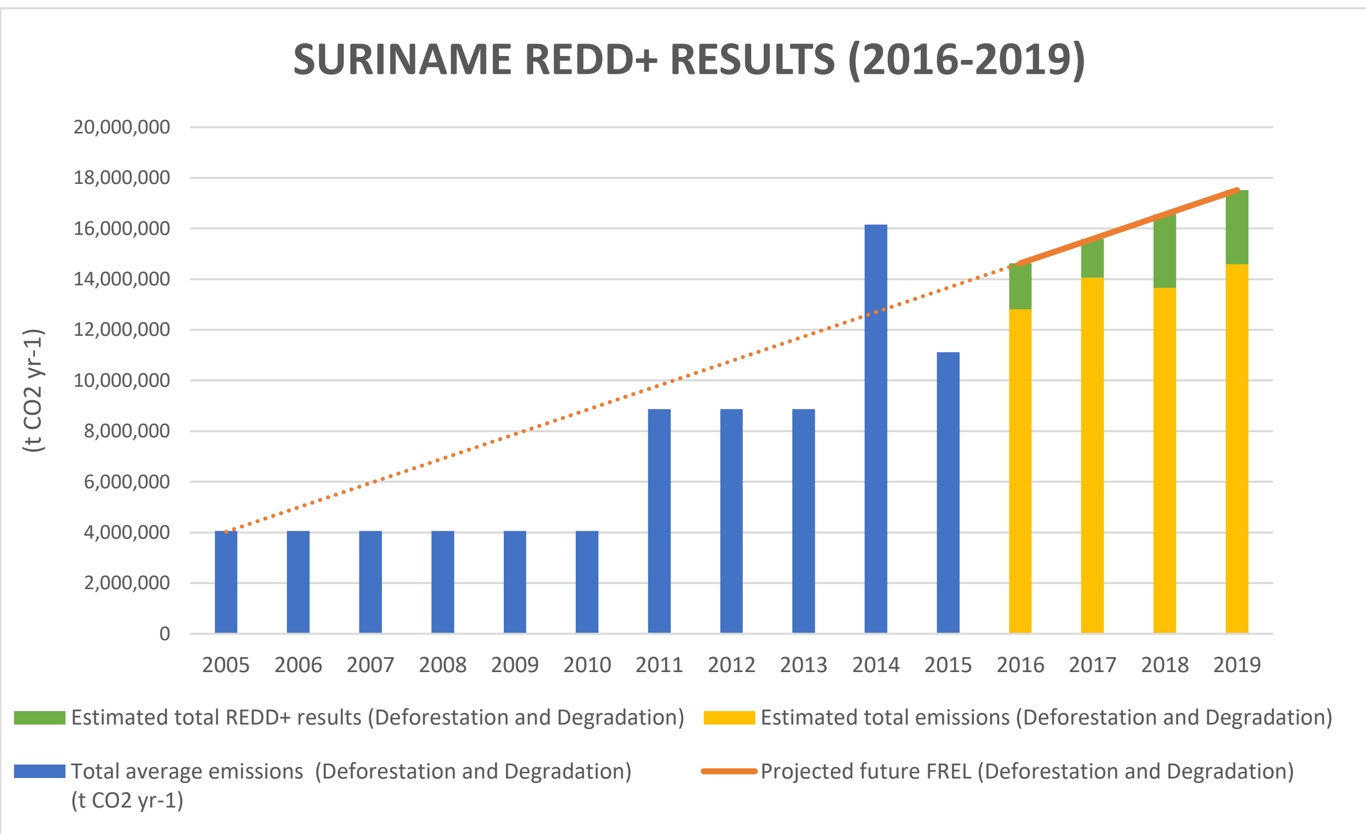

Figure 6. Suriname REDD+ results (2016-2019)

3.3 Consistency with National GHG Inventory and Forest Reference Level

The FREL and REDD+ results were developed following the guidance provided in Decision 12/CP.17, decision 4/CP.15, paragraph 7, however this first FREL and the Suriname GHG national inventories are not consistent.

The REDD+ results 2016-2019 and the FREL are full consistency and transparency in national reporting to UNFCCC. The FREL and REDD+ results were estimated following the 2006 IPCC Guidelines. The reports are based on the same database, methods, and assumptions and apply the same estimation procedures.

Chapter 4. Consistency of methods used to obtain the 2016-2019 results relative to methods used to establish the assessed Forest Reference Level

The methods used to obtain the annual emissions and removals for the period 2016-2019 are consistent with those used to calculate the first FRL submitted by Suriname. The same REDD+ activities, greenhouse gases, carbon pools, activity data and emission factor estimation methods and data sources, as well as methods for mapping land use were used in estimating annual emission and removals of both the FRL and the results presented in this Technical Annex. Table 10 summarizes how the methods used to obtain the FRL and those used to obtain the 2016-2019 results are consistent.

Table 10. Consistency between the FREL and the Technical Annex Results (2016-2019)

Parameter	1rst FRL for 2005 to 2015	Technical Annex Results 2016-2019
IPCC Guidelines	IPCC GPG 2003, IPCC GL 2006	IPCC GPG 2003, IPCC GL 2006
REDD+ Activities	Deforestation and forest degradation	Deforestation and forest degradation
Greenhouse Gases	CO_2, CH_4 and N_2O	CO_2, CH_4 and N_2O
C pools	Above-Ground Biomass (AGB), Below-Ground Biomass (BGB) and Dead Organic Matter (DOM).	Above-Ground Biomass (AGB), Below-Ground Biomass (BGB) and Dead Organic Matter (DOM).
Forest stratification	- Mangrove forest - Coastal plain - Forest belt - Forest in the interior	- Mangrove forest - Coastal plain - Forest belt - Forest in the interior
Estimating Activity Data	AD was estimated by a combination of approaches 2 and 3 from the 2006 IPCC Guidelines. - 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.	AD was estimated by a combination of approaches 2 and 3 from the 2006 IPCC Guidelines. - 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.

[9] https://fieldguides.com/bird-tours/suriname-cotingas-trumpeters/

	- Activity data are disaggregated by drivers of deforestation for three periods. This has been done using ancillary data and field experience from multiple institutions. - Guidelines for the visual interpretation of the different land use and land cover classes (LULC) were developed and adjusted (SBB, 2017c).	- Activity data are disaggregated by drivers of deforestation for three periods. This has been done using ancillary data and field experience from multiple institutions. - Guidelines for the visual interpretation of the different land use and land cover classes (LULC) were developed and adjusted (SBB, 2017c).
Estimating Emission Factors	- 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 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.	- 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 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.

Chapter 5. National Forest Monitoring System

REDD+ TECHNICAL ANNEX

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

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

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

[11] https://www.flickriver.com/photos/okrodam/sets/72157624098906469/

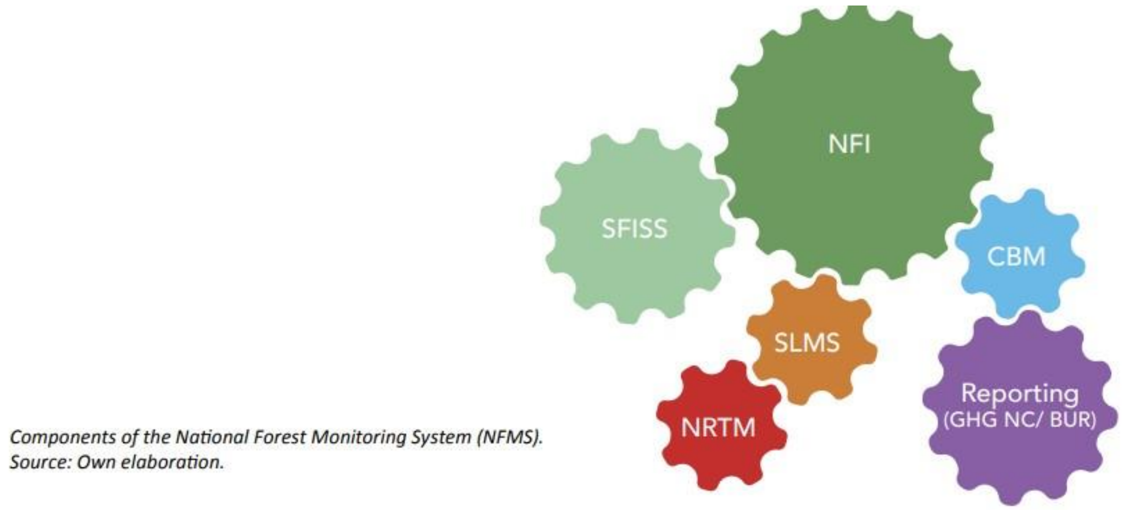

Figure 7. Components of the National Forest Monitoring System

5.1 Tools within the National Forest Monitoring System:

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

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

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

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

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

4) Involving communities in forest monitoring

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

5) National Forest Inventory

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

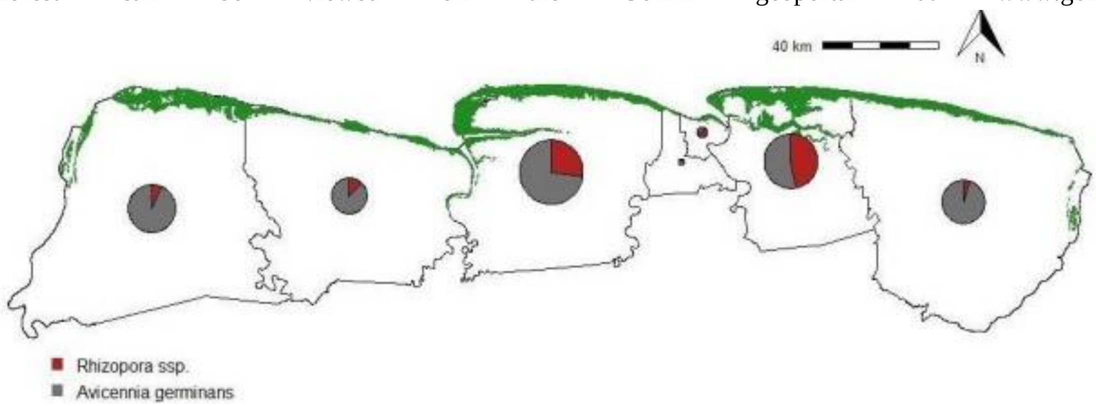

Figure 8. Mangrove coverage 2019 (Gonini)

6) Reporting

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

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

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

Chapter 6. Information necessary to reconstruct results

REDD+ Results for Suriname background information is openly available online. All spatially explicit information on forest cover change is available through the open-access geoportal www.gonini.org. There is a multi-stakeholder collaboration in the development of national Land Use Land Cover (LULC) Maps and an exchange of data between these stakeholders, which promotes transparency regarding spatial data in Suriname. Reports and documents on spatial and non-spatial information such as Emission Factors (EF), Timber production and Forest Inventory data are published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the KOPI statistical portal (kopi.sbb.sr).

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

Data sets and information:

FREL calculation tool 2018:
https://drive.google.com/drive/folders/11AyfuYZUeStfxAiLiusguHO55qGEjsMy?usp=sharing

REDD+ data results are available on the KOPI statistical database via:
https://drive.google.com/drive/folders/1fisCZyUZ8GdyYyVtS2evIS6eq9nrM_6r?usp=share_link

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

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

Suriname FREL and this REDD+ Technical Annex both use the methodologies described in the IPCC Good Practice Guidance for LULUCF (2003) and IPCC Guidelines, 2006 as the basis for estimating the changes in carbon stock in forested areas converted to other land uses. Suriname applies the basic method for estimating emissions suggested by IPCC, i.e., emissions are estimated as the product of activity data and emission factor for a given activity.

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

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

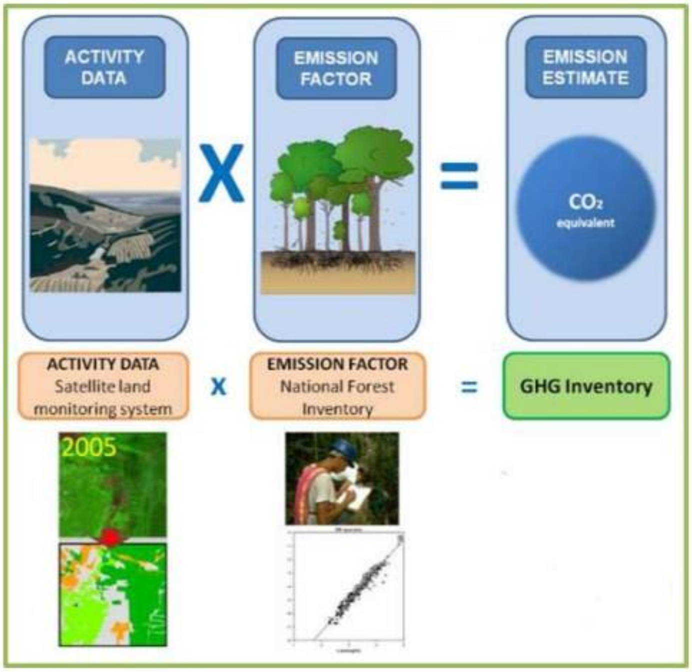

Figure 9. Measurement of AD x EF = GHG reporting

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

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

- **Transparency:** FREL and REDD+ results Suriname background information is openly available online[12]. 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 Factors (EF), Timber production and Forest Inventory data are published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the website of the SBB (www.sbbsur.com).
- **Accuracy:** Area estimations based on remote sensing are generated following the good practices recommended by Olofsson *et al.* (2014) 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

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

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

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Annexes

ANNEX I. Information used to construct the FREL and RESULTS

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)[13], 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. Guiding principles for the NFMS in Suriname include national ownership, open data accessibility and transparency, cost efficiency, and adaptation to context (e.g. different contexts require a different monitoring approach specific for each aspect of the FREL, such as methods used for determining emissions from forest degradation and deforestation) (SBB, 2017).

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[14].

[13] 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.

[14] 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.

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)[15]:

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

The forest definition in Suriname excludes:

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

It should be noted that shifting cultivation (slash and burn agriculture) is included as forest, as long as it is done in a traditional way so that the forest gets the chance to grow back after harvest.

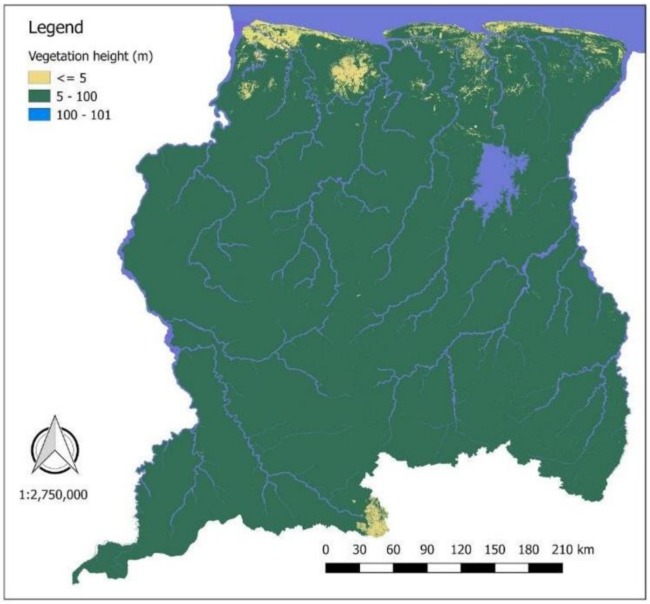
The administrative forest definition in the Forest Management Act (1992) will need to be adjusted and improved based on the above-mentioned criteria. For reporting done within the FAO Forest Resource Assessment 2015, the above-mentioned criteria to define forest is applied. This will also be implemented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

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 11). This corresponds with general field observations.

[15] 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.



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 10. 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 11. 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 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.

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.

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[16]. 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 Factors (EF), Timber production and Forest Inventory data are published and disseminated through the website of the National REDD+ Program (www.surinameredd.org) and the website of the SBB (www.sbbsur.com).
- **Accuracy:** Area estimations based on remote sensing are generated following the good practices recommended by Olofsson *et al.* (2014) 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 National Communication (based on 2008 data for the GHG inventory) was submitted on 15 March 2016[17]. This FREL does not fully coincide with the National Communications GHG inventory. Because the forest related emissions within the GHG inventory were

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

[17] http://unfccc.int/resource/docs/natc/surnc2.pdf

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.

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

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. 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).

Measuring the damage to lianas after timber harvesting is an almost impossible task (they are mostly already decomposed or grow further in another tree). Because of the limited number of trees extracted per hectare (3-4 stems per ha), the associated emissions related to lianas are even more limited (less than 1%) and are therefore not included in this FREL. Within a future submission, methods to increase consistency will be evaluated.

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

Gases

The only GHG that is included in this FREL is carbon dioxide (CO_2). As exception, the estimations of the emissions of non-CO_2 gases (nitrous oxide, N_2O, and methane, CH_4) from burned forest land are included. These estimations are based on the IPCC 2006 AFOLU method and factors, where after they are and converted to CO_2-equivalents.

CH_4 is also released when swamp area or mangrove forest are deforested. Nevertheless, the swamp area being deforested contributes approximately less than 1% to the total deforestation.

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

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[18]. 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), (GFOI, GOFC-GOLD & NSC, 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.

Within this method a stratified random sampling design is used, because it makes it possible to increase the sample size in classes that occupy a small proportion of area to reduce the standard errors of the class-specific accuracy estimates for these rare classes (change map). (SBB, 2016; SBB, 2017c)

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

[18] With the deforestation 2000-2009, it is meant that the deforestation after 2000 (thus 2001) and until 2009 (thus including 2009) is measured. And thus for the following period 2009-2013 the deforestation is measured after 2009 (thus 2010) until 2013 (thus including 2013).

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.

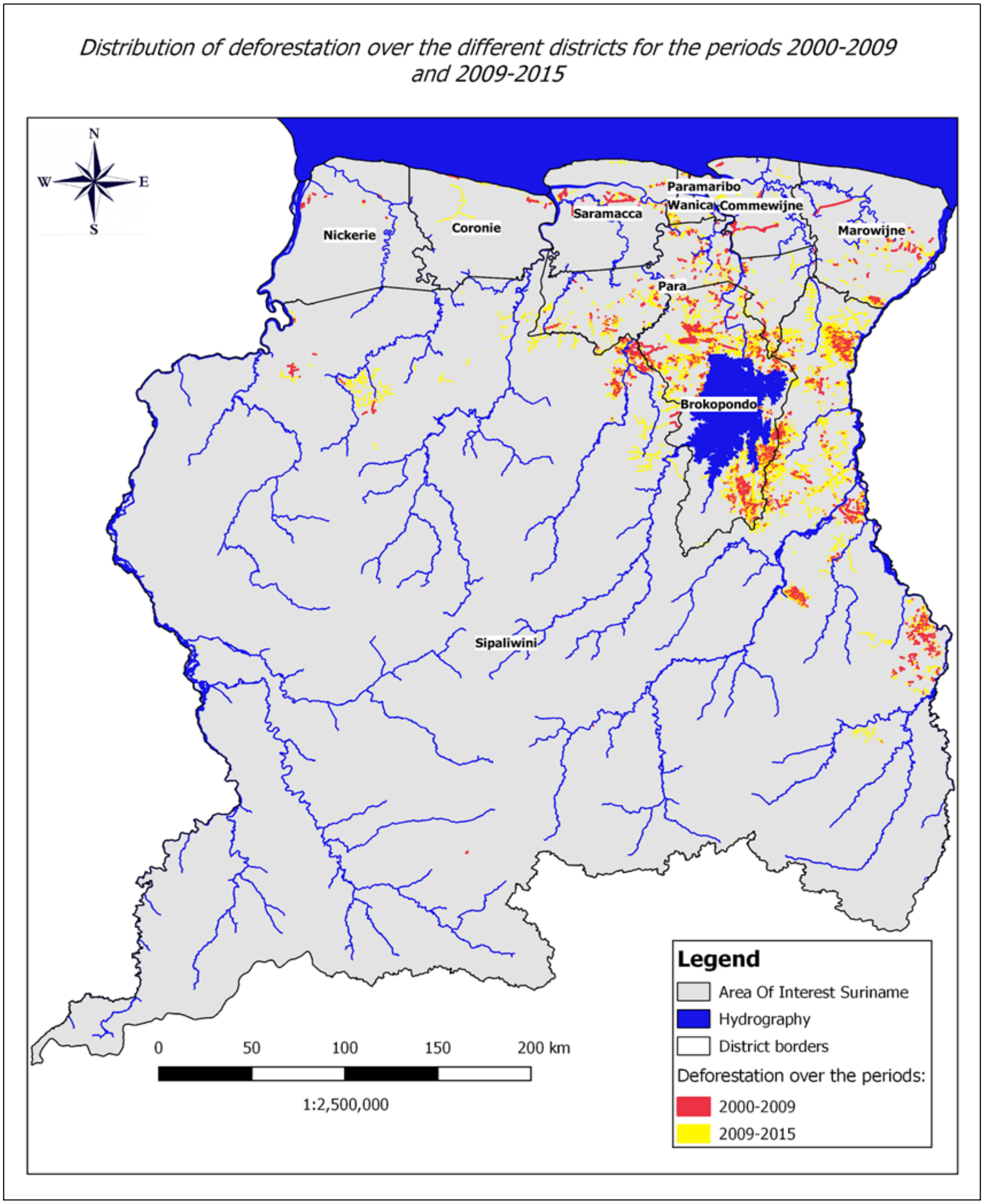


Figure 11. Overview of the deforestation per district in Suriname over the periods 2000-2009 and 2009-2015

Table 12 shows a general increase in deforestation between 2009-2015. Nevertheless there is a decrease for the period 2014-2015 (year 2015) compared to the earlier period 2013-2014 (year 2014). This could be due to a slight decrease of the gold price during that year.

Table 12. 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 drivers of deforestation for the period 2000-2015 are infrastructure (15%), urbanization (4%), agriculture (3%), pasture (1%), burned area (3%) and other deforestation (1%) (SBB, 2017c). Land use change matrices have been created for the period 2000-2009, 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.

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).

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. 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:

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

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[19] and cross checked with the Taxonomic Name Resolution Service (TNRS)[20] 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. The four general are delineated on a general understanding of large different landscapes: ***Stratum 1****:* Mangrove forest, because of its specific characteristics and dynamics, but also the role this forest type plays in both, climate change mitigations and adaptation; ***Stratum 2*****:** "Younger" Coastal plain. This stratum is delineated based on the occurrence of the precambrian Guiana Shield; ***Stratum 3*****:** the area were logging concessions are granted (North of the 4°Northern Latitude); ***Stratum 4:*** Forest areas where very limited activities are carried out (south of the 4°Northern Latitude) including the the Central Suriname Nature reserve, where little anthropogenic activities are carried out. While a full NFI is currently being prepared to be carried out in the coming years (SBB, 2017), the EF due to deforestation was calculated using these four general strata, based on this compiled database.

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

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

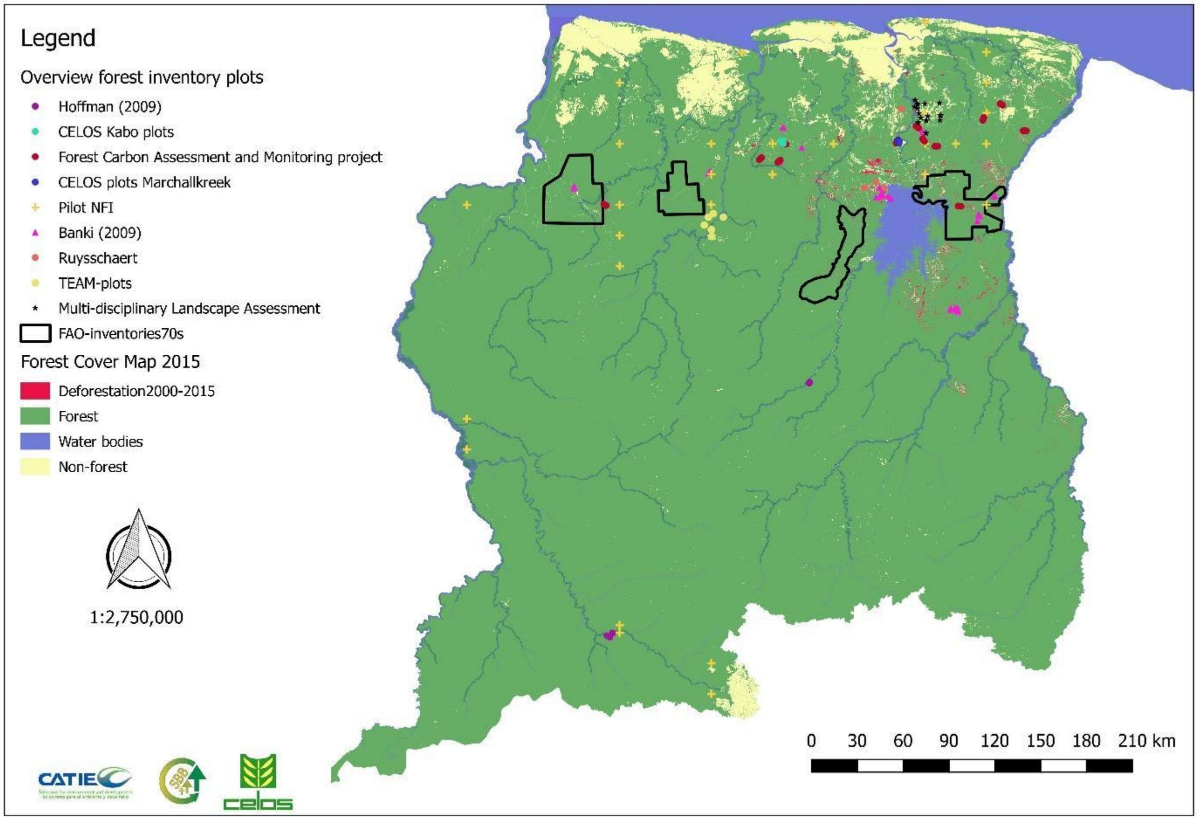


Figure 12. Overview of the forest inventory plots in Suriname (SBB et al., 2017a)

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 14.

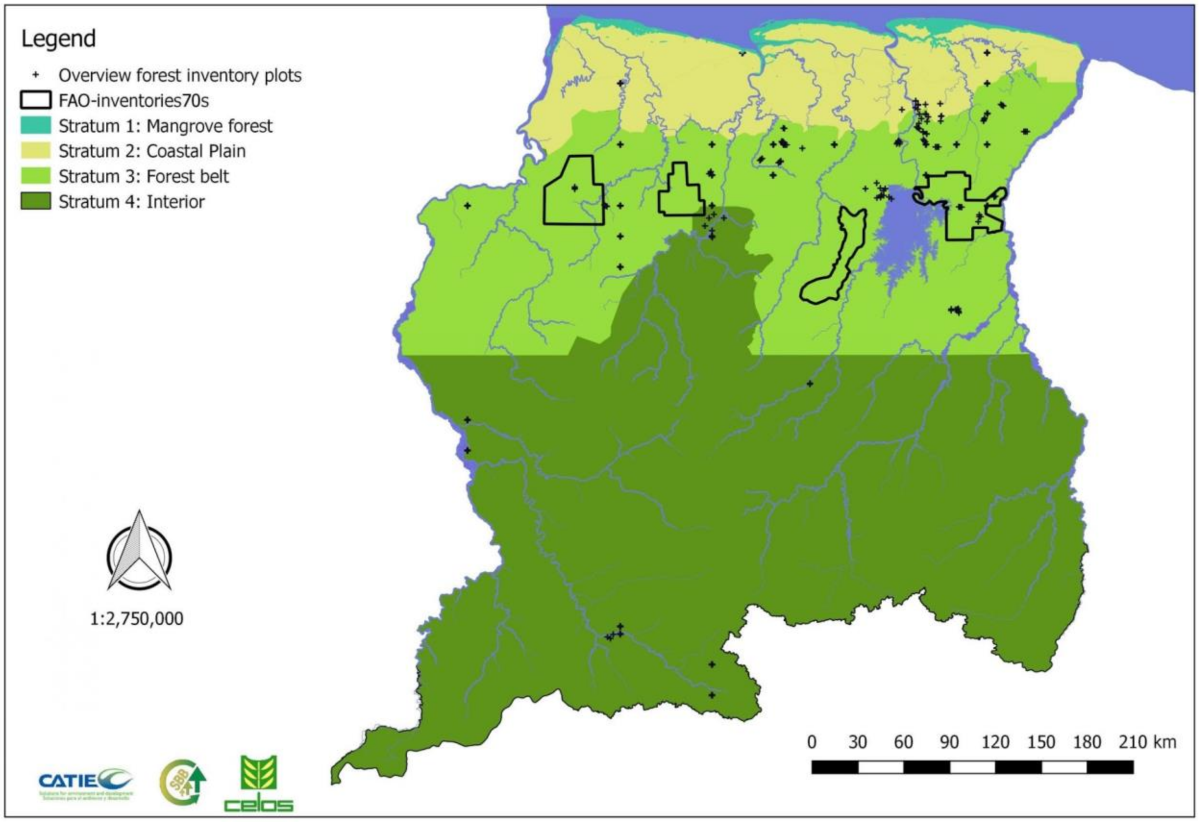


Figure 13. Preliminary stratification of Suriname

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.

Method used to estimate deforestation emissions factors

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[21] 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).

To avoid biased estimates for carbon stock, all data within the harmonized database was weighed by the plot size. The average carbon stocks and related uncertainties were calculated under a stratification sample frame.

[21] 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 13. 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 based on the dbh measured in the field and using the Chave *et al.* (2005) equation developed for estimating biomass in living trees. After this, knowing that the wood density is lower for standing dead trees, it was assumed that all standing dead trees were decomposing, thus a biomass reduction factor representing 75% of the individual total weight was applied to each individual, as suggested by Brown *et al.* (1992) and Saldarriaga *et al.* (1998), cited by Sarmiento, Pinillos and Garay (2005).

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 14 the average carbon stocks in t C per hectare per pool per 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 fact that the interior is difficult to access, resulting in a limited number of plots there (Figure 5), or by a sparser tree cover in the interior because of the mountainous landscape and/or savanna. For the mangrove forest, the carbon stock estimates based on national data are very low and the uncertainties are very high (SBB *et al.*, 2017a), because of the limited number of plots in the mangrove forest. Therefore, for mangrove forest the IPCC default values have been used. The information will be improved when more field data is collected during the implementation of a National Forest Inventory the coming years.

Table 14. Carbon stocks (t C ha-1) in the selected pools in each stratum (SBB et al., 2017a)

Carbon Pools		**Carbon stock (t C ha^{-1})**			
		Mangrove forest	**Coastal plain**	**Forest belt**	**Interior**
Above-Ground Biomass	**Living trees (dbh ≥ 5cm)**	90.24	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**	44.22	37.12	42.51	40.14
Dead Organic Matter	**LDW**	0.00	3.23	11.54	4.50
	SDW	0.00	1.31	3.14	1.92
Total		**134.46**	**197.00**	**237.18**	**216.19**

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

The emission factors for deforestation per stratum (table 5) are calculated by converting the carbon stocks per stratum (table 4) to its CO_2-equivalent by using the factor 44/12.

Table 15. Emission factors for deforestation per stratum

Stratum	***Emission factors for deforestation***	
	t CO_2 ha^{-1}	***Uncertainty***
Mangrove forest	493.01	4.7%
Coastal plain	722.34	17.1%
Forest belt	869.68	3.6%

Interior	792.70	9.6%

Activities are planned to improve these estimations, especially through the implementation of a full multipurpose National Forest Inventory. In 2018 more data will be collected especially from the mangrove forest, to provide national data improve the estimations as in this report IPCC Tier 1 values have been used for mangrove.

Non-CO_2 emissions from deforestation due to forest fire

Emissions from deforestation due to forest fire include not only CO_2, but also other greenhouse gases, or precursors of greenhouse gases, that originate from incomplete combustion of the fuel. These include carbon monoxide (CO), methane (CH_4), non-methane volatile organic compounds (NMVOC) and nitrogen (e.g., N_2O, NO_x) species. In this FREL, the only non-CO_2 gases included are CH_4 and N_2O (IPCC, 2006).

These emissions were estimated by using equation 2(IPCC (2006) (cf. Volume 4, Chapter 2, Section 2.4.):

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

Where:

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

A = area burnt, ha

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

<u>Note</u>: This includes aboveground biomass and dead wood.

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

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

Equation 2. Calculation method for the non CO_2 forest fire emissions from deforestation.

Historical emission due to deforestation

Emissions caused by deforestation will be determined with the IPCC 2006 basic equation (see equation 3), by multiplying the AD with the EF for gross deforestation (the average carbon stock of the forest in t C per ha). While more detailed carbon stocks for other land use types need to be determined, it was assumed that the carbon stock 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.

$$E = AD \times EF$$

Where:

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

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

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

Equation 3. 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 (for deforestation and forest fire emissions). 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 **75,440,919 t CO_2** (see table 6). Using the error propagation method proposed by IPCC 2003, the uncertainty is **± 4,511,086 t CO_2** or **± 5.98%** 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_FRELCalculationTool[22]).

Table 16. Emissions due to deforestation for the period 2000-2015

Period (years)	Historical activity data (deforestation)			Annual deforestation emissions		Total deforestation emissions
	Area (ha)	Area (ha) yr^{-1}	Uncertainty (%)	t CO_2 yr^{-1}	Uncertainty (%)	t CO_2
2000-2009	33,051	3672	16.22%	3,034,882	13.09%	27,313,938
2009-2013	32,071	8018	7.45%	6,757,268	7.25%	27,029,071
2013-2014	15,757	15757	13.21%	13,282,026	11.81%	13,282,026
2014-2015	9,442	9442	17.16%	7,815,882	14.45%	7,815,882
Total period 2000-2015	90,322	6021	7.12%	**5,029,395**	**5.98%**	75,440,919

*Note: * The emission factor of 219.79 was used for deforestation emissions, excluding forest fire deforestation where IPCC (2006) was used for calculating the emissions factors from CO_2, CH_4 and N_2O.*

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

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

Activity data

Activity data due to the construction of haul roads for logging and log yards are included within the deforestation LULC class 'infrastructure'. 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 15, 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).

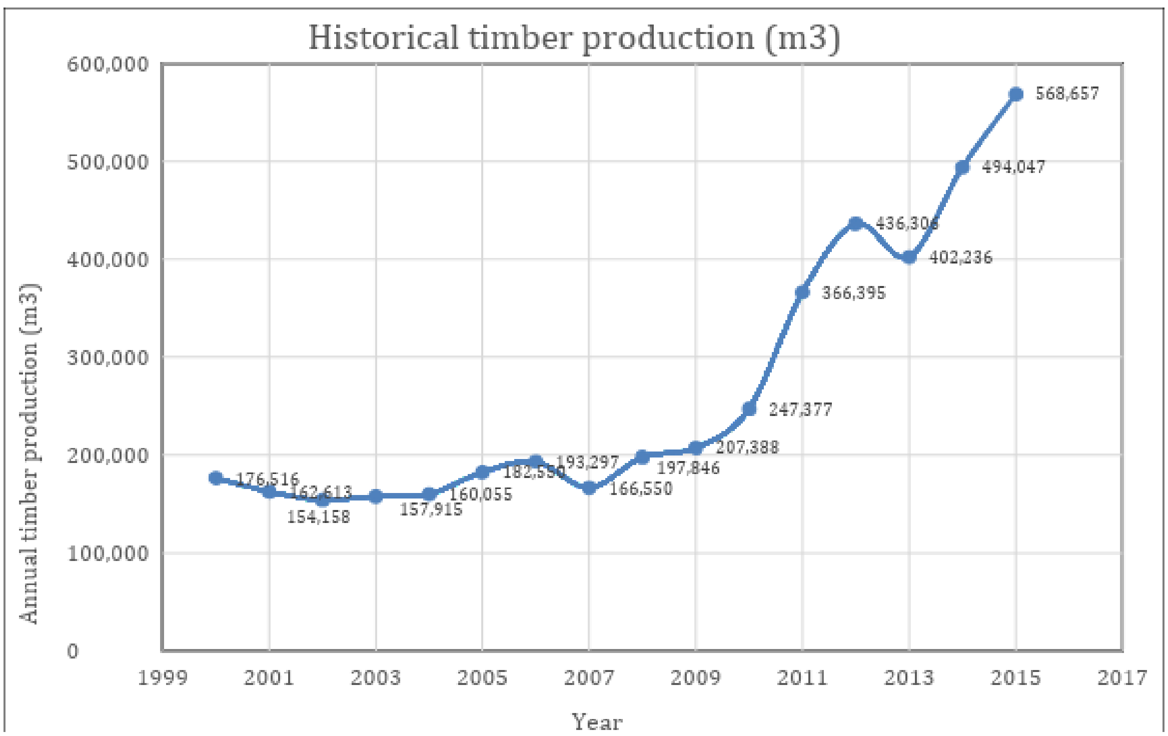


Figure 14. Timber production for the period 2000-2015 (SBB, 2016)

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.

Within the development of the NFMS, two subsystems are currently being developed which will strengthen the monitoring of activity data and emissions factors from legal and illegal logging:

- **Sustainable Forestry Information System Suriname (SFISS):** based on agreed definitions of legality, this SFISS will strengthen the registration of legal and illegal logs. This will make it possible to report separately on both components. The development of the SFISS includes the revision and improvement of the current procedures in a collaborative manner (private and public sector), a training component, and the construction of a new database accompanied with relevant front-end applications.
- **Near Real Time Monitoring (NRTM)- system:** This currently semi-operational system provides alerts on unplanned activities. The feedback mechanism related to unplanned logging will be integrated within the SFISS, improving the detection of illegal logging activities.

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 t 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 half 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).
- No measurements were done in areas overlapping with other land use, mainly gold mining, because this could result in an over- or underestimation of the emissions related to selective logging.

Field data collection

Because the emissions can vary as a function of the management types as defined in SBB (2017a, 2017b), different logging intensities and physical terrain conditions, a random stratified sampling approach was conducted over the whole range of active logging concessions (including community forest)[23].

Emission calculation

The Total Emission Factor (TEF) in t of carbon emitted per m^3 timber extracted from selective logging is estimated using equation 4 (Pearson *et al.*, 2014).

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

$$TEF = ELE + LDF + LIF$$

Where:

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

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

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

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

Equation 4. 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[24], which uses the measured log length and the log diameters (top and bottom diameters of extracted logs). This volume was converted to biomass using the wood density of the tree species (Zanne *et al.*, 2009). The ELE value was calculated for logging units by dividing the sum of the calculated carbon emission for that logging unit by the sum of the extracted log volume (see equation 5).

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

Where:

ELE= Extracted log emissions (t C m^{-3})

WD= Wood density of felled trees (10^3 kg m^{-3})

CF= Carbon fraction, which is 0.47

GAPVol= Volume of timber over bark extracted in gap (m^3)

Equation 5. 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, where only snapped and grounded trees are included as actual fatalities, as advised by regional experts.

A total of 258 felled trees were sampled. The AGB of the total tree is estimated by using the equation 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

[24] 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

the sum of the AGB and BGB of the total tree minus the extracted log piece. The carbon losses from collateral damage were calculated by measuring all the grounded and snapped trees in the felling gaps 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 6, 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.

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

Where:

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

Equation 6. 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 t carbon emissions per hectare of skid trail. This is calculated by estimating how much biomass is lost per area of skid trail constructed. For this, the biomass damaged on the skid trails was measured using sample plots on the skid trails. Snapped and grounded trees on the skid trail were measured to determine emissions from skidding.

The skid trail area (SA) for each sample unit was calculated by multiplying the average measured width of the skid trails 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 data from the harvested trees sampled is used to calculate the production (extracted volume) for each sampling unit. To calculate the LIF (see equation 7), the skid trail area (ha) is used, which was calculated by multiplying the skid trail total length with the average skid trail width.

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

Where:

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

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

SA= Area of skid trails in ha

Equation 7. Calculation method for the LIF

Resulting EF for forest degradation

The total emission factor (TEF) for forest degradation due to logging was estimated to be 1.58 t C m^{-3} with an uncertainty of 15.96% . The contribution of the LIF, LDF and ELE to the TEF were respectively 0.24 t C m^{-3}, 1.04 t C m^{-3} and 0.30 t C m^{-3}. The uncertainties for the LIF, LDF and ELE were respectively 55.26%, 20.62% and 4.74%. These high uncertainties in LIF and LDF can be explained through the large variation between samples in the field and the small sample size (n=10).

Table 17. Emission factors for logging

	Logging emission factors (t C m-3)			
	LIF	**LDF**	**ELE**	**TEF**
Mean	0.24	1.04	0.30	1.58
95% CI	0.13	0.21	0.01	0.34
Uncertainty	55.26%	20.62%	4.74%	15.96%

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Stakeholder consultations and awareness moments, from which questions and comments were used as input to 1st 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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