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Gabon National Results Report

Results-Based Payments under the Central African Forest Initiative – Gabon partnership

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Preface

Forestry has been practiced in Gabon for over 130 years. For the first 120 years the majority of wood exports were in the form of unprocessed logs, representing about 3% of the full value of the timber. Gabon's timber helped to develop many economies off the African continent.

When Natural resources are considered a cheap commodity, they are rarely managed wisely. When the trans-gabonais railway was built it opened up the remote forests of central Gabon to logging. Primary forests were opened up by international companies who high-graded the forests, moving on after the first pass and leaving infrastructure that allowed smaller companies to follow behind and cut lesser trees. Intense hunting was the rule rather than the exception. Gabon's forests were going the way of those of Ivory Coast.

In 1992 at the Rio Earth Summit President Omar Bongo said: "*All too often in Africa we have felt ourselves obliged to develop at no matter what the cost*". He was referring to the environmental costs of development and he was already formulating a new vision for the country. In 1993 he signed Gabon's first Environment Law; in 1997 Gabon published its Environmental Action Plan; and in 2001 President Bongo signed a new forestry code into law, making sustainable forest management compulsory from 2006 onwards. In 2002 he announced the creation of 13 national parks covering 13% of Gabon's land area, formalised in 2007 in the National Parks Law. In so doing President Omar Bongo Ondimba began to chart a new development trajectory: Sustainable Development.

When President Ali Bongo Ondimba was elected in 2009 his first major international engagement was to attend the Copenhagen COP. There he participated in the formulation of the Copenhagen Agreement and said:

> *"By implementing REDD+ Gabon will shoulder its forest sector mitigation responsibilities. By doing so I am certain we will save human lives in Africa and in small island states, whose disappearance seems inevitable as a result of the perturbations in the climate.*
>
> *In the light of this emergency everybody needs to shoulder their responsibilities. Rather than being simply a political or economic challenge the climate crisis is first and foremost a moral duty.*
>
> *In this context, I can announce on behalf of the Gabonese people that we will continue to do all that is in our power, with or without an agreement.*
>
> *In front of you here in Copenhagen, I can commit that the Gabonese people will continue to advance the cause of sound forest management."*

He banned the export of logs, created the Climate Council, which adopted Gabon's Climate Action Plan, he created AGEOS, our space agency, to monitor deforestation and forestry-driven degradation and signed the Sustainable Development Law. Later he committed to a 50% decrease in carbon emissions relative to a business-as-usual scenario.

This report describes how Gabon's carbon emissions have evolved over 3 decades – increasing steadily through the '90s; stabilized from 2000 onwards; and significantly reduced from 2010 onwards, with carefully planned land-use planning constraining agricultural development to low carbon degraded forests and savannas. In the next plan Gabon is committed to further reducing emissions, in close collaboration with the Central African Forest Initiative.

Professor Lee White

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1 Acknowledgements

The Government of Gabon would like to acknowledge the financial and technical support provided by the Government of Norway, the United Nations Development Programme, the Central African Forest Initiative and the Forest Carbon Partnership Facility.

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4 Introduction

Gabon is situated on the Gulf of Guinea in Equatorial Africa, flanked to the west by the Atlantic Ocean and inland by the Republic of Congo, Cameroon and Equatorial Guinea. The country enjoys a stable and prosperous economy and has designed extensive programmes for sustainable development. Substantial oil and mineral resources and a low population contribute to making Gabon one of the wealthier countries in Africa per capita. It covers an area of 267,667 km^2. Forest covers 88% of the area of Gabon (23.5 Million ha), making it the second most forested country in the world after Suriname.

Although REDD+ wasn't formally tabled in the negotiations under the United Nations Framework on Climate Change (UNFFCCC) until after 2005 (when Papua New Guinea and Costa Rica requested it to become an agenda item in the negotiations), it had been evolving under the term of "avoided deforestation" for several years. The Government of Gabon (GoG) has been a key player in shaping REDD+, from "Reducing Emissions of Deforestation (RED)" in 2005, to "Reducing Emissions from deforestation and forest degradation (REDD)" with the Bali Action Plan in 2007 and finally leading to REDD+ in Copenhagen in 2010. These efforts resulted in the 2013 "Warsaw Framework for REDD+" and the recognition of REDD+ within the Paris Agreement in 2015. President Ali Bongo Ondimba (then Minister of Defense) also worked closely with His Royal Highness the Prince of Wales, as Gabon's representative on the African Council of his Rainforest Project, attending the watershed meeting at St. James Palace in 2008 during the G24 meeting in London which launched the idea of a quick start fund for REDD.

Recognising the importance of forests and climate and sustainable development as part of the UNFCCC negotiations, the GoG imposed a national whole log export ban in 2009 and created its National Climate Council in 2010, demonstrating its high-level national ambition and commitment to tackle greenhouse gas emissions from the forestry sector.

4.1 Gabon – CAFI Results-Based Partnership

On 27 June 2017 the GoG and the Central African Forest Initiative (CAFI) signed a Letter of Intent to establish a partnership to implement the National Investment Framework of Gabon.

In 2019, Gabon and CAFI signed a 150 million US dollars agreement (2019 addendum to the 2017 Letter of intent). Through this, Gabon is rewarded a 10-year deal for both reducing its greenhouse gas emissions from deforestation and degradation, and absorptions of carbon dioxide by natural forests. The National Results Report is submitted in the framework of this partnership.

The Partnership aims to reward Gabon, a High Forest Low Deforestation (HFLD) country, for maintaining a high forest cover and low deforestation rate, recognising the ecosystem services provided for by natural forests and the real and additional efforts needed to maintain a low deforestation rate. The Parties seek to do this in a way that ensures the highest environmental and social integrity and that can set a model for other countries.

Gabon's National Results Report for Results-Based Payments (RBPs) presents national results in gross emissions reductions and removals for 2016 and 2017. The National Results Report for RBPs is based on Gabon's Forest Reference Level (to be submitted to the UNFCCC). The GoG aims to apply to the 'Architecture for REDD+ Transactions REDD+ Environmental Excellence Standard' (ART-TREES) in the future.

4.2 Relevant national institutional arrangements

Gabon's natural resources are governed by the Ministry of Water, Forests, Sea, the Environment charged with the Climate Plan and Land-use Planning, generally known as the Ministry of Water and Forests (MINEF). All forests are owned by the state, and are divided into two categories: (i) the permanent forest estate including production forests (which are managed by private concession holders), protection forests (which are protected areas managed by the state) and community forests (where rural communities may exercise customary rights); and (ii) the rural domain consisting of agricultural landscapes including young and mature secondary forests, traditional shifting cultivation agriculture and villages.

The GoG has embarked on the strategic planning process of Emergent Gabon to pursue sustainable development and diversify its economy. Gabon's vision for Emergent Gabon is laid out in a strategic roadmap (PSGE) (République Gabonaise, 2012) and is governed by the Sustainable Development Law adopted in 2014. The PSGE is based on three pillars:

1. Industrial Gabon (optimising oil and mining, construction and agro-industrial processing);
2. Green Gabon (sustainable forest management, certified timber production, agriculture and livestock development and sustainable fisheries). This is implemented through the Operational Plan for Green Gabon (POGV) that details specific actions and targets for achieving the country's sustainable development goals by 2025 (République Gabonaise, 2016); and
3. Gabon Services (development of financial services for ecotourism, education, health, and information technologies).

Also enshrined in the PSGE are the 'Plan Climat' (National Climate Plan) (Conseil Climat, 2012), the National Land-Use Plan (PNAT – interactive platform) (République Gabonaise, 2015) and the "Knowledge and preservation of natural resources" programme, which is delivered through a National Observation System of Natural Resources and Forests (SNORNF).

The National Climate Plan incorporates climate change considerations into the country's sectorial development strategies. Gabon has been an active participant in the UNFCCC negotiations with this strategic vision.

The PNAT is cross-ministerial and is Gabon's primary tool for the implementation of the country's sustainable development policy and for optimizing management of its national territory that promotes development while protecting Gabon's natural heritage and contributing to international commitments to prevent climate change.

In addition to the PSGE, a number of legislative and policy measures have been developed to improve forest and land governance, and which have already contributed to reducing Gabon's forest sector carbon emissions. Forests are regulated by the 2001 Forestry Code (République Gabonaise, 2001), which introduced sustainable management plans for forestry concessions (CFADs); the 2007 National Parks Law (République Gabonaise, 2007); the Environment Code of 2014 as well as the Sustainable Development Law adopted in 2014.

Other relevant policy decisions include a 2010 ban on exporting raw timber, a Forest and Environment Sector Program (PSFE) (République Gabonaise, 2005), a National Action Plan to Reduce Illegal Logging (République Gabonaise, 2013), and a policy that is due for adoption soon on managing the environmental and social impacts of palm oil production.

4.3 Gabon's political commitment to protect its forests – the story

Protecting the natural environment is a core principle enshrined in Gabon's Constitution, and the country's Low Emissions Development Strategy (LEDS) builds on a history of environmental leadership spanning three decades. In 1992, President Omar Bongo stated in his address to the plenary of the Rio Conference Earth Summit, that "all too often in Africa we have been forced to develop at no matter what the cost", [in our rush to catch up with the rest of the World]. He was referring to the willingness to see natural resources plundered to generate jobs and revenues, often resulting in huge environmental damage that will handicap future generations. In 1993 he signed Gabon's first Environment Law, which defines the basic principles for guiding national policy in the protection of the environment. Gabon adopted its first forest policy in 1996, to increase the forestry sector's contribution to economic and social development. The National Environmental Action Plan was subsequently adopted in 2000. Since the 1990's, the GoG has progressed towards its current policy of sustainable development, marking unmistakable achievements in sustainable forestry, protected area creation, climate change policy, and land-use planning and monitoring (Figure 1).

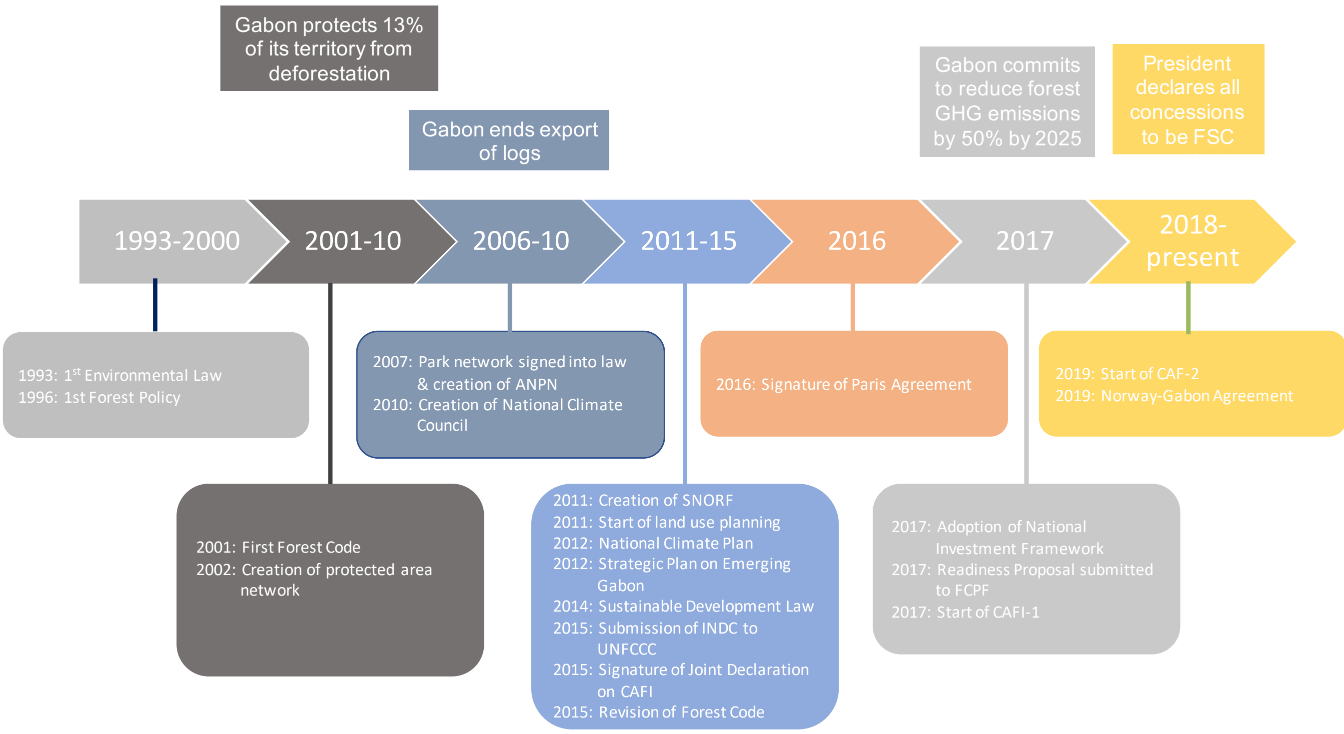

Figure 1 Timeline of Gabon's achievements related to GHG emissions reductions.

Gabon's forestry laws cover a variety of planning, mapping, and impact mitigation parameters. In 2001, the country revised and updated its Forest Code (Law No 16/01 of 2001) to further improve forest governance and management. The new law set out a contractual framework, which became automatically applicable to operators in 2006 and serves as the guidelines under which all harvesting, and wood processing entities must operate today. The Code's objective is for all permits to operate as sustainable management forest concessions (CFAD – Concession Forestière d'Aménagement Durable). It provides for a transition period to develop management plans, inventories and sustainable harvest plans, during which the permit is considered a provisional management and exploitation concession (CPAET – Convention Provisoire d'Aménagement et de l'Exploitation Forestier).

The 2001 Forest Code required logging companies to undertake sustainable management of their concessions, to employ low impact harvesting techniques, to lengthen harvest rotation to at least 20 years, to submit 30-year management plans for forest concessions, and prescribing that by 2009, 75 percent of raw logs would be processed in Gabon prior to export.

As of March 2020, 15.5 million ha is under logging concession. Of these, 1.9 million ha are CFADs that are FSC certified, 10.7 million ha are CFADs, 1.5 million ha are CPAETs, and 1.3 million ha are permits not yet in the management process (Lee, 2020).

Gabon's forest ecosystems, including mangroves, coastal forests, and lowland rainforests, are globally important for their large trees and high carbon stocks, exceptional biodiversity and large number of endemic and emblematic species. Conservation of these ecosystems through a protected area network is a key component of Gabon's low emissions development strategy. In 2002, Gabon announced the creation of 13 national parks covering 3 million ha, 11% of the country's land area. In order to achieve park creation, 1.03 million ha of logging permits were cancelled between 2004 and 2007 (Lee, 2020). Provisional legislation was signed, but it was not until 2007, with the adoption of the National Parks Law, that the park creation process was finalized and the issues of compensation for cancelled logging permits resolved. (République Gabonaise, 2007). The National Park Agency (ANPN, Agence Nationale des Parcs Nationaux) was created to protect and manage the parks, their buffer zones and their natural resources; develop the park network; and, promote the parks and their resources. In addition, in 2007 and 2008 Gabon created 6 new RAMSAR Sites and Lopé National Park was extended in 2007 when it became a mixed Natural and Cultural World Heritage Site, including 8 cultural sanctuary areas ("Ensembles Historiques"). Gabon's terrestrial protected areas network covers 3.8 million ha, 14.3% of its land area (not including buffer zones or peripheral zones). In 2017, Gabon also created a network of 20 protected marine areas, covering 26% of the country's Exclusive Economic Zone (EEZ), which ANPN manages.

By late 2009, Gabon was still far from reaching its wood processing goal, so President Ali Bongo-Ondimba halted all export of raw logs and required that 100 percent of timber be processed in country. This radical measure was intended to generate more value-added and jobs on national territory, but also contributed to professionalizing the sector and to a significant drop in total wood production, thereby reducing emissions. In November 2009, the Council of Ministers strengthened the provision of Law 16/01 of the Forest Code, imposing restrictions on whole log export and requiring operators to transform timber in country (Cassagne and Diallo Follea, 2016). These restrictions started to come into effect in 2010 and were fully implemented in 2011, resulting in a significant decrease in the production of industrial roundwood logs (Figure 2).

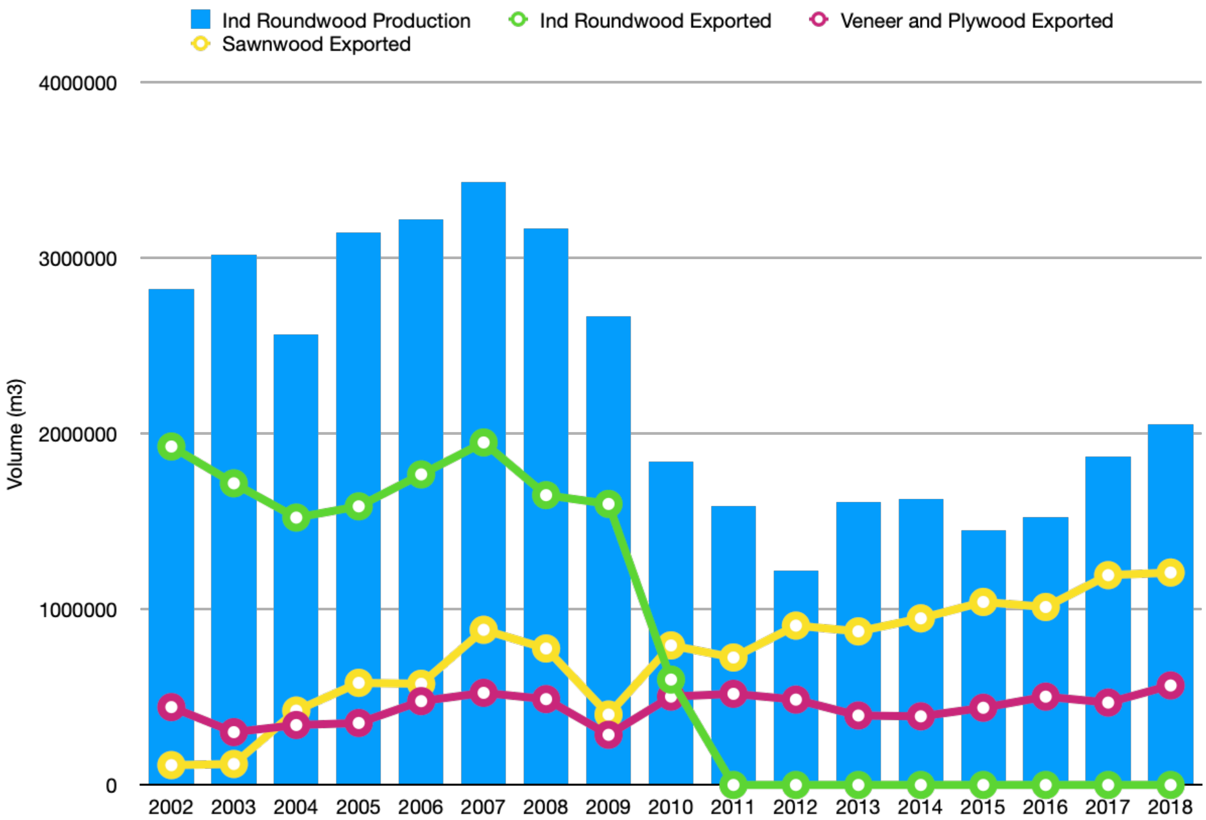

Figure 2 Impact of whole log export ban on the production and export of industrial roundwood, as well as exported sawnwood, veneer and plywood. Based on data from the Tableau de Bord d'Économie (TBE) Ind = Industrial (FRM Ingenierie, 2020).

In 2014, Gabon adopted the General Law on Sustainable Development that required companies to offset damage to forests or community land by buying sustainable development credits (carbon, biodiversity, ecosystem and community capital credits) as part of a national credit trading scheme.

In 2015, a process to revise the 2001 Forest Code was initiated. This process is still underway, and a revised Code that incorporates the country's sustainable forest management goals – specifically, the prohibition against the export of raw logs and stricter provisions for implementing forest management plans and preserving national parks and to reduce carbon emissions due to selective timber harvesting – is expected to be submitted to parliament in 2021. The new Code should help strengthen the regulatory framework for reducing emissions from LULUCF and be closely aligned with Gabon's NDC under the Paris Climate Change Agreement. With a view to reducing forest sector emissions, the Government has also undertaken to reduce the surface area of forest licenses. This reduction of land area in production should automatically reduce total GHG emissions from LULUCF.

Demonstrating further commitment to sustainably develop its forest sector and implement the Green Gabon pillar, the Gabonese President announced in September 2018 that all logging concessions must be FSC certified by 2022. As part of the implementation of this policy, a cooperation agreement was signed between MFME and FSC in January 2020. The agreement aims to promote the sustainable management of Gabonese forests and improve access for FSC certified wood products from Gabon to international markets. As such, the GoG conveyed its intent to become a world leader in the certified timber market while protecting and managing its natural resource base with the highest of standards[1].

To reduce illegal logging, in 2020 Gabon formally requested that the European Union re-open negotiations on Forest Law Enforcement, Governance and Trade (FLEGT), to strengthen control over timber exported from Gabon.

The PSGE's 'Legal Framework for Emergent Gabon' provides for the revision and improvement of the legal framework governing the agricultural sector, specifically Act No. 22/2008 enacting the Agriculture Code in the Gabonese Republic (République Gabonaise, 2008a) and Act No. 23/2008 enacting the sustainable agricultural development policy (République Gabonaise, 2008b). Based on the experience of setting up a fully-RSPO certified palm oil sector, the GoG is has established national guidelines for the "Management of the environmental and social impacts of the production of palm oil in Gabon", which will soon be published to guide economic operators and government ministries and agencies in responsible management (Commission Nationale d'Affectation des Terres, 2020). The document offers policy and technical analyses to guide agricultural site selection, including consideration of agriculturally suitable areas, High Conservation Value (HCV) and High Carbon Stock (HCS) areas.

In terms of oil palm, the company Olam International, in joint venture with the GoG, currently manages an overall concession area of 144,000 ha in Gabon, of which 64,000 ha have been planted, including the rehabilitation of an oil palm plantation acquired from SIAT in 2016 (Olam Palm Gabon). They also protect 72,000 ha of HCV forest and other areas such as buffer zones. To date 55,385 ha of Olam Palm Gabon's operations are RSPO certified (Roundtable on Sustainable Palm Oil) and are in the process to achieve 100% RSPO certification of their operations in Gabon by 2021. In a scientific paper entitled "Reducing Carbon Emissions from Forest Conversion for Oil Palm Agriculture in Gabon" (Burton et al., 2017) demonstrated that the OLAM Palm development in the Mouila area should be carbon neutral across its 25-year rotation.

The investment in palm plantations in Gabon has created employment opportunities for about 9,000 Gabonese nationals, of whom many had never previously had permanent employment. Olam Palm Gabon has engaged with communities from the outset through the process of Free Prior and Informed Consent (FPIC) with 32 villages in the proximity of the plantations and have established social contracts across all of these villages.

Achieving this economic diversification in the agriculture sector has led to an increase in deforestation in Gabon since 2011. However, it is important to note that, especially since 2014, the siting of new oil palm plantations has been more strategic, targeting locations of high crop suitability and avoiding areas of high potential environmental impact. Starting in 2017, data from Gabon's National Resource Inventory (NRI) allowed the GoG to quantify the average carbon content of Gabonese secondary forests (Burton et al., 2017). Preliminary analyses allowed the government to set a threshold of 118t/ha as Gabon's definition of HCS, above which deforestation is only authorised exceptionally. Forested areas below this threshold have mostly previously been subject to traditional agriculture (shifting slash and burn agriculture) which developed at the beginning of the Iron Age, some 2,800 years ago (Oslisly et al., 2013).

[1] The country could revise this FSC specific certification requirement to include other certification schemes upon future evaluation (e.g. when the certification process is well advanced and the country-specific technical requirements - national certification norms- have been defined (Pre-Activity 1). The creation of the Registry and traceability data bases will allow the Ministry to evaluate concession scale, stepwise, progress toward certification benchmarks and make recommendations for policy modifications if appropriate.

5 Institutional arrangements for data collection and MRV of results

In 2011, Gabon initiated the establishment of the SNORNF to effectively monitor, evaluate and adapt Gabon's low emissions development activities in the Land-use, Land-use change and Forestry (LULUCF) sector, including sustainable forestry, management of protected areas and buffer zones, agricultural expansion, and land-use planning. The SNORNF will ensure effective implementation of national land-use activities and achievement of emission reductions, including increasing forest carbon sequestration potential through the expansion of its protected area network and avoiding or minimizing future emissions from the agricultural sector while meeting the country's food consumption needs through land-use optimization. It uses satellite image analysis, field inventories and modelling in order to evaluate, monitor and report on the PNAT.

Completion of both the PNAT and SNORNF are of primary importance for Gabon to achieve its climate targets, reach its goals of reducing and avoiding emissions and ensure it respects UNFCCC commitments. Gabon also has a scientific research station located in the Lopé World Heritage Site which has been monitoring the impacts of climate change on weather patterns and vegetation for over 35 years, resulting in the site being designated as a "mega-site" for climate research by NASA.

Two presidential agencies also work in close alignment with MINEF and are key to the implementation of Green Gabon. Gabon's National Parks Agency (ANPN – soon to be restructured as the Nature Preservation Agency) manages Gabon's protected areas, including the network of 13 National Parks and buffer zones. Gabon's Space Agency (AGEOS) runs a national programme of spatial observation and analysis for strategic land-use and environmental planning. Both ANPN and AGEOS are responsible for implementing the SNORNF and are closely tied to the PNAT. The relevant institutional arrangements for data collection and reporting to the UNFCCC in relation to forests are presented in Figure 3.

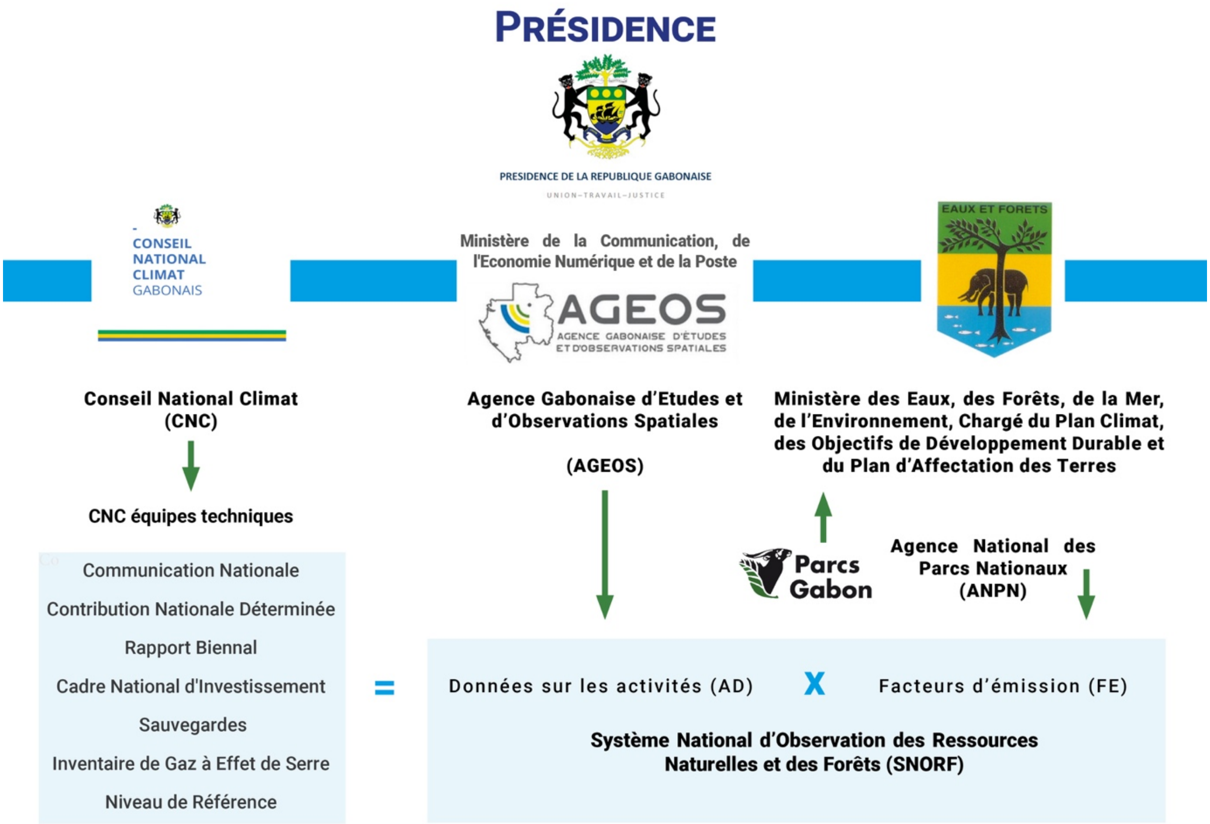

Figure 3 Institutional arrangements for data collection for the FRL and reporting to the UNFCCC.

5.1 Institutional arrangements for Gabon's National Forest Monitoring System

Gabon's National Forest Monitoring System (NFMS) which is presented in Figure 4, is a subset of the SNORF.

ANPN is responsible for the collection and analysis of field data through Gabon's National Resource Inventory (NRI), while AGEOS is responsible for the collection and analysis of the remote sensing data. It is supported by SIRS (Systèmes d'Information à Réfèrence Spatiale) which has a long-term partnership agreement with AGEOS to provide technical assistance and transfer of capacity. Information on reduced impact logging to support sustainable forest management practices is being gathered by ANPN with support from The Nature Conservancy. MINEF is responsible for the reporting and data management systems of timber production.

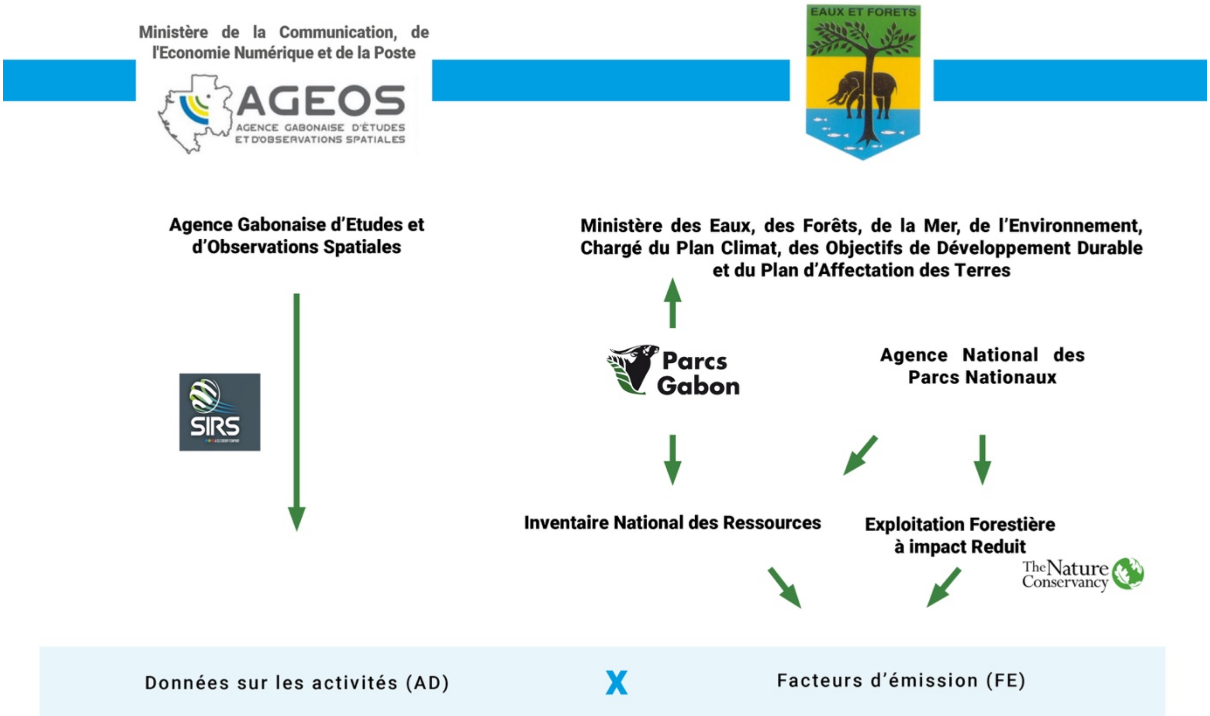

Figure 4 Institutional arrangements for Gabon's NFMS.

6 Definitions used

The definitions used in this document are consistent with Gabon's draft Forest Reference Level (FRL) (Conseil National Climat, 2020a). The definitions restated in this document include, among others: definition of forest, deforestation, forest degradation and the historic reference level for RBPs.

6.1 Forest definition

In terms of UNFCCC reporting Gabon uses the following definition: "Tree formation covering at least 30% of the soil over more than 1 ha and more than 20 m wide with trees at least 5 meters high, but not subject to any agricultural practice. It does not include land that is predominantly under agricultural or urban land-use". However, the conventional concept behind the definition of "forest" (« la forêt »), consistent across all ethnic groups in Gabon, corresponds much closer to "Old Growth Forest" (see below).

All forest in Gabon is considered as managed forest, under the 2001 Gabonese Forestry Code (République Gabonaise, 2001).

6.2 Forest subdivisions

Gabon uses four forest subdivisions at the national level to report to the UNFCCC. These are derived from remote-sensing and are:

- Dense forest: Closed forest formation where trees meet, resulting in high cover. It consists of several strata with a dense canopy and interlocking crowns,
- Secondary forest: Open stand with small and medium-sized trees whose crowns are more or less contiguous, the entire canopy letting the light filter through,
- Flooded forest: Tree-dominated areas along rivers and streams subject to dramatic water fluctuations and seasonal flooding (de Sousa et al., 2020),
- Mangrove forest: Areas of forest growing along the coastlines, in calm, brackish and poorly oxygenated waters.

Forests are further subdivided into types according to current ecological understanding and in order to align with the most appropriate emissions and removals factors (Table 1). These are:

- Old Growth Forest: undisturbed forest with no or inconsequential recent human disturbance,
- Old Secondary Forest: forest that has regrown on land that was totally or almost totally cleared of its original forest vegetation, and is between 20 and 100 years old,
- Young Secondary Forest: forest that has regrown on land that was totally or almost totally cleared of its original forest vegetation, and is no more than 20 years old,
- Older Logged Forest: forest that has been degraded by selective timber harvesting more than 25 years ago,
- Logged Forest: two subcategories, forest that has been degraded by selective timber harvesting between 1-10 years ago and forest that has been degraded by selective timber harvesting 11-25 years ago,
- Mangrove Forest: coastal intertidal wetland forest composed of halophytic tree and shrub species, notably in Gabon the species *Rhizophora racemose* and *Avicennia germinans*,
- Colonising Forest: natural forest encroachment by forest adjacent to savannahs,

- Degraded Forest: forest that is degraded through activities other than selective logging but does not incur a permanent change in land-use such as for example shifting agriculture.

Table 1 Alignment between national forest subdivisions and forest types according to ecological understanding.

National forest subdivisions	Forest types according to ecological understanding
Dense forest	Old Growth Forest Old Secondary Forest Older logged forest
Secondary forest	Young Secondary Forest Logged Forest Colonising Forest Degraded Forest
Flooded forest	Flooded Forest
Mangroves	Mangrove Forest

6.3 Subnational land allocations

In line with Gabon's National Land Allocation Plan (in French Plan National d'Affectation des Terres - PNAT), land in Gabon is subdivided into one of six subnational land allocations (Figure 5). These are used to identify the REDD+ activity under which emissions and removals are reported for the purposes of the FRL. These are:

1. Logging Concessions: concessions allocated for industrial permits for selective timber harvesting (production zones),
2. Protected Areas (PAs): areas that have national protection status and that do not overlap with active production zones. This includes: National Parks, Integral Nature Reserves, Presidential Reserves, Faunal Reserves, Hunting Domains, Managed Faunal Exploitation Areas, Arboretums, Cultural/historic areas[2],
3. Rural Areas: areas in a 3km radius around villages excluding all other five land-uses,
4. Agricultural Areas: industrial agriculture concessions, ranches and agricultural set-aside zones in forestry concessions,
5. Community Forests: forests allocated to a village community with a view to carrying out sustainable activities under a management plan. Gabon has recently initiated a process to promote and recognize community forestry,
6. Conservation set-aside zones: these are conservation and protection set-aside zones inside agricultural concessions and forestry concessions.

Any land that is not considered as one of these six land allocations is considered as unallocated land. Furthermore, although Sustainable Development Concessions are part of the Gabon's PNAT, they are

[2] Ramsar sites were not included in this definition, because in reality they are not spatially explicit with respect to the other identified land-use types, including forestry concessions. Further, management plans for Ramsar sites are not yet in place, apart from those that overlap with protected areas that have management plans. To avoid double-counting, the land-use types identified within Ramsar sites were allocated as such. Therefore, the part of a Ramsar site that overlaps with a protected area was considered under protected area, and the part under logging was considered under forestry concession.

at the time of the submission of the national results report and FRL not yet operational and therefore not included.

These subnational land-use allocations are not to be confused with the IPCC land-use categories and national land-cover subdivisions presented in Table 2.

For methodological reasons that are outlined in Annex 19.1, agricultural areas and conservation set-aside zones were combined with all unallocated land into a single category: “Other Land Allocation”, and community forests were combined with ‘Forestry Concessions’.

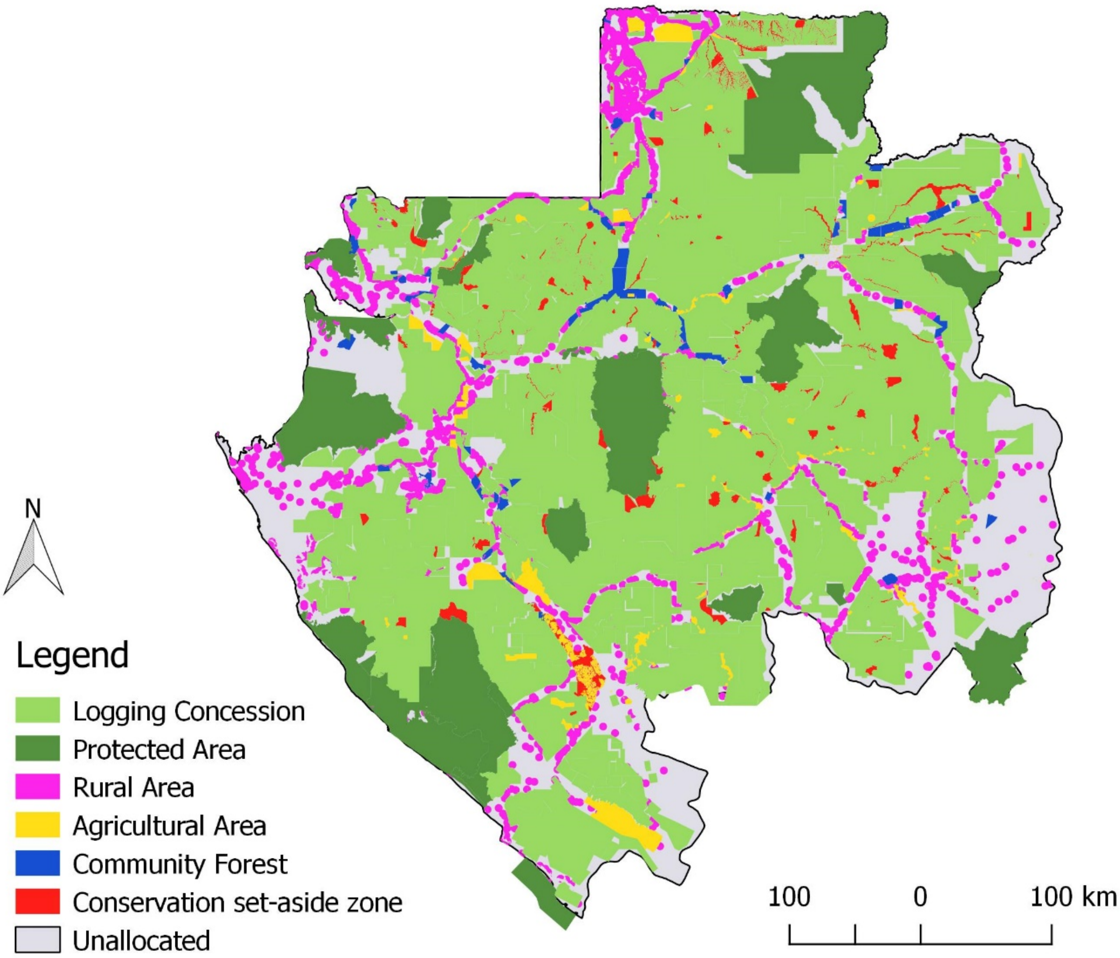

Figure 5 Map of subnational land-use types 2019[3].

[3] Note an error was made in the identification of forestry concessions (approximately 200,000 ha forestry concessions were misallocated to the Unallocated category) - this will be rectified as part of the improvement plan.

7 Scale

The accounting area (26,766,700 ha) for Gabon's National Results Report is consistent with the draft FRL and is the land area within the political borders recognized by Gabon. Therefore, Gabon addresses deforestation, forest degradation and removals at the national level.

8 Scope

The scope of Gabon's National Results Report is deforestation, forest degradation, selective timber harvesting (including deforestation and forest degradation) and removals.

8.1 Emissions types

The emissions types included in the national results report are defined below.

8.1.1 Deforestation

Deforestation is characterised as the human-induced conversion of forest land to a 'permanent' non-forest land-use category (i.e. a change in forest cover and/or land-use which has been observed for at least 10 years and is considered permanent). Deforestation in Gabon is caused by the expansion of urban areas, the creation of large infrastructures such as mines and dams, the construction of permanent roads and some forms of agriculture.

8.1.2 Forest degradation

Forest degradation is characterised as the reduction in biomass when a change in forest cover and/or land-use is not considered as permanent. This includes shifting agriculture and other unknown forms of degradation.

8.1.3 Logging

Logging includes loss of forest carbon stocks caused by felling of trees, creation of haul roads, skid trails and log yards as part of selective timber harvesting activities.

8.1.4 Removals

Removals were calculated as carbon biomass accumulation in standing forest, in naturally regenerating forests following human disturbance and in naturally encroaching forests into grasslands and wetlands.

8.2 Land-use and land cover categories

The IPCC land-use categories, national land cover subdivisions (including forest types) used in Gabon are presented below in Table 2.

These land-use and land cover categories are not to be confused with the subnational land allocations defined in Section 6.3. The subnational land allocations can occur across IPCC land-use categories, and the national land-cover subdivisions can occur across the subnational land allocations. For example, it is possible to find both grasslands and croplands inside logging concessions.

Table 2 Definition of national land-use and land cover classes adopted by Gabon.

IPCC land-use category	Description	National land-cover subdivisions	Description
Forest land	Tree formation covering at least 30% of the soil over more than 1 ha and more than 20 m wide with trees at least 5 meters high, but not subject to any agricultural practice.	Dense Forest	Closed forest formation where trees meet, resulting in high cover. It consists of several strata with a dense canopy and interlocking crowns.
		Secondary Forest	Open stands with small and medium-sized trees whose crowns are roughly contiguous, with plenty of light filtering through the entire canopy.
		Flooded forest	Tree-dominated areas along rivers and streams subject to dramatic water fluctuations and seasonal flooding (de Sousa et al., 2020)
		Mangrove	Areas of forest growing along the coastlines, in calm, brackish and poorly oxygenated waters.
Cropland	All crops, including rice fields and agroforestry systems whose vegetation structures are below the thresholds used in the definition of the “forest” class.	Cropland	Land covered with crops and animal products intended for food for sale, home consumption or industrial uses.
Grassland	Pastures and meadows not considered as crops. This also includes systems composed of woody vegetation that are below the threshold values used in the “forest” category. Also includes all grasslands from wilderness areas to areas as well as agricultural and sylvo-pastoral systems, in accordance with national definitions.	Savannah and grassland	Plant formation characterized by the presence of a continuous herbaceous layer dotted with woody plants mainly consisting of shrubs.
Wetland	Sectors of peat extraction and areas covered or saturated with water for all or part of the year and which do not fall into the categories "forest", "culture", "prairie" and "infrastructure". This includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.	Water	Land permanently covered with water. These zones include submerged surfaces (land covered with fresh, salt or brackish water.
		Swampy Area	Grassy formation developing on soil covered by a permanent layer of water with varying depth.
Settlement	Any developed land, including transportation infrastructure and human settlements of any size, unless they are already included in other categories.	Artificial surface excluding roads	Area covered with buildings or other types of construction.
		Roads	Any area of infrastructure that resembles a road.
Other land	Bare soils, rock, ice and all areas that do not correspond to the other categories. This implies that the total sum of identified surfaces corresponds to the national surface	Bare soil	Natural land with bare soil. This class includes soils covered with sand, rocks, stony surfaces or any other mineral material.

9 Pools and Gases

9.1 Pools

Above-ground live biomass, and below-ground live biomass are included in the draft FRL and Gabon's National Results Report.

Carbon stocks for Dead Organic Matter (DOM) are not included in emissions calculations. This is because DOM data are not available for all emissions factors and are not part of removals factors, meaning the net accounting in the FRL would be asymmetrical.

Soil carbon stocks are not included in emissions calculations. Gabon does not consider soil carbon changes in Forest Land Remaining Forest land to be significant and adopts the IPCC assumption that for forest remaining forest land, mineral soil carbon stocks on land that has been forest for at least 20 years are in equilibrium and do not change. For Forest land converted to other land-use types, Gabon does not consider soil-related emissions to be a key category at this time but recognises that it may become so in the future and aims to include it as part of the improvement plan, following the collection of country-specific data on soil carbon stock changes due to land-use and management. Litter is not considered due to a lack of data.

9.2 Gases

Only CO_2 is included in Gabon's FRL as emissions of other gases from land-use and land-use change are considered to be minor. This is considered conservative as limited information exists on other gases.

10 Reference period

In its national FRL that is to be submitted to the UNFCCC, Gabon uses a 10-year historical period either side of 2005, from 2000-2009, which reflects the fact that Gabon's efforts to reduce emissions from deforestation and forest degradation and protect its forests (as explained in Section 4.3) were developed during this decade under the leadership of President Omar Bongo Ondimba and then implemented by President Ali Bongo Ondimba from 2010 onwards.

The negotiated historical reference period agreed with CAFI for Gabon's National Results Report is 2006-2015. Again a 10-year period was chosen to avoid stochastic effects and provide a realistic historic average.

11 Information used to construct the historical reference period

All information used to construct the historical reference period (activity data, emissions and removals factors and calculations used to derive them) are presented in the accompanying workbook (Conseil National Climat, 2020b)

11.1 Activity Data

11.1.1 Deforestation and Degradation Emissions (outside selective logging)

A significant part of the Activity Data is derived from remote-sensing analyses. This was collected using the semi-random sampling method (Sannier et al., 2014), building on existing work conducted with AGEOS (SIRS, 2020). The approach consists of dividing the study area into vector blocks of 20km × 20km, then randomly selecting Primary Sampling Units (PSU's) of 2km × 2km in each of these blocks. A twostage sampling approach was implemented by selecting Secondary Sampling Units (SSUs) of 30mx30m within the PSUs (Figure 6) which were then compared to the results of the map. This sampling approach was adopted as it represents the best compromise between the ease of data collection and a good geographic distribution. The respective sizes of the PSUs and the blocks were adjusted to correspond to the desired sampling intensity. In the end 665 PSUs of 400 ha distributed across the country were distributed over the whole territory of Gabon. Full methodological details are described in Gabon's FRL document (Conseil National Climat, 2020a) and (SIRS, 2020).

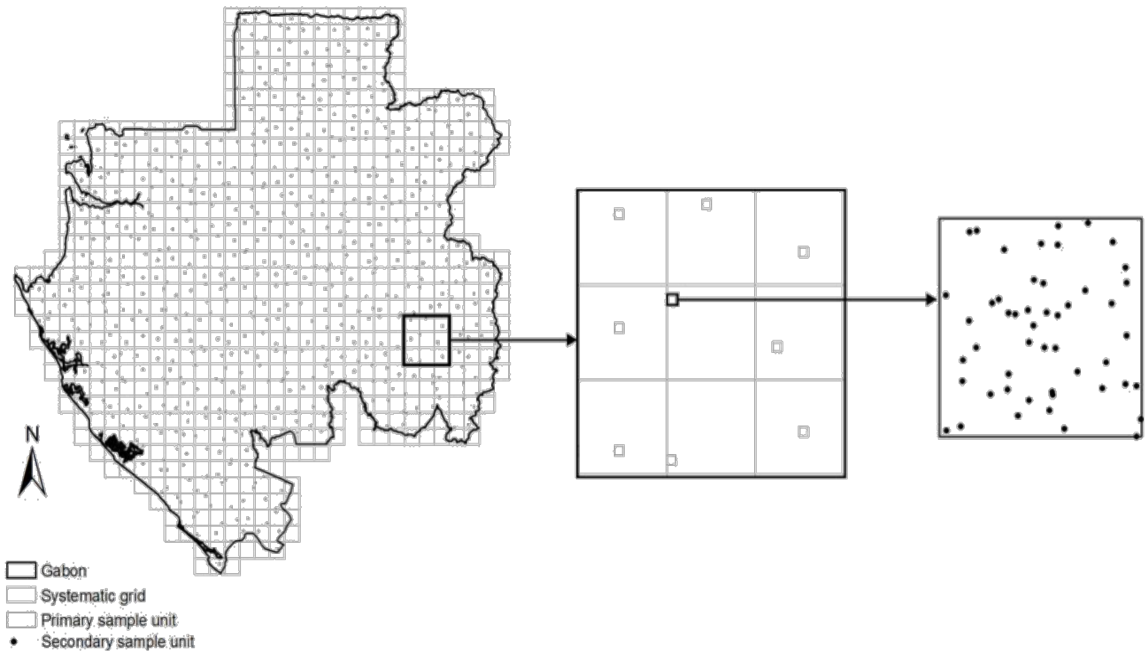

Figure 6 Sampling approach using a systematic grid, primary and secondary sample units (from SIRS, 2013).

For the FRL analysis, assessment years 1990, 2000, 2005, 2010, 2015 and 2018 were chosen, IPCC land-use categories and sub-categories were assigned to data for all years except 1990, and land-use change matrices were generated for the following assessment periods: 1990-2000, 2000-2005, 2005-2010, 2010-2015 and 2015-2018.

For each assessment period, matrices were generated at both the national level, and at the sub-national level for each of the four sub-national land allocations (Rural Area, Logging Concession, Protected Area, Other Land Allocation). Individual data-points generated included the area of stable forest cover and forest cover change (deforestation, degradation and regeneration) for each assessment period, sub-national land allocation, IPCC land-use change category, and forest subdivision.

For emissions calculations, deforestation and degradation data detected in Rural Areas, Protected Areas and Other Land Allocation were retained, but were excluded for Logging Concessions. This is because it was assumed that this type of forest cover loss was already included in the method used to estimate logging emissions and was done to avoid double-counting.

Specific rules were developed to distinguish Deforestation and Degradation (see Annex 19.2 for more information).

To convert the remote-sensing data from the matrices into Activity Data, for each assessment year (i.e. the status of the forest at the 'end' year for each assessment period), data were first extracted from the relevant forest cover change matrices (provided by SIRS, 2020) and inserted into tables. Separate tables were created for Deforestation and Degradation, each organised by Sub-national Land Allocation, IPCC Land-use change category and Forest subdivision. These data concerned both Forest land remaining Forest land (Degradation where Dense forest was degraded to Secondary forest), and Forest converted to non-forest (Degradation as temporary forest cover loss and deforestation) and the forest types were interpreted according to ecological understanding as shown in Table 3.

Yearly change values were derived by dividing the total value for each assessment period by the number of years between each assessment period. These data constituted the activity data for Deforestation emissions and Degradation emissions outside selective logging.

Table 3 Interpretation of forest types for (a) forest cover losses due to deforestation and degradation in emissions calculations and (b) Forest land remaining Forest land in removals calculations. Note that no forest cover loss or regeneration was detected in mangrove forests.

Forest type as designated by RS method	Forest type according to ecological understanding	Justification
Dense and Flooded Forest	Old growth, Old secondary and Older logged (mixed category)	Old secondary forest, old growth and older logged forest are likely to appear identical with remote-sensing, therefore 'dense' forest and 'flooded' forest are likely to contain all three of these forest types (as they are defined by disturbance history). Dense and Flooded forest are combined here, as there is no separate removals factor available.
Secondary forest	Young secondary and Degraded forest (mixed category)	Secondary forest that is detected by the remote-sensing method as stable or lost between assessment years is likely to be young secondary forest during the time frame of the FRL. A change from Dense forest to Secondary forest in the remote-sensing method is detected as degradation, and therefore interpreted as being degraded forest.
Mangrove forest	Mangrove forest	Stable mangrove forest is included for removals calculations.

11.1.2 Logging Emissions

The Activity Data for selective logging emissions are derived from national timber production volume data and are expressed in cubic metres of harvested timber per year from 1990-2018 (see Annex 19.3.1). These were compiled following a detailed analysis that compared multiple sources of declared national timber production volume data against national export weight data converted to equivalent volumes (FRM Ingenierie, 2020). The Activity Data were validated at a national level (Conseil National Climat, 2020c).

11.1.3 Removals

Activity Data for Removals includes:

- Standing forest of different forest types,
- Naturally regenerating forests following human disturbance,
- Naturally encroaching forests into grasslands and wetlands.

Activity Data were derived from a mixture of data types as follows:

- Remote-sensing data (collected using the method described in Section 11.1.1),
- Auxiliary historical data on administrative areas (Lee, 2020).This was to ensure extrapolations of forest cover between assessment years reflected historical changes in administrative area over time,
- Activity Data used to calculate logging emissions (Section 11.1.2). This was used to derive estimates of recently logged forest which were not detectable by the remote-sensing method.

The approach for deriving the Activity Data for removals was conducted in several steps, as follows (see Annex 19.4 for more details). Firstly, for each assessment year (i.e. the status of the forest at the 'end' year for each assessment period), data from the remote-sensing matrices (stable forest, regenerating forest and "dense forest" degraded to "secondary forest") were extracted and reorganised into tables. Separate tables were created for each of the four subnational land-use categories, and all were organised by IPCC LU and forest subdivision. For data that was Forest land remaining Forest land (stable and degraded forest during an assessment period), the forest types were interpreted as shown in Table 3.

For data that was Non-forest converted to Forest land (regeneration detected during an assessment period), the forest types were organised and interpreted as shown in Table 4.

Table 4 Interpretation of forest types for Non-forest converted to Forest land in removals calculations. Note that no regeneration was detected in mangrove forests.

Forest type as designated by the remote-sensing method	Forest type according to ecological understanding	Justification
Secondary forest: Non-Forest converted from Cropland, Settlement and Other Land	Young Secondary Forest	Where forest has regenerated from Cropland, Settlement or Other land, it is assumed to have occurred following human disturbance. Therefore, the newly regenerated forest is designated as Young Secondary Forest
Secondary forest: Non-Forest converted from Grassland and Wetland	Colonising Forest	Where forest has regenerated from Grassland or Wetland, it is assumed to have occurred as part of the ongoing process of natural encroachment of forests into savannahs and wetland habitats. Therefore, the newly regenerated forest is designated as Colonising Forest

Secondly, to extrapolate the forest cover area data accurately between the remote-sensing assessment years, the history of administrative changes to the area of each of the sub-national land allocations was taken into account. However, these historical data were themselves incomplete and did not exactly match the data for the remote-sensing assessment years. Therefore, best efforts were made to make adjustments to the extrapolations so that the change in forested area reflected the administrative changes over time.

Once the total forest cover for each sub-national land allocation was established for each year, extrapolations were made to each of the five forest subdivisions (identified in Table 3 and Table 4). In order to ensure all totals added up correctly, for any given year between assessment years, the area of forest subdivision was estimated as a proportion of the total for the subsequent assessment year.

Thirdly, the area of logged forest was estimated from timber production volume data. This approach was taken because (a) the remote-sensing method was unable to detect logged forest with great accuracy, and (b) this approach ensures methodological consistency with the logging emissions calculations. Logged forest was defined as 'up to 25 years since logging' as this is consistent with a single harvest cycle under Gabonese forestry management. In order to be able to apply the most appropriate removals factors, logged forest was further subdivided into two categories: Logged forest (1-10) (LF_{10}) for forests logged up to 10 years previously, and Logged forest (11-25) (LF_{25}) for forests logged between 11 and 25 years previously. Logged forest was accounted for within Logging Concessions and Protected Areas, to take account of the fact that over 1 million ha logging concession were cancelled and replaced by National Parks between 2004 and 2006 (Lee, 2020). The method adopted is as follows. First, the timber production volume data (available for 1990-2018) were converted to Equivalent Harvest Areas (A_{EH}) by applying the mean harvest intensity (HI) for Gabon (10 m^3/ha, derived from Ellis et al., 2019; Medjibe et al., 2013, 2011). A_{EH} values were summed across years to provide the cumulative area of logged forest: the area of LF_{10} for each year was calculated as the sum of the equivalent harvested areas (A_{EH}) for the previous 10 years and the area of LF_{25} for each year was calculated as the sum of the equivalent harvested areas (A_{EH}) for the previous 11-25 years. To derive A_{EH} values pre-1990 (required for the cumulative area calculation of LF_{25} prior to 2015), projections were made based on concession area data. The proportion of logged forest (LF_{10} and LF_{25} respectively) that would have been found inside newly created protected areas was calculated, using data on the area of cancelled logging concession that was replaced by protected area; the remainder was assigned to logging concessions.

Finally, the area of logged forest (LF_{10} and LF_{25} respectively) as calculated above replaced the remote-sensing data that were originally identified as 'Secondary' Forest (Young secondary and Degraded forest under Forest land remaining forest land, Table 3) within logging concessions and protected areas. Any differences were further deducted from the area of 'Dense and flooded' forest (Old growth, Old secondary and Older logged under Forest land remaining forest land, Table 3) to ensure the total forested areas were correct.

The final AD for removals comprised a composite annual time-series of forest cover between 1990-2018 for six forest subdivisions (seven with the inclusion of 'unidentified' forest for 1990-2000 data) spread between four subnational land-use categories, that summed to the total forested area for Gabon for each year.

11.2 Emissions Factors

For all emissions and removals factors, data were partitioned into above-ground (AGB) and below-ground (BGB) portions for trees using the shoot-root ratio of 0.235 at the stand level for moist tropical forests >125 Mg /ha (Mokany et al., 2006). A standard carbon fraction of 0.456 was applied following (Martin et al., 2018) to convert biomass to carbon. Carbon stock values in t C/ha were converted to t CO_2eq/ha with the formula:

$$CO_2 = C * (44/12)$$

Equation 1

Emissions Factors for Deforestation are sourced from carbon stock data reported in Gabon's National Resource Inventory (Poulsen et al., 2020). An average Emissions Factor for 'Dense and Flooded' forest

(Old growth, Old secondary and Older logged forest, Figure 3) was derived: this was the arithmetic mean carbon stock value for old growth, secondary and logged forest, as reported by (Poulsen et al., 2020). The Emissions Factor for ‘Secondary’ forest (Young secondary and degraded forest, Table 3) was the carbon stock value for secondary forests, as reported by (Poulsen et al., 2020) (EF 1 and EF2, Table 5).

Emissions Factors for selective logging are sourced from three national studies conducted in 12 logging concessions, combined to provide a single mean EF (Ellis et al., 2019; Medjibe et al., 2013, 2011). Final logging emissions from the studies are expressed in tCO_2/m^3 (EF4, Table 5).

Emissions Factors for Degradation other than selective logging are derived as follows. The Activity Data is derived from remote-sensing data, where two types of degradation are recognised:

- Forest remaining forest (where ‘Dense and flooded’ forest is degraded to ‘secondary’ forest),
- Forest temporarily converted to non-forest, that regenerates in the following assessment period. (where ‘Dense and flooded’ forest or ‘Secondary’ forest is temporarily lost).

For the **first** type (Forest land remaining Forest land), the Emissions Factor applied is the difference between the Forest Average and the Secondary Forest Emissions Factor (EF3, Table 5).

For the **second** type (forest temporarily converted to non-forest), the same Emissions Factors as for deforestation emissions were used, to ensure methodological consistency (EF1 and EF2, Table 5).

Table 5 Emissions Factors retained for gross Emissions calculations from Deforestation, forest Degradation and Logging.

EF no.	EF type	Units	Carbon Pool				Activity Data applied to	Source
			Above-Ground	Below Ground	Total			
			Mean	Mean	Mean	U		
EF1	Secondary forest	tCO_2eq/ha	350.4	82.3	432.7	22%	Area of “Secondary” forest cover loss (deforestation and degradation)	Poulsen et al. (2020)
EF2	Forest Avg (old growth, logged, secondary)	tCO_2eq/ha	519.7	122.1	641.8	9%	Area of “Dense” forest cover loss (deforestation and degradation)	Poulsen et al. (2020)
EF3	Difference (Forest Avg – Secondary Forest)	tCO_2eq/ha	169.3	39.8	209.1	10%	Area of “Dense” Forest degraded to “secondary” forest (Degradation)	Derived from Poulsen et al. (2020)
EF4	Total Logging EF	tCO_2eq/m^3	7.6	1.8	9.4	28%	Timber production volume (logging)	Ellis et al.(2019); Medjibe et al. (2011,2013)

11.3 Removals Factors

Removals Factors are derived from available sequestration rates for different forest types in Gabon, taken from both published research and more recent outputs of Gabon's National Resource Inventory (Cuni-Sanchez et al., 2016; Gourlet-Fleury et al., 2013; IPCC, 2014; Medjibe, 2020; Requena Suarez et al., 2019).

Mean values were derived for "Dense and Flooded" forest (Old growth, old secondary, older logged forest) – here the arithmetic mean sequestration rate of old growth and old secondary forest was taken, as reported by (Medjibe, 2020). For "Secondary Forest" (Young secondary and degraded forest) the arithmetic mean sequestration rate of old and young secondary forest was taken. For logged forest (1-10) (LF_{10}), the sequestration rate for logged forests (10 years since disturbance) measured in Gabon (Medjibe, 2020) was applied. For logged forest (11-25) (LF_{25}), in the absence of Gabon-specific data, a value was derived from LF_{10} based on the observed rate of biomass accumulation change in a Central African study (Gourlet-Fleury, *pers.comm.*; Gourlet-Fleury et al., 2013). For the other forest types, the most appropriate sequestration rate was taken from the literature (Table 6).

Table 6 Removals Factors retained for removals calculations

Removals Factor No	Forest type	Years since disturbance	Δ Above ground Carbon	Δ Below ground Carbon	Δ Total Carbon	
			Mean (tCO2/ha/yr)	Mean (tCO2/ha/yr)	Mean (tCO2/ha/yr)	U
RF1	Logged Forest (1-10)	1-10	10.61	2.49	13.10	35.0%
RF2	Logged Forest (11-25)	11-25	7.64	1.80	9.44	XX
RF3	Young Secondary	<20	12.71	2.99	15.69	39.5%
RF4	Colonising	undisturbed	5.18	1.22	6.40	42.4%
RF5	Mangrove	undisturbed	16.55	3.89	20.44	5.3%
RF6	Average: Old growth, Old Secondary	unknown	3.78	0.89	4.67	33.8%
RF7	Average: Old and young secondary	0-100	8.72	2.05	10.77	21.4%

11.4 Emissions and Removals Calculations

Carbon losses (emissions) were determined following the basic IPCC equation (IPCC, 2006) :

$$E = AD\,x\,EF$$

Equation 2

Where:

E = Emissions in t $C0_2$eq/yr
AD = Activity Data (in ha/yr or m^3/yr)
EF = Emissions Factor (in t CO_2eq/ha or t CO_2 eq /m^3)

Carbon gains (removals) were determined following the basic IPCC equation (IPCC, 2006) :

$$R = AD\,x\,RF$$

Equation 3

Where:

R = Removals in Mg $C0_2$eq/yr
AD = Activity Data in ha/yr
RF = Removals Factor in Mg CO_2eq/ha/yr

Deforestation and degradation emissions were calculated annually for each land-use conversion category, forest type and carbon pool.

In the absence of more detailed information in carbon stocks for other land-use types, it was assumed that the carbon stock immediately following deforestation and degradation due to temporary forest loss is zero, and carbon stocks from all pools were assumed to be committed to the atmosphere immediately at the time of deforestation.

Total annual removals were calculated for:

- natural forest regrowth following human disturbance,
- natural forest encroachment into savannahs and wetlands,
- biomass accumulation in standing forests.

Removals were calculated for each forest type and carbon pool.

12 National Results

12.1 Results for emissions reductions

The results for gross emissions reductions from deforestation, forest degradation and logging in Gabon for the period 1990-2017 are presented in Figure 7. This figure demonstrates Gabon's ability to calculate performance against a variable historical reference period.

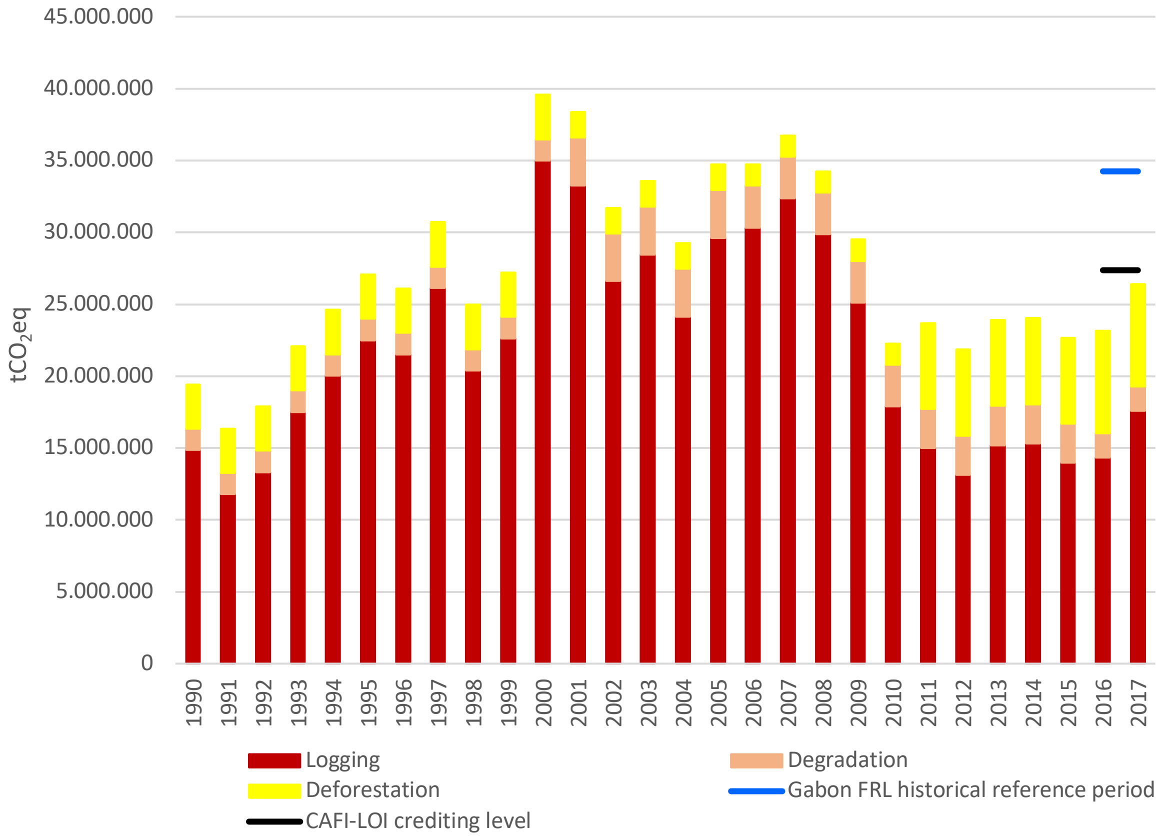

Figure 7 Gross emissions in Gabon from deforestation, forest degradation and selective timber harvesting or the period 1990-2017 with the crediting level under the CAFI LoI Addendum (black line) and Gabon's FRL (blue line).

Emission reductions calculated in Gabon's draft FRL to be submitted to the UNFCCC using a historic reference period from 2000-2009 total 18,960,369 tCO_2 for 2016 and 2017 (Table 7).

Table 7 Gross emissions reduction results from deforestation, forest degradation and logging under Gabon's UNFCCC FRL.

Reference Period FRL		2000-2009
Historical average		34,247,229
Results Year	**tCO_2**	**Results (tCO_2)**
2016	23,143,458	11,103,771
2017	26,390,631	7,856,598
Total		**18,960,369**

The results for gross emissions reductions from deforestation, forest degradation and logging under the CAFI LoI are presented in Table 8. These total 5,203,391 tCO_2 for 2016 and 2017.

Table 8 Gross emissions reduction results from deforestation, forest degradation and logging under CAFI LoI Addendum.

Reference Period CAFI LoI Addendum		2006-2015
Historical average		27,368,740
Results Year	**tCO_2**	**Results (tCO_2)**
2016	23,143,458	4,225,282
2017	26,390,361	978,109
Total		**5,203,391**

12.2 Results for removals

The results for gross removals in Gabon for the period 1990-2017 are presented in Figure 8. This figure demonstrates Gabon's ability to calculate performance against a variable historical reference period.

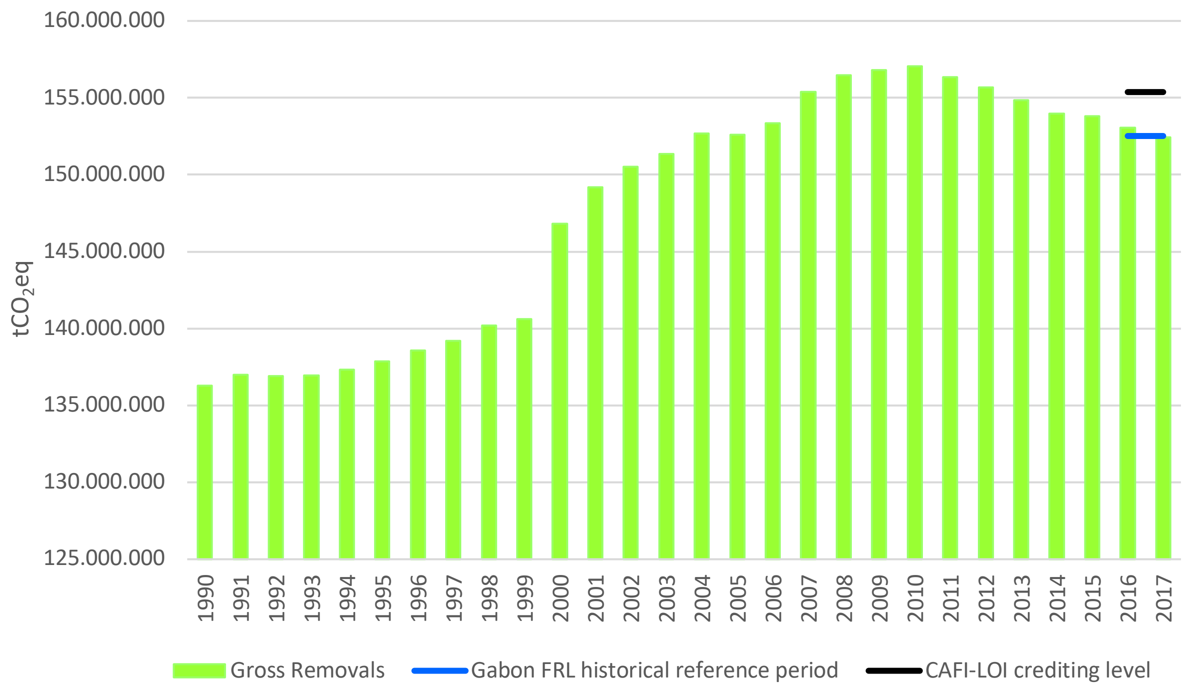

Figure 8 Gross removals in Gabon for the period 1990-2017 with the crediting level under the CAFI LoI Addendum (black line) and Gabon's FRL (blue line).

The gross removals result for 2016 and 2017 under Gabon's draft FRL to be submitted to the UNFCCC are presented in Table 9. These total 475,543 tCO_2 for 2016 and 2017.

Table 9 Gross removals results under Gabon's UNFCCC FRL.

Reference Period FRL		2000-2009
Historical average		152,518,372
Results Year	**tCO_2**	**Results (tCO_2)**
2016	153,069,789	551,417
2017	152,442,498	-75,875
Total		**475,543**

The results for gross removals under the CAFI LoI Addendum are presented in Table 10, totalling -5,237,342 tCO_2 for 2016 and 2017.

Table 10 Gross removals results under CAFI LoI Addendum.

Reference Period CAFI LoI Addendum		2006-2015
Historical average		155,374,814
Results Year	**tCO_2**	**Results (tCO_2)**
2016	153,069,789	-2,305,025
2017	152,442,498	-2,932,317
Total		**-5,237,342**

13 Uncertainty analysis

Uncertainties were calculated at 95% Confidence Intervals as:

$$U = 95\%\ \text{CI} / \text{mean}$$

Equation 4

For remote-sensing Activity data, U was calculated as:

$$U = 95\%\ \text{CI} / \text{Area}$$

Equation 5

Combined Uncertainty estimates were calculated using the IPCC Approach 1, simple propagation of error (IPCC, 2019).

Where quantities were combined by addition across categories, Uncertainty was calculated using IPCC equation 3.2 for combining uncertainties (IPCC, 2019) (Equation 6).

$$U_{total} = \frac{\sqrt{(x_1 \times U_1)^2 + \ldots + (x_i \times U_i)^2 + \ldots + (x_n \times U_n)^2}}{(x_1 + \ldots + x_i + \ldots + x_n)}$$

Equation 6

Where quantities were combined by multiplication across categories, Uncertainty was calculated using IPCC equation 3.1 for combining Uncertainties (IPCC, 2019) (Equation 7).

$$U_{total} = \sqrt{U_1^2 + \ldots U_i^2 + \ldots U_n^2}$$

Equation 7

13.1 Uncertainty for Emissions and Removals Factors

For above-ground biomass, uncertainty was computed for each emissions and removals factor using Equation 4.

For below-ground biomass, as BGB is entirely dependent on AGB, the uncertainty for BGB was not calculated on its own. However, the Uncertainty around the scaling factor used to compute BGB from AGB was considered in the Uncertainty calculation for the total (AGB+ BGB) carbon biomass values[4]

From Mokany et al., 2006, the Uncertainty of the scaling factor applied (median = 0.235, SE = 0.011, n=10) was first calculated to be 9.17%.

When BGB is estimated from AGB using the scaling factor of 0.235, total carbon stocks are estimated as above-ground carbon stocks multiplied by (1 + 0.235). Gabon assumes that the value 1.235 is the sum of the certain value 1 and the uncertain value 0.235 with Uncertainty 9.17%.

Therefore, Uncertainty for the quantity 1.235 was computed with the equation:

$$9.17\% * (0.235/1.235) = 1.75\%$$

[4] Note that for EF4, U was calculated directly for total above and below-ground carbon values, as from Ellis et al. (2019) BGB was computed at stem level using the model for tropical forests from Mokany et al., 2006

The Uncertainty of total carbon biomass (AGB+BGB) was then computed using IPCC equation 3.1 for multiplication (Equation 7), combining Uncertainty for the quantity 1.235 with Uncertainty for aboveground carbon biomass.

The result gives a higher Uncertainty in total stocks than the above-ground uncertainty, as the expansion to include below-ground introduces some additional uncertainty.

Uncertainty for the EFs ranged from 8.9% - 27.8% (mean 17.2%; Table 11). Higher uncertainties are generally associated with lower sample sizes; this reflects the limitations in the available ecological data for Gabon/Central Africa. While the NRI involved over 100 plots, the logging emissions studies (although thorough) were more restricted in scope: a total of 12 concessions were sampled, and logging practices varied quite widely between operators. The Uncertainty is reasonable given the nature of the available data.

Uncertainties for the RFs varied more widely (5.3% - 42.4%, mean= 25.4%), reflecting also the limitations in available data and the wide range of studies that were necessarily sourced to provide sequestration rates for the different forest types. Due to the practical difficulties of maintaining long-term sites and repeated measurements in Central African forests necessary to measure biomass accumulation, data are lacking for many forest types and disturbance histories. It is therefore unsurprising that some RFs (e.g. for colonising forest) are sourced from only a few measurements, and show quite high Uncertainty values. This dataset represents the best available data at the time of analysis.

Table 11 Summary of Uncertainties for all emissions and removals factors

Emissions/removals Factor No.	Derived from	Source	N	Units	Total Above and Below Ground	
					Mean	U
EF1	Secondary forest carbon stocks	NRI- field measurements	30	t CO_2eq/ha	432.71	21.7%
EF2	Average forest carbon stocks (old growth, logged, secondary)	NRI- field measurements	104	t CO_2eq/ha	641.84	8.9%
EF3	Difference: Avg Forest - Secondary carbon stocks	Derived	-	t CO_2eq/ha	209.12	52.6%
EF4	Logging emissions factor	Field measurements	12	tCO_2eq/m^3	9.4	27.8%
RF1	Logged forest sequestration rate (1-10yrs)	Field measurements	18	t CO_2eq/ha/yr	13.10	35.0%
RF2	Logged forest- (11-25)	Derived (72% * RF1)	-	t CO_2eq/ha/yr	9.44	35.0%
RF3	Young Secondary	IPCC default value	15	t CO_2eq/ha/yr	15.69	39.5%
RF4	Colonising	Field measurements	5	t CO_2eq/ha/yr	6.40	42.4%
RF5	Mangrove	IPCC default value		t CO_2eq/ha/yr	20.44	5.3%
RF6	Avg: Old growth, Old Secondary	Derived	-	t CO_2eq/ha/yr	4.67	37.6%
RF7	Avg: Old and young secondary	Derived	-	t CO_2eq/ha/yr	10.77	32.5%

13.2 Uncertainty for AD for logging emissions

The AD for logging emissions consist of individual timber production volume data points selected from a range of available datasets following expert analysis and national validation. As there is no way to compute Uncertainty around a single data-point, expert judgement must be used to define an appropriate uncertainty. IPCC recommends a 3% uncertainty for official statistics, however, here a more conservative approach was taken. In the analysis conducted by (FRM Ingenierie, 2020), uncertainty values for each year were calculated from the different available national data-sets that were analysed. Uncertainty varied considerably (1.63% - 30.37%), and the mean uncertainty across all years was 11.5%. From this, Gabon applied here a fixed Uncertainty of **11.5%** to each year for the AD for logging emissions. As this is based on the measured variability in the available national data, Gabon considers this is a reasonable Uncertainty to apply, and more conservative than the IPCC-recommended value.

13.3 Uncertainty for Forest classifications

The remote sensing method had high accuracy and precision for estimating forest cover. Uncertainty values for forest cover (calculated using Equation 5) were between **2.2 and 2.3%** for each assessment year (Table 12).

Table 12 Forest cover, 95% CI and uncertainty for each assessment year (from the national-level analysis).

IPCC LUC	Forest Land		
Year	Area (ha)	95% CI (ha)	Uncertainty
1990	23,663,312	532,580	2.3%
2000	23,589,451	529,886	2.2%
2000	23,619,984	529,886	2.2%
2005	23,607,573	529,896	2.2%
2010	23,600,088	530,179	2.2%
2015	23,546,258	531,327	2.3%
2018	23,523,037	531,380	2.3%

13.4 Uncertainty for remote-sensing data on deforestation and degradation

Using Equation 5, uncertainties were first calculated for each individual forest cover change event, organised by subnational land-allocation, forest type and assessment period.

For the annual change data, which was derived by dividing the area of forest cover change per assessment period by the number of years between assessments, the Uncertainty remained the same (no change to Uncertainty values when dividing a number). This provided Uncertainty values at the most disaggregated level.

13.5 Uncertainty for Total Emissions

Using IPCC Approach 1, overall Uncertainty for the crediting period 2006-2015 was computed for Deforestation, Degradation, Logging Emissions and for Total Emissions combined.

First, for Deforestation and Degradation, Uncertainty values at the most disaggregated level (for each year, for each data subcategory) for the AD were combined to provide the total U per year, applying Equation 6 (IPCC equation 3.2 for addition). For Logging, this was not necessary, as there was only one subcategory of AD (the fixed U of 11.5% per year was retained).

Then, for each emissions type, the overall Uncertainty for the AD for the crediting period 2006-2015, was computed using Equation 6 (IPCC equation 3.2); where $(x_i \times U_i)^2$ was calculated for years 2006-2015 and summed, and x = AD.

To compute the Uncertainty for emissions, the Uncertainty at the most disaggregated level was first calculated using Equation 7 (IPCC equation 3.1 for multiplication), where U_1 = U for AD and U_2 = U for EF (applying the Uncertainty associated with the correct EF that was applied to each subcategory of AD). For Deforestation and Degradation this was then combined across all sub-categories using Equation 6 (IPCC equation 3.2 for addition) to provide a total Uncertainty for emissions per year. For logging this was not necessary, as there was only one subcategory of AD.

For each emissions type, the overall Uncertainty for emissions for the crediting period 2006-2015 was also computed using Equation 6 (IPCC equation 3.2 for addition); where $(x_i \times U_i)^2$ was calculated for years 2006-2015 and summed, and x = AD.

Once yearly Uncertainty values for Deforestation, Degradation and Logging Emissions were derived, the total yearly Uncertainty for all emissions was calculated by applying Equation 6 (IPCC equation 3.2 for addition), and the overall U for total emissions for the crediting period 2006-2015 was also computed using Equation 6 (IPCC equation 3.2 for addition); where $(x_i \times U_i)^2$ was calculated for years 2006-2015 and summed, and x = AD.

The overall Uncertainties for Deforestation, Degradation, Logging Emissions and Total Gross Emissions are presented in Table 13. Overall Uncertainty for the crediting period 2006-2015 is 8.78%.

Table 13 Overall Uncertainties for Gross Emissions, for the crediting period 2006-2015.

Value	Deforestation	Degradation	Logging	Total Emissions
Mean (tCO_2eq)	**3,736,968**	**2,817,883**	**20,813,889**	**27,368,740**
U	**29.17%**	**15.07%**	**10.08%**	**8.78%**

13.6 Potential sources of bias

Several sources of potential bias associated with the remote-sensing data are discussed below:

- The sampling design for remote-sensing analysis is optimised for a national-level analysis: to improve accuracy of estimates within each of the sub-national land allocations, increased sampling will be required.
- A recognised drawback of remote-sensing method in High Forest Low Deforestation countries is that the lower the rates of deforestation, the higher the Uncertainty associated with detecting forest cover losses.
- The rules adopted to distinguish deforestation and degradation in the remote-sensing method also introduce potential bias into the data. As the method requires knowledge of a future state to distinguish deforestation and degradation there may be differences in the rates of forest cover change detected in the most recent assessment period compared to previous assessment periods. For example, 2015-2018 is compared against 2019, whereas 2005-2010 is compared against 2015.
- As remote sensing technology improves, so does the resolution in detecting forest cover change. This means that the rates of deforestation and degradation for the most recent assessment period (2015-2018) may be higher than for previous years, simply because of the increased quality of the images analysed.

For the field measurements, as part of the National Forest Monitoring system, plans are underway to strengthen the current national dataset, including re-measurements of existing permanent plots and new plots in logging concessions and forests of differing disturbance histories and management practices.

14 Information that allows for the reconstruction of the historic reference level and results

For reconstruction of the historic reference level and results, the following are provided:

- the excel workbook with the raw data and calculations,
- the draft FRL document and accompanying excel workbook to be submitted to the UNFCCC.

15 Quality Control and Quality Assurance (QC/QA)

Quality Control (QC) (routine technical activities to assess and maintain the quality of the data as it is being compiled) was performed throughout the compilation of the database and the FRL document with inputs from Gabonese and international technical experts. Every effort was made to source the most complete, transparent and accurate data to construct the FRL. Wherever possible, published national datasets using internationally recognised methods (e.g. the RIL-C TerraCarbon metholodogy, and the RAINFOR plot measurements method) to ensure the highest scientific standards were applied. Where published national data were not available, supplementary data were collected specifically for the purposes of the FRL by trusted national (ANPN, AGEOS, CNRS and others) and international scientific partners (e.g. University of Oxford, NASA, SIRS, The Nature Conservancy, CIFOR, FRM Ingenerie, University of Stirling, Duke University, University of Leeds, and others) with a long-term involvement in the published studies and providing active support to the GoG. All unpublished data are accompanied by scientific reports, raw data are available for all of the datasets used and have been checked and discussed at length with the authors of the studies. To ensure QC of national datasets and statistics, specialist partners conducted independent analyses to clean the data, verify its quality and remove potential sources of error. IPCC default values were only used when there were no national data available through published studies or the aforementioned long-term scientific collaborations.

Quality Assurance (QA) (review procedures conducted by personnel not directly involved in compilation of the data) of the FRL took place by the Coalition for Rainforest Nations that are supporting the National Climate Council to 'translate' the FRL data into the national greenhouse gas inventory. Furthermore, the FRL will undergo an informal QA by experts of the UNFCCC roster that do formal FRL/FREL reviews before it is submitted to the UNFCCC. The verification process for the NRR and the informal QA for the FRL will take place in parallel.

16 Proposed stepwise improvements for MRV and NFMS

Gabon's FRL, and therefore the proposed RBPs, was developed with the data that is currently available. Gabon will endeavour to improve its future FRL submissions with the availability of new data. One of the key points in terms of transparency is to make the SNORF publicly accessible. Potential stepwise improvements in terms of data collection and analysis for MRV and NFMS (a subset of the SNORF) are described below. Such improvements are subject to national capabilities and policies and based on the importance of adequate and predictable support as referenced by decision 1/CP.16, paragraph 71.

16.1 Steps to improve Tier 2 Emissions and Removal Factors

Gabon may consider the following points towards improving Tier 2 Emissions and Removal Factors and start collecting information at Tier 3 level:

- Emissions:
    - Continue the NRI to re-measure existing forest plot network and improve the sequestration rates so that these come from the same source as the carbon measurements,
    - Improve the resolution of the field data so that there is more information on disturbances in forests, so that forest types can be refined in the model,
    - Add plots in under-represented forest types such as young secondary forest and degraded forests,
    - Add plots in non-forest areas such as savannahs and grasslands,
    - Include mangrove forests in the NRI sampling design, re-measure mangrove plots that have been measured as part of research projects, include central mangrove area of Gabon which is missing from current research projects. Confidence Intervals to be computed and included for mangroves based on this work,
    - Include plots where land-use changes have or may happen, particularly the conversion of forest land to other IPCC land-use categories such as cropland and settlement and subnational land-use types,
    - Include litter and soil,
    - Refine the methodology to estimate carbon stock changes in logging concessions by undertaking a short study to compare the RIL-C methodology and before and after methodology for logging emissions. Additionally, include a few extra sites to reduce uncertainty in the emissions factors for logging concessions,
    - Ensure that everything that is needed for carbon stock measurements for all the main carbon pools for emissions and removals factors are consistent and that the NRI fully reflects the needs of the FRL and the GHG-I and is updated regularly.
- Removals:
    - Refine the analysis to incorporate forest growth dynamics and consider issues of symmetry in the removals and carbon stock calculations (ensuring that accounting for forest growth changes and carbon stocks over time is improved),
    - Analyse GIS shapefiles to provide estimates for the percentage forest cover within each administrative area for the annual time-series to improve the estimates of forest cover change over time with respect to changes in administrative areas. This applies to logging concessions, protected areas and rural areas.

16.2 Steps to improve national Activity Data for Approach 2

Gabon may consider the following points towards improving Activity Data for Approach 2 and start collecting information for Approach 3. Improvements to two types of Activity Data are considered here, production volume and remote sensing:

- Production volume data:
    - Improve the system and centralisation to report, store and manage logging production data.
- Remote sensing data:
    - Broaden and intensify the sampling design to capture the land-use and change dynamics in Gabon by using the PNAT framework,
    - Improve monitoring of changes in mangroves forest,
    - Improve monitoring of Forest degradation,
    - Remote sensing analysis: the sampling design was optimised for the national level analysis and adapted to suit the sub-national level analysis. However, this resulted in observed differences between the national and sub-national matrices (all within 95% CIs), as well as an inability to detect forest area change in the smaller land-use categories. A more optimal sampling strategy designed specifically for the sub-national level analysis will be developed,
    - Agricultural concessions were not included in the FRL due to limitations in the methodology to derive the Activity Data,
    - A re-analysis of the 2015-2019 assessment period.
- Time series GIS layers and administrative boundaries: Refine the time series of administrative boundaries historically to present reflecting the PNAT. Complement with a GIS analysis to produce an accurate time series for the changes in administrative areas and the subsequent annual changes in forest cover within each subnational land-use type.

17 Proposed Results-Based Payments

The RBPs crediting level for the first reporting period is developed using the historical reference period from 2006-2015.

Based on the Addendum to the CAFI LoI and further negotiations, both Parties have agreed terms to treat statistical uncertainty, reversal risk, and possibly other risk factors, i.e. deductions. From the reported emission reduction and removals results, the following deductions are applied to determine the maximum number of emission reductions and removals for Gabon under the current agreement:

a) Uncertainty: a deduction of 20% is applied to reflect the risk of uncertainty in estimates for the reported emission reduction and removal results,
b) Leakage: CAFI and Norway agreed to not apply any deduction on leakage as Gabon is presenting emission reduction and removal results at the national level. The national accounting approach is consistent with the GoG's draft FRL, NDC and BUR,
c) On an exceptional basis, a 15% buffer is added to account for the novelty of the approach during this period. This figure is expected to be adjusted in subsequent years to accurately reflect the risk of uncertainty and reversal.

The proposed RBPs after deductions are presented in Table 14. These amount to emissions reductions of 3,382,204 tCO_2 totalling USD 16,911,021. No RBPs are claimed for removals.

Table 14 Summary of results and RBPs after agreed deductions.

	Accounting type	**Gross Emissions**
	Crediting Level	**CAFI LOI**
	Reference Period	2006-2015
	Historical average	27,368,740
Results Year	**Gross Emissions (tCO2)**	**Emissions Reductions (tCO_2)**
2016	23,143,458	4,225,282
2017	26,390,631	978,109
	Total Results	**5,203,391**
	20% deduction for Uncertainty	1,040,678
	Additional 15% deduction	780,509
	Total Deductions	1,821,187
35% deduction	**Eligible Results**	**3,382,204**
	Amount @ $5/ton	**USD 16,911,021**

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19 Annexes

19.1 Analysis at the sub-national level

Primary Sample Units (PSUs) were cross-reference with sub-national land allocation data provided by MINEF, enhanced with historical data from the literature (Lee, 2020). From these datasets, shapefiles for most of the remote-sensing assessment years spanning the FRL historical reference period were generated for the six discrete sub-national land allocation types identified in Section 6.3 (in line with the PNAT). These were: forestry concessions, protected areas, rural areas, agricultural areas, community forests and conservation set-aside zones (Table 15 and Figure 5).

Table 15 Subnational land-use allocations included in the remote-sensing analysis.

Subnational land-use allocation	Areas included	Years Shapefiles available
Forestry concessions	- Production zones	1990, 2000, 2005, 2010, 2015, 2019
Protected areas	- National Parks - Integral Nature Reserves - Presidential Reserves - Faunal Reserves - Hunting Domains - Managed Faunal Exploitation Areas - Arboretums - Cultural/historic areas	1990, 2000, 2005, 2010, 2015, 2019
Rural Areas	- 3km buffer around villages	1990, 2000, 2005, 2010, 2015, 2019
Agricultural areas	- Industrial agriculture concessions - ranches - Agricultural set-aside zones in forestry concessions	1990, 2000, 2005, 2010, 2015, 2019
Community Forests	- Forests allocated to village communities	2015, 2019
Conservation set-aside zones	- Conservation and protection set-aside zones inside agricultural concessions and forestry concessions	2000, 2005, 2010, 2015, 2019

However, due to their small surface area, the study design and placement of PSUs did not permit detection of land-use and cover changes to develop individual matrices for agricultural areas, community forests and conservation set-aside zones. Instead, agricultural areas and conservation set-aside zones were combined with all unallocated land that fell outside the boundaries of the other sub-national land allocation types in Table 15 into a single category: “Other Land Allocation”. Community Forests were combined with Forestry Concessions. The surface areas for each of these sub-national land allocation types is indicated in Table 16.

Table 16 Area in hectares of the four different sub-national land allocation categories retained for remote-sensing analyses.

Year	Rural Area	Forestry Concession	Protected Area	Other Land Allocation	Total Land
1990	2,248,022	6,671,269	920,158	16,927,250	26,766,700
2000	2,226,577	12,485,068	1,804,024	10,251,032	26,766,700
2005	2,409,083	14,383,136	1,924,292	8,050,190	26,766,700
2010	2,383,918	13,478,967	3,710,728	7,193,087	26,766,700
2015	2,038,646	14,447,663	3,818,044	6,462,348	26,766,700
2018	**1,771,902**	**15,752,606**	**3,817,903**	**5,424,289**	**26,766,700**

From this analysis, sub-national level matrices were generated to allow land cover and land-use changes to be quantified at the sub-national level, and for the activity data for emissions and removals calculations to be derived for each of the REDD+ activities.

19.2 Rules for distinguishing between deforestation, forest degradation and regeneration

Rules to distinguish deforestation, forest degradation, forest regeneration and stable forest cover were defined as part of the remote-sensing methodology (SIRS, 2020). This approach was taken in part, to attempt to distinguish forest degradation due to shifting agriculture (which is often temporary forest clearing followed by regeneration) from deforestation as a permanent land-use change. Five-year assessment periods were used: 2000-2005; 2005-2010; 2010-2015, with a three-year assessment period for 2015-2018 (using 2019 as the calibration year). For the 1990-2000 period, the different land use / land cover categories were not available since year 1990 was not specifically re-analysed for the FRL. Hence, the distinction was based on the available categories (Forest and Non-forest) using the same rules described below used for the other periods.

For all periods the following rules were applied (Table 17):

- **Deforestation**: A polygon was coded as forest for assessment year, and non-forest for the two consecutive assessment years (year + 5, year + 10). The change in land cover / use, which was observed for at least 10 years, was considered permanent and the land-use change identified as 'deforestation'.
- **Forest degradation**: A polygon was coded as forest for assessment year, non-forest for the following assessment year (year + 5), and forest for the subsequent assessment year (y + 10). The change in land cover / use was not considered permanent and the land-use change identified as 'degradation'. Degradation was also identified when a polygon was coded as dense forest for assessment year "y", and secondary forest for assessment year (year + 5) (i.e., degraded forest within Forest Land remaining Forest land).
- **Regeneration**: A polygon was coded as non-forest for assessment year, and forest for the following assessment year (year + 5). By default, this was classed as secondary forest following the remote-sensing methodology (Table 17). (Note that for the FRL here, an additional step was taken, after this analysis was complete, to distinguish secondary forest as the result of forest regeneration following human disturbance (e.g. Cropland becomes Forest) from colonising forest as the result of natural forest encroachment into savannahs (e.g. Grassland becomes Forest land).

- **Stable:** A polygon where no change from forest to non-forest or non-forest to forest was observed between assessment years, or where no change in forest type (e.g. dense forest to secondary forest) was observed.

Table 17 Examples of rules applied to distinguish the different forest cover change events and land-use changes in the remote-sensing analysis.

Year 0	Year + 5	Year + 10	Interpretation
Dense Forest	Secondary Forest	Secondary Forest	Degradation at Year + 5, then stable
Dense Forest	Non-forest	Secondary Forest	Degradation at Year + 5, regeneration at Year + 10
Dense Forest	Non-forest	Non-forest	Deforestation at Year + 5, Stable at Year + 10
Dense Forest	Dense Forest	Non-forest	Stable at Year + 5, Degradation or Deforestation at Year + 10 depending on state in Year + 15. For the period 2015-2019, considered as degradation, except if in an agricultural area whereby considered deforestation5
Non-Forest	Secondary Forest	Secondary Forest	Regeneration at Year + 5, then stable

The attribution of the areas of each land cover and land-use type and the change between assessment years were compiled into matrices, which allowed for the grouping of different types of forest change and forest cover statistics at a national level. All data were classified first under one of the six IPCC land-use categories and subsequently in one of the 11 national land-cover subdivisions referred to in Table 2. The exception was 1990 which was included *post-hoc* from the original study and not reanalysed, therefore the 1990-2000 analysis only distinguishes forest and non-forest.

[5] Note that although some PSUs fell within agricultural areas, there were not enough to generate a separate matrix for this type of forest cover change.

19.3 Methodological details for estimating Logging Emissions

19.3.1 Activity Data

Obtaining accurate Activity Data for logging emissions is notoriously challenging, particularly at national scales and over long historical time periods. For the FRL, three different sources of Activity Data were considered for estimating logging emissions, before the volume-based method was adopted:

- *Area-based data*. For its INDC, Gabon derived area-based Activity Data by estimating the area of logged forest from management plans, administrative documents and historical data. This method was re-examined in detail during the development phase of the FRL, however, the approach was not retained as it was decided it runs the risk of applying generalised assumptions which may over or underestimate the actual logged area, e.g. by ignoring inactive concessions or illegal logging.
- *Remote-sensing data*. The remote sensing method used to derive activity data for the FRL was also considered for logging concessions. However, the remote sensing method is only able to detect forest changes where disturbance to the canopy cover is visible. As selective logging leaves much of the forest canopy intact it was decided that this method risks greatly under-estimating the extent of logging damage. The area of forest cover loss detected by the remote sensing method within logging concessions was therefore not considered as Activity Data for the FRL.
- *Timber production data*. A more direct source of Activity Data are national timber production volumes: however, the data has unknown levels of uncertainty. For example, uncertainty may arise due to administrative errors or undeclared timber. Illegal logging is known to be an issue in the country, but Gabon is working hard to tackle this, as can be seen for example through the investigation 'Toxic Trade' undertaken by the Environmental Investigation Agency (EIA) with the Ministry of Environment. After much consideration, Gabon decided to adopt the volume-based data for estimating logging emissions, based on the analysis and treatment of the data outlined in the following section.

19.3.1.1 Analysis and treatment of timber production volume data

Multiple sources of declared timber production volume data are available in Gabon, however they all differ to varying degrees, for reasons which are unknown. To address this, a study was conducted with the aims of: (a) analysing all existing declared timber production volume data from different sources to produce a single time-series composed of the most reliable data, and (b) comparing the declared production volumes to exported volumes (FRM Ingenierie, 2020) to examine data discrepancies and potentially identify any unregistered or undeclared timber in the production volume data. From this study, an adjustment was applied to correct for identified discrepancies.

First, declared production volume data were compiled from all known sources. Based on expert knowledge of the country and sources, the data were cleaned and filtered to produce a single dataset (Figure 9 and FRM Ingenierie, 2020). Exported timber weight data from the official national data-set (*Tableau de Bord de l'Economie* - TBE) were used to validate the timber production data. Equivalent export volumes (V_X) were calculated from this data-set and were compared with the declared production volume data (Figure 9) (FRM Ingenierie, 2020).

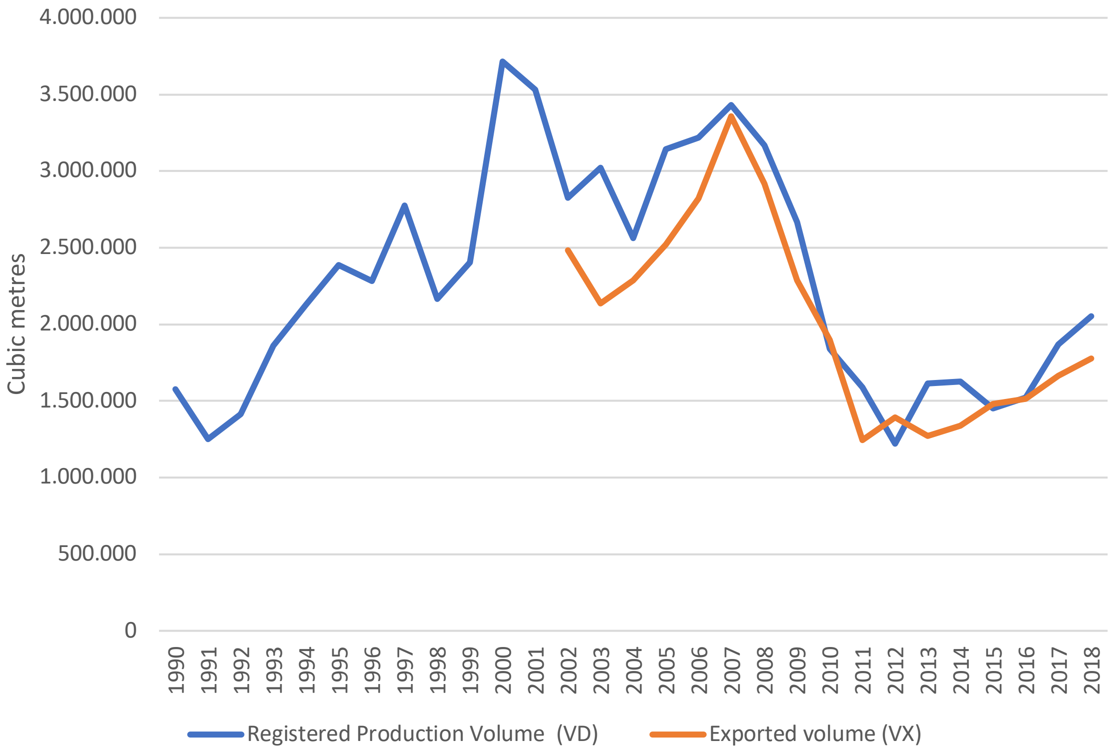

Figure 9 Comparison of registered production volume (V_D, blue line) and exported volume (V_X, red line).

In order to ensure a conservative approach, an adjusted production volume (V_{AD}) time series was generated by taking the highest value from the two datasets for each year (Figure 10).

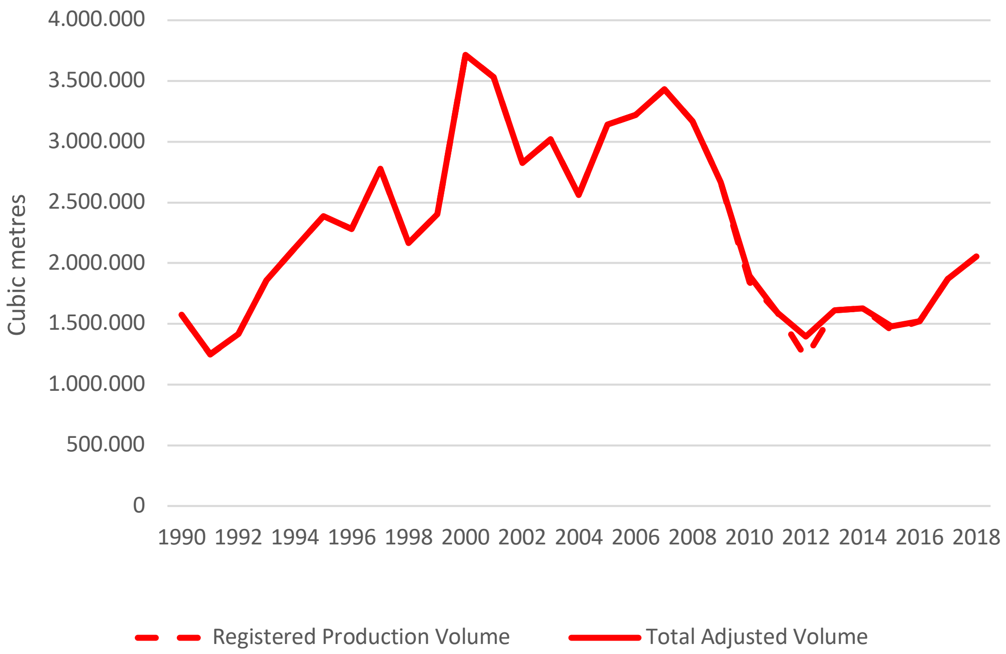

Figure 10 Adjusted, conservative production volume data (solid red line), retained as the Activity Data, 1990-2018.

This final dataset was validated at a national level (Conseil National Climat, 2020c).

The total adjusted annual production volumes of timber in m^3 for each year (1990-2018) were retained as the Activity Data to calculate emissions from selective logging practices (Table 18). The approach taken to derive Uncertainty is described in Section 13.

Table 18 Activity Data retained for the calculation of emissions from selective logging practices, reported under REDD+ activity SMF.

Year	Total Adjusted Volume of timber (m^3)	Uncertainty
1990	1,576,600	11.51%
1991	1,250,000	11.51%
1992	1,414,800	11.51%
1993	1,859,100	11.51%
1994	2,127,000	11.51%
1995	2,388,000	11.51%
1996	2,284,000	11.51%
1997	2,775,000	11.51%
1998	2,164,000	11.51%
1999	2,402,000	11.51%
2000	3,715,000	11.51%
2001	3,531,000	11.51%
2002	2,825,000	11.51%
2003	3,020,000	11.51%
2004	2,563,000	11.51%
2005	3,143,000	11.51%
2006	3,220,000	11.51%
2007	3,433,000	11.51%
2008	3,169,000	11.51%
2009	2,666,000	11.51%
2010	1,897,406	11.51%
2011	1,590,000	11.51%
2012	1,393,027	11.51%
2013	1,613,000	11.51%
2014	1,625,000	11.51%
2015	1,481,377	11.51%
2016	1,523,163	11.51%
2017	1,867,755	11.51%
2018	2,052,590	11.51%

19.3.2 Emissions Factor

To determine the emissions factor for logging, two sources of national-level data were used. The first source is a study conducted by (Ellis et al., 2019), following Reduced Impact Logging for Climate (RIL-C) methodology (The Nature Conservancy and TerraCarbon LLC, 2016). Data were collected from 9 logging concessions in Gabon (4 CFADs, 3 CFADs with FSC certification and 2 'provisional' CPAET concessions, which is the status concessions hold prior to obtaining CFAD status). Total AGB and BGB carbon emissions from commercial timber harvesting were estimated as the sum of Hauling emissions (log landings, haul roads, and road corridors), Skidding emissions (from skid trail plots and skid trail networks) and Felling emissions (harvested trees and those that suffered collateral damage). Emissions calculations consider live biomass only and were reported for both above and below-ground biomass combined together. DOM (standing biomass and downed wood) is not included, according to RIL-C methodology.

Logging emissions expressed in Mg C/ha were calculated using the following basic equations:

$$E = H + S + F$$

Equation 8

Where:

E = total logging emissions (Mg C)
H = hauling emissions (Mg C)
S = skidding emissions (Mg C)
F = felling emissions (Mg C)

$$E_w = \frac{E}{RW_{total}}$$

Equation 9

Where:

E_W = logging emissions per volume wood harvested (t/m^3 of C)
RW_{total} = extracted roundwood timber volume in sampled block (m^3)

The second source of data were taken from two studies (Medjibe et al., 2013, 2011)- here raw data from three additional logging concessions were combined with the data from (Ellis et al., 2019). In Medjibe et al., (2013) existing E_W values were used, whereas in (Medjibe et al., 2011), E_W was computed by dividing the logging emissions (Mg C/ha) by the harvesting intensity (m^3/ha).

The combined dataset from 12 concessions were adjusted for the FRL as follows:

- For the data from (Medjibe et al., 2013, 2011), BGB was estimated from AGB using the shoot-root ratio of 0.235 at the stand level for moist tropical forests >125 Mg /ha (Mokany et al., 2006).
- For the data from (Ellis et al., 2019), the raw data were reported as both above and below ground biomass. As 0.235 refers to the ratio of BGB: AGB, and not BGB: total (AGB+BGB), the following equations (Equation 10) were applied to the original (total) emissions factors in order to partition the data into AGB and BGB in the correct proportions according to the following equation:

$$\text{AGB} = \text{total} * 0.8097166$$
$$\text{BGB} = \text{total} * 0.1902834$$

Equation 10

- Biomass was converted to carbon with a standard carbon fraction of 0.456 following (Martin et al., 2018);
- Data were reorganised into GOFC-GOLD recommended equivalent logging emission categories, following (Pearson et al., 2014), according to Equation 11 and Table 19:

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

Equation 11

Where:

TEF = Total Emissions Factor
ELE = Extracted Log Emissions
LDF = Logging Damage Factor
LIF = Logging Infrastructure Factor

Table 19 Equivalence of logging emission categories in Ellis et al (2019) compared to standard (GOFC-GOLD recommended) accounting method for estimating EFs from selective timber harvesting (Pearson et al., 2014)

Emissions categories used in Ellis et al., 2014	Equivalent emissions categories following Pearson et al., 2014
Felling Emissions: Timber	Extracted Log Emissions (ELE)
Felling Emissions: Collateral damage + felled tree remainder	Logging Damage Factor (LDF)
Skidding Emissions + Hauling Emissions (Roads + log yards)	Logging Infrastructure Factor (LIF)

Values in t C/m^3 were converted to t CO_2 eq/m^3 using Equation 1.

Logging emissions factors by carbon pool and emissions category are presented in Table 20. Only the data from (Ellis et al., 2019) were available in a format that could be broken down by emissions category, however, it can be seen that the inclusion of the data from the additional three concessions from (Medjibe et al., 2013, 2011) did not alter the total mean emissions factor, but reduced the uncertainty in the data.

Table 20 Total Emissions Factor (TEF) by carbon pool and component, in tCO_2eq/m^3. U= Uncertainty, ELE (Extracted Log Emissions), LDF (Logging Damage Factor), LIF (Logging Infrastructure Factor), TEF* = adjusted TEF with the inclusion of additional data from three extra sites.

Emissions Factor no.	Emissions category	N	Carbon Pool (tCO_2eq/m^3)			
			Above-Ground	Below Ground	Total	
			Mean	Mean	Mean	U
EF4	ELE	9	0.4	0.1	0.5	11.0%
	LDF	9	2.4	0.6	2.9	51.4%
	LIF	9	4.9	1.1	6.0	45.9%
	TEF	9	7.6	1.8	9.4	37.5%
	TEF*	**12**	**7.6**	**1.8**	**9.4**	**27.8%**

19.4 Supplementary information for the construction of activity data for removals

The Activity Data for removals was derived from a combination of the remote sensing data, activity data used to calculate logging emissions and data concerning the administrative areas of the different sub-national land allocation types. This approach was taken to:

- ensure that administrative changes in the area of different subnational land-use types were taken into consideration when constructing the annual time series,
- enable the inclusion of logged forest which was not adequately detectable by the remote sensing method.

Removals were calculated as carbon biomass accumulation in standing forest, in naturally regenerating forests following human disturbance and in naturally encroaching forests into grasslands and wetlands.

19.4.1 Step 1. Organisation of remote sensing data

For each sub-national land allocation category and assessment year for the remote sensing analysis, data from the remote sensing matrices were first extracted and reorganised into tables. Data were taken from the end of each assessment period (apart from 1990, which only occurs at the start, and 2000, which was taken for both the 1990-2000 and 2000-2005 periods to account for the methodological differences between the two assessment periods). Only forest cover and change data that were identified as Stable forest, Degraded forest (from Dense to Secondary forest) and Regenerating forest (from non-forest to forest) were retained. Separate tables were created for each of the four subnational land-use categories, and all were organised by the Forest cover and change classes described in Table 2 (with the exception that Dense and Flooded forest were combined into one category, and Artificial surfaces excluding roads were combined with roads).

The designation of different forest types, as identified by the remote sensing method were re-classified according to current ecological knowledge of Gabonese forests to (a) ensure consistency with the approach taken for deforestation and degradation emissions, and (b) to ensure application of the most appropriate removals factors.

19.4.2 Step 2. Extrapolation of data to create annual time series

In this step, an annual time series was constructed from the extracted and reorganised remote sensing data. To extrapolate the forest cover area data accurately between the remote sensing assessment years, the history of administrative changes to the area of each of the sub-national land allocation types was taken into account. For example, the remote sensing analyses indicated that Protected Areas had 1.7 Mha of forest in 2005 and 3.2 Mha forest in 2010, but the increase in forest cover did not occur incrementally given the national parks were created in 2007. However, the historical data for administrative areas were themselves incomplete and did not exactly match the data for the remote sensing assessment years. Therefore, best efforts were made to make adjustments to the extrapolations so that the change in forested area reflected the administrative changes over time. For each sub-national land allocation type, the approach taken is described below.

For logging concessions:

A detailed (annual) historical time-series of administrative areas for logging concessions was generated from 1961-2020 (Lee, 2020). For the assessment years 1990, 2000, 2005, 2010, 2015 and 2019, the data were provided in GIS format for the remote sensing analysis (SIRS, 2020b) to ensure methodological consistency. However, some adjustments were subsequently made to the shapefiles prior to the remote –sensing analyses to account for slight layer overlaps, meaning that the areas reported by SIRS, (2020) and Lee (2020) for the same layers were not identical. Because of this, rather than directly use the annual time-series of administrative areas for logging concessions provided by Lee (2020), the percentage **change** in total surface area from one year to the next was instead used to extrapolate the area of forestry concession between assessment years as reported by SIRS (2020). Any differences between extrapolated area and reported area for each assessment year were adjusted for.

Once this adjusted time series of administrative areas for logging concessions was created, the **percentage forest cover** within logging concessions was calculated for each assessment year by dividing the forested area (as detected by the remote sensing analyses) by the total administrative area for that year (also detected by the remote sensing analyses). The **percentage annual change** in forest cover between assessment years was then derived by taking a yearly average of the difference in percentage forest cover. This was summed to the percentage forest cover for the assessment year and then all subsequent years to derive an estimate of the percentage forest cover for each year. The area of forest for each year between assessment years was derived by multiplying the total administrative area by the percentage forest cover for that year. This method was considered adequate given that the percentage forest cover within the total area of logging concessions was fairly consistent, varying between 97.6% and 98.4%. Corrections to the complementary datasets will be made to ensure they are identical, and the method improved as part of the stepwise improvements to the FRL.

For Protected areas:

The percentage forest cover is much more variable for protected areas than for logging concessions, however, no annual time-series for the administrative areas for protected areas was available at the time of analysis. Instead, the area of forest within protected areas was taken for each assessment year from the remote sensing analysis (SIRS, 2020b). To extrapolate between these years, supplementary information provided by (Lee, 2020) on the changes to forest cover that occurred as a result of administrative changes to protected areas was incorporated. As the changes informed by these data did not sum exactly to the forested areas reported for each assessment year by (SIRS, 2020b), adjustments were made whereby the differences were averaged out over the years administrative changes occurred. This step ensured that the accrued forest area changes between assessment years matched the forested areas for each assessment year. As precise GIS data for all years were not available at the time of analysis, this is considered indicative for now. This will be addressed as part of the stepwise improvements to the FRL (see Section 16).

For Rural areas

At the time of analysis, no annual time series of surface areas was available for the Rural Areas for the whole historical period. For this reason, forest cover was directly extrapolated between assessment years. This is considered indicative for now and will be addressed as part of the stepwise improvements to the FRL (see Section 16).

For Other Land Allocation:

The total forested area for the fourth subcategory (Other Land Allocation) was calculated for each year between assessment years by subtracting the sum of the three other categories from the total forested area.

For each forest type within sub-national land allocation types:

Once the total forested areas for each sub-national land allocation type were derived for all years, the areas for each forest type within each sub-national land allocation were calculated for the years between assessment years. This was done by dividing the total forested area for a given year by the total forested area of the subsequent assessment year, and multiplying by the area of the forest type in question for the same assessment year. This gave a value for the area of each forest type which was proportional to that of the total for any given year.

All forested areas were carefully cross-checked to ensure they added up correctly to match the totals.

19.4.3 Step 3. Estimation of the area of logged forest

Methodological limitations meant that it was unlikely that the full extent of logged forest would be detectable with the remote sensing method. Due to this, and in order to ensure methodological consistency, the area of logged forest was instead derived from the Activity Data used to calculate logging emissions (timber production volume data, see Annex 19.3.1). Logged forest was defined as 'up to 25 years since logging' as this is consistent with a single harvest cycle under Gabonese forestry management. In order to be able to apply the most appropriate removals factors, logged forest was further subdivided into two categories: Logged forest (1-10) (LF_{10}) for forests logged up to 10 years previously, and Logged forest (11-25) (LF_{25}) for forests logged between 11 and 25 years previously. Logged forest was accounted for within Logging Concessions and Protected Areas, to take account of knowledge that over 1 million ha logging concession were cancelled and replaced by National Parks between 2004 and 2006 (Lee, 2020). The method adopted is described below.

For years 1990-2018, timber production volume data (Table 18) were converted to Equivalent Harvested Areas (A_{EH}) using Equation 12 and a mean harvest intensity (HI) of 10.0 m^3/ha (n= 12, U= 31.9%, source: Ellis et al., 2019; Medjibe et al., 2011, 2013):

$$A_{EH} = V_{AD} * HI$$

Equation 12

Where:

A_{EH} = equivalent harvested area (ha)
V_{AD}= adjusted annual production volume (m^3)
HI = Harvest Intensity

However, A_{EH} values were required for years starting from 1965 in order to derive the cumulative area of logged forest from 1990 onwards. In the absence of production volume data for years 1965-1989, available historical data for the area of logging concessions were instead used. Annual historical data for the area of logging concession (A_C) were available from 1990-2018 (Lee, 2020) but prior to 1990 values for 1961 and 1975 only were available (Lee, 2020). These data were extrapolated to provide an annual time series between 1961 and 1990.

Next, the area of logging concession (A_C) was used to derive the percentage equivalent harvested area (% A_{EH}) for each year between 1990 and 2000 using Equation 13:

$$\% A_{EH} = A_{EH} / A_C$$

Equation 13

Where:
% A_{EH} = % equivalent harvested area of logging concession (%)
A_C = area of logging concession (ha).

The mean % equivalent harvested areas (% A_{EH}) for 1990-2000 was then derived (2.3%, U = 9.9%).

For 1965-1989 A_{EH} was calculated by multiplying the mean % A_{EH} value (2.3%, U = 9.9%) by the logging concession area data (A_C) for that year (Equation 14):

$$A_{EH} = A_C * 2.3\%$$

Equation 14

From 1990- 2018, the area of LF_{10} for each year was calculated as the sum of the equivalent harvested areas (A_{EH}) for the previous 10 years and the area of LF_{25} for each year was calculated as the sum of the equivalent harvested areas (A_{EH}) for the previous 11-25 years.

19.4.3.1.1 Logged forest in Protected Areas

To estimate the area of logged forest within Protected Areas, the following information was used: between 2004 and 2007 1,030,589 ha of logging concession permits were cancelled and replaced by protected areas as follows (Lee, 2020):

- 291,540 ha logging concession cancelled in 2004,
- 38,742 ha logging concession cancelled in 2006,
- 700,307 ha logging concession cancelled in 2007.

To account for this in the FRL, for each year from 1980 until the year of permit cancellation, the annual area of logged forest within each block of permits was calculated by dividing the Equivalent Harvested Area (A_{EH}) for that year (estimated in the previous step) by the total area of logging concession (A_C, also derived in the previous step) and multiplying by the permit block size that was cancelled. From the first year following permit cancellation and every subsequent year, the annual harvested area was assumed to be 0.

For each block of cancelled permits, from the year following permit cancellation the area of LF_{10} now within a protected area was calculated as the sum of the area of annually logged forest within that block for the previous 10 years. The area of LF_{25} was similarly calculated as the sum of the area of annually logged forest within that block for the previous 11-25 years.

Once these areas were derived for each block of cancelled permits, they were summed for each year to provide the total area of LF_{10} and LF_{25} respectively in Protected Areas. From 1990 to the year of permit cancellation the area of LF_{10} and LF_{25} within Protected Areas was assumed to be zero.

19.4.3.1.2 Logged forest in Logging Concessions

The area of logged forest (LF_{10} and LF_{25} respectively) inside Logging Concessions was finally calculated by subtracting the area LF_{10} and LF_{25} within protected areas from the total area of LF_{10} and LF_{25}.

19.4.4 Step 4. Integration of logged forest into the removals time series.

In this final step the time-series of the areas of logged forest (LF_{10} and LF_{25} respectively) inside Logging Concessions and Protected Areas were combined with the remote sensing data.

To do this, the assumption was made that all forest identified in the category “Secondary forest” (Young secondary and degraded forest) within Protected Areas and Logging Concessions was logged forest. Based on this assumption the area of logged forest then replaced all Young secondary and degraded forest under Forest Remaining Forest land within Protected Areas and Logging Concessions. As the area of logged forest was greater than the area of Young secondary and degraded forest it replaced (for all years), the remainder was subtracted from the area of “Dense and flooded forest”, (Old growth, Old secondary and Older logged under Forest land remaining forest land within logging concessions and protected areas, to ensure the total forested areas were correct.

19.4.5 Activity Data derived for removals calculations

Steps 1-4 above resulted in an annual time-series of forested areas in hectares disaggregated by (a) four subnational land-use allocation (b) IPCC land-use category and (c) six forest subdivisions (seven with the inclusion of ‘unidentified’ forest for 1990-2000 data). These data were retained for the activity data for removals calculations (an example is presented in Table 21). All data sum to the total forested area for Gabon for each year.

Table 21 Example of the activity data derived for removals calculations. Presented here are the activity data for logging concessions, 2010-2018.

Land-Use type	Logging concessions											
IPCC LUC	**Forest Land remaining forest land**					**Cropland becomes Forest**	**Grassland becomes forest**	**Wetland becomes forest**	**Settlement becomes Forest**	**Other Land becomes forest**	**Non-forest becomes forest**	Total
Forest Type Year	Old growth, old secondary, older logged	Logged (1-10)	Logged (11-25)	Mangrove	Unidentified	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary	Young Secondary	
2010	**7,691,852**	**2,953,183**	**2,488,339**	**13,552**	**0**	**4,557**	**654**	**0**	**23,267**	**0**	**0**	**13,175,402**
2011	8,442,572	2,802,092	2,684,187	0	0	6,739	816	0	9,193	0	0	13,945,598
2012	8,201,764	2,635,507	2,867,590	0	0	6,631	803	0	9,045	0	0	13,721,340
2013	8,457,120	2,513,416	2,989,605	0	0	6,754	818	0	9,214	0	0	13,976,927
2014	8,959,782	2,394,898	3,132,847	0	0	7,010	848	0	9,562	0	0	14,504,946
2015	**8,617,473**	**2,320,992**	**3,235,477**	**0**	**0**	**6,858**	**830**	**0**	**9,355**	**0**	**0**	**14,190,984**
2016	9,843,406	2,170,982	3,400,320	0	0	8,732	72	0	13,254	0	0	15,436,766
2017	10,135,980	2,017,983	3,599,690	0	0	8,924	73	0	13,545	0	0	15,776,196
2018	**9,668,375**	**1,882,538**	**3,801,161**	**0**	**0**	**8,697**	**72**	**0**	**13,200**	**0**	**0**	**15,374,043**