CONSEIL NATIONAL CLIMAT

Gabon's Proposed National REDD+ Forest Reference Level

Gabonese Republic

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Executive Summary

With 88% forest cover, Gabon holds a special status as a High-Forest, Low-Deforestation (HFLD) country with the second-highest percentage forest cover in the world (after Suriname). The Government of Gabon (GoG) has demonstrated strong leadership and action to protect its forests. Gabon's forests store high levels of carbon, harbour exceptional biodiversity, provide resources and livelihoods for rural populations, and regulate rainfall and mitigate climate change at the national, regional and global scales. Climate change is the greatest environmental challenge the planet faces today, yet also represents an opportunity for creating a path to sustainable development through international cooperation. Gabon is forging that path with its Low Emissions Development Strategy (LEDS) to increase economic growth and become an emerging economy through sustainable policies and actions, while conserving its natural ecosystems and contributing to global climate efforts.

Gabon adopted its first forest policy in 1996, to increase the forestry sector's contribution to economic and social development. In 2001, a new Forest Code was signed into law requiring 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% of raw logs would be processed in Gabon prior to export. 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% of timber be processed in country. These restrictions started to come into effect in 2010 and were fully implemented in 2011. 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. The Gabonese President announced in September 2018 that all logging concessions must be FSC certified by 2022.

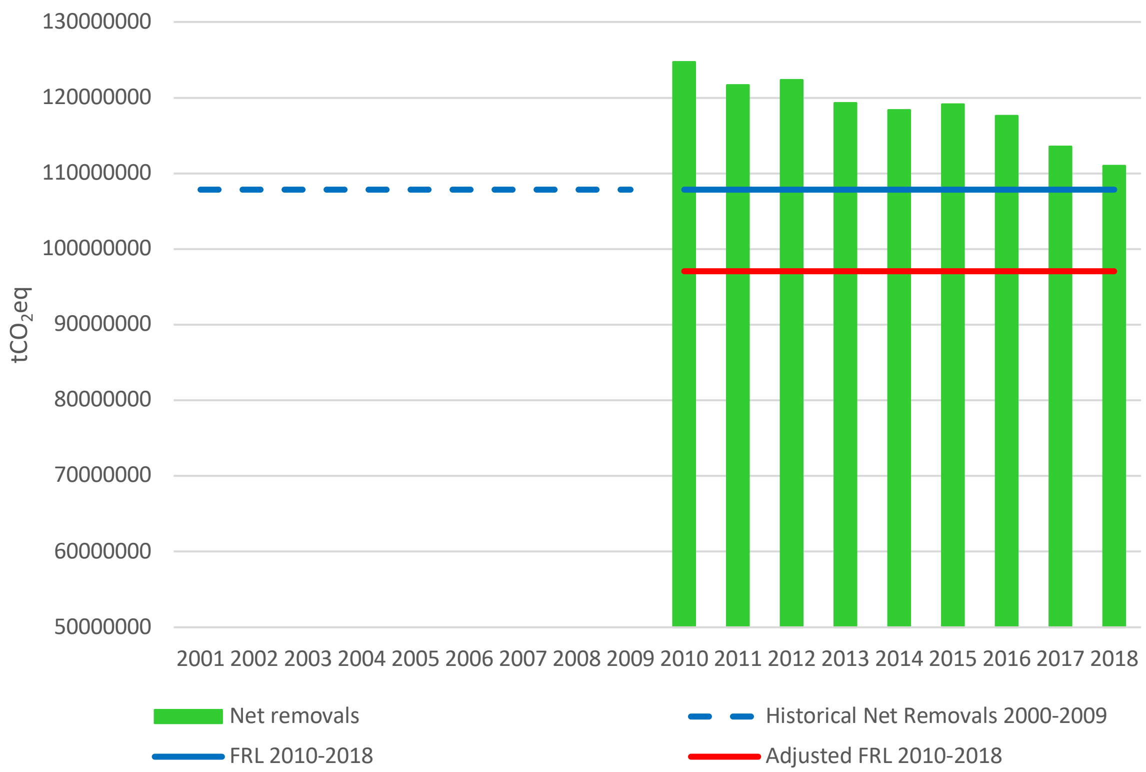
Gabon's Forest Reference Level (FRL) serves as a benchmark for assessing the country's performance in implementing the five REDD+ activities: Reducing emissions from deforestation, reducing emissions from forest degradation, Sustainable Management of Forests, Conservation of Forest carbon stocks and Enhancement of Forest carbon stocks, following paragraph 70 in decision 1/CP.16. The FRL presents the net removals for 2010-2018 from these activities against the historical period 2000-2009. Gabon's FRL is national in scale.

Gabon's FRL is transparent with clear documentation of methods and data that are openly shared. They are complete as all data, methodologies, procedures used are presented and shared to allow for the independent reconstruction of the FRLs. Estimates of emissions and removals are accurate and include estimates of uncertainty represented at the 95% confidence interval. The construction of the historical reference periods and the FRLs is consistent with the guidance and guidelines of the Intergovernmental Panel for Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) decisions 12/CP.17 and 13/CP.19.

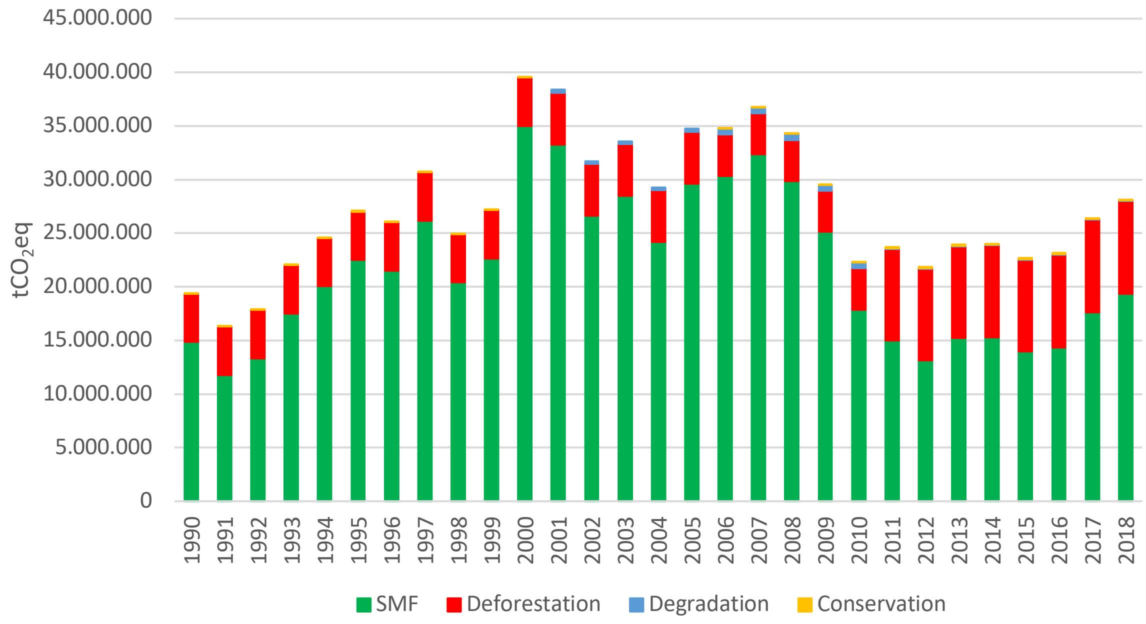
In accordance with relevant decisions of the Conference of the Parties (COP), Gabon's FRL is established transparently taking into account historic data and are adjusted for national circumstances (paragraphs 7 and 9 decisions 4/CP.15 and 12/CP.17 respectively). Recognising the impact of national circumstances in terms of Gabon's political decisions and implementation thereof, Gabon's FRL is adjusted upwards by the maximum allowed by the Green Climate Fund for HFLD countries. This upwards adjustment is

applied to the net average historical removals for the period 2000-2009 and applied to Gabon's FRL for 2010-2018.

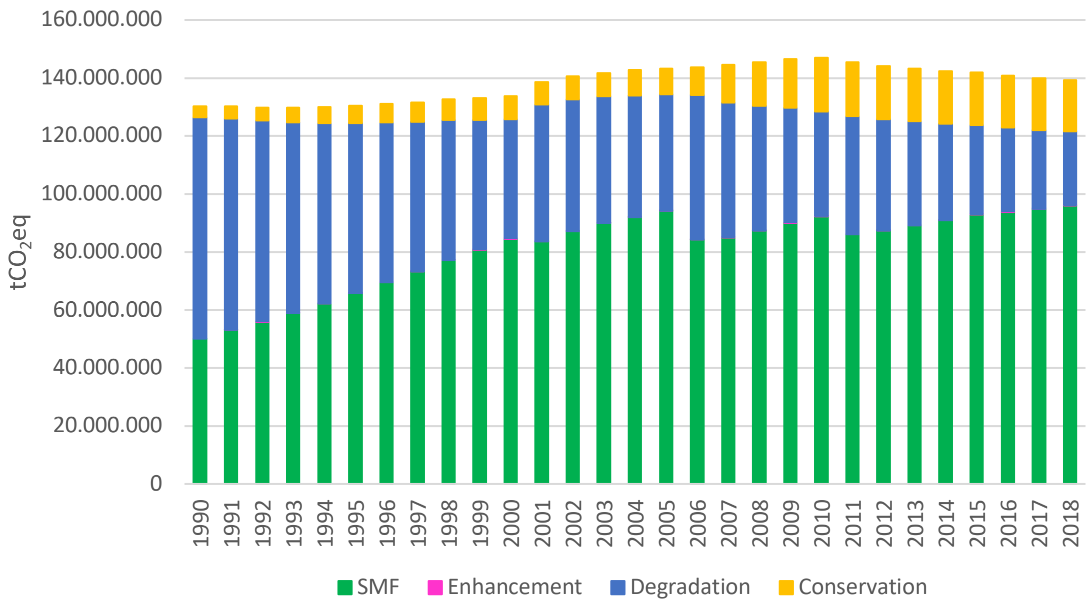
For the historical reference period 2000-2009, the total average annual net removals from Deforestation, Forest Degradation, Sustainable Management of Forests and Conservation of Forest Carbon Stocks and Enhancement of Forest Carbon stocks is 107,839,499 tCO_2eq /year. The proposed national adjusted FRL (applied to results years 2010-2018) is 97,055,549 tCO_2eq (see Figure below).



Historical patterns of emissions reduction per REDD+ activity (shown in the figure below), evidenced from 2007 onwards (40% gross emissions were reduced between 2007 and 2012, remaining stable and low for most of the 2010s), coincides with the implementation of several key national policies (national park creation, operationality of the 2001 forestry law and the raw timber export ban) and demonstrates Gabon's early commitment to Sustainable Management of Forests (SMF). The average annual change for the REDD+ activity Deforestation is: 0.03% for 1990-2000, 0.04% for 2000-2005, 0.03% for 2005-2010, 0.07% for 2010-2015 and 0.07% for 2015-2018.

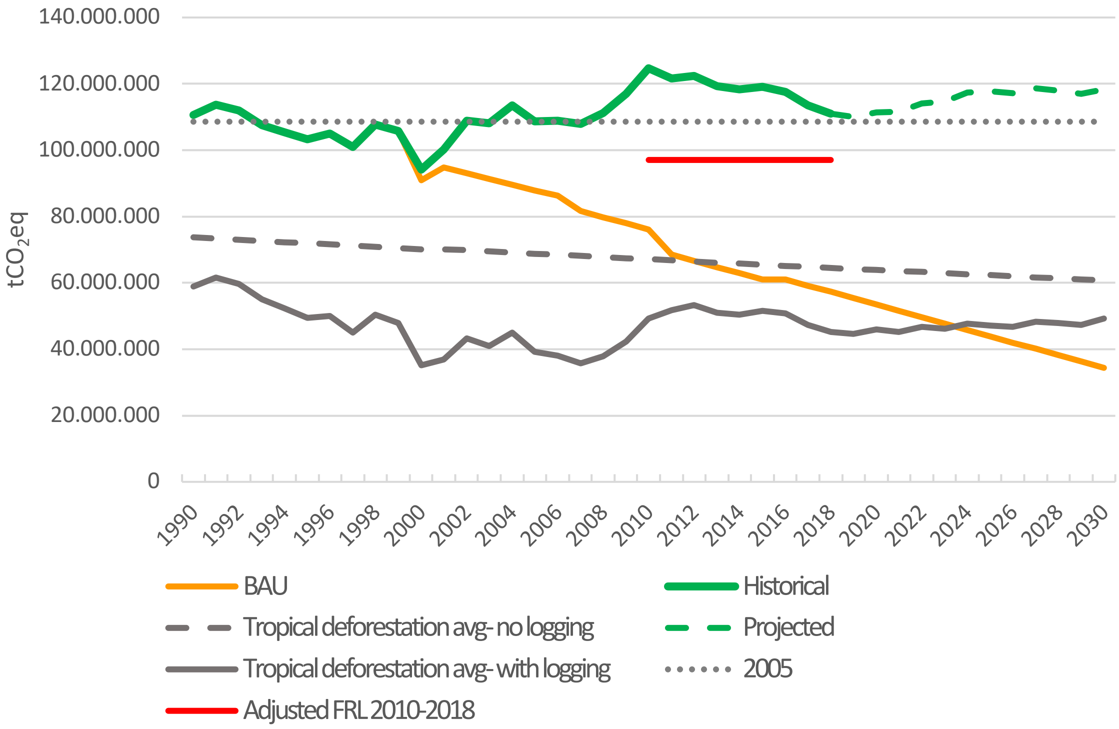


Although gross emissions have increased slightly in recent years, it is important to highlight the significant contribution of gross removals in Gabon's forest carbon balance (shown in the figure below). Across the reporting period (1990-2018) Gabon's net absorptions in the AFOLU sector are about 3.2 billion tCO_2eq. Considering emissions levels from other sectors as reported in the 1st and 2nd national communications, Gabon's net absorptions for this period are in excess of 2.75 billion tCO_2eq (République Gabonaise, 2011, 2004).



Based on its national circumstances and future development plans, Gabon estimates (a) its projected net removals will be 117.8 million tCO_2eq/year by 2025, representing an increase of 8.5% compared to

2005 levels (see figure below), and (b) its projected gross emissions to be 23.8 million tCO_2eq/year by 2025, representing a reduction of 31% compared to 2005 levels.



The historical net removals objectively demonstrate the positive contribution to global climate change mitigation objectives that Gabon has made as well as its overall performance. These are the results of the significant policy decisions made and implemented by the GoG to protect its forests through conservation and by enforcing sustainable forest management practices.

Gabon's Business-as-usual (BAU) scenario (shown in figure above) illustrates that without the forestry and conservation reforms made in the 2000's, net removals would be 53.7 million tCO_2eq/year lower than they are today (48%) and steadily decreasing each year. However, even under the BAU scenario, Gabon would still be set to have net gains by 2030.

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National Focal Point

Tanguy Gahouma,
Permanent Secretary, Conseil National Climat
BP 3850, Libreville, Gabon
tanguygahouma@gmail.com

Technical contributors

Lee JT White (MINEF), Kathryn Jeffery (University of Stirling / CAFI), Danae Maniatis, Justine Huge (SIRS), Christophe Sannier (SIRS), Vincent Medjibe (Agence Nationale des Parcs Nationaux), Peter Ellis (The Nature Conservancy), Michelle Lee (Duke University), Cécile Hervo (FRM Ingénerie), Flore Hirsch (FRM Ingénerie), Nicolas Bayol (FRM Ingénerie), Oswaldo Carrillo (Coalition for Rainforest Nations), Wannes Hubau (University of Leeds), Ketil Flugsrud (Norwegian Environment Agency), Eloïse Guidi (Coalition for Rainforest Nations).

List of Acronyms

AD	Activity Data
AGB	Above-ground biomass
AFOLU	Agriculture, Forestry and Other Land Use
AGEOS	Agence Gabonaise d'Études et d'Observation Spatiale
ANPN	Agence Nationale des Parcs Nationaux
ART	Architecture for REDD+ Transactions
BAU	Business as Usual
BGB	Below-ground biomass
CAFI	Central African Forest Initiative
CFAD	Concession Forestière sous Aménagement Durable
	Forest Concessions under Sustainable Management
CNC	Conseil National Climat du Gabon
CPAET	Temporary development, exploitation and processing licenses for timber
DBH	Diameter at Breast Height
DOM	Dead Organic Matter
ER	Emissions Reduction
EF	Emissions Factor
FAO	Food and Agriculture Organisation
FCPF	The Forest Carbon Partnership Facility
FCPF-RPP	The Forest Carbon Partnership Facility Readiness Preparation Proposal
FREL	Forest Reference Emissions Level
FRL	Forest Reference Level
FSC	Forest Stewardship Council
GoG	Government of Gabon
HCS	High Carbon Stocks
HCV	High Carbon Value
HFLD	High Forest Low Deforestation
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
LEDS	Low Emissions Development Strategy

MINEF	Ministère de la Foret, de la Mer, de l'Environnement, Chargé Du Plan Climat
NDC	Nationally Determined Contributions
NFMS	National Forest Monitoring System
NIF	National Investment Framework
NRI	National Resource Inventory
OSF	Old Secondary Forest
POGV	Plan Opérationnel Gabon Vert
PNAT	Plan National d'Affectation du Territoire Gabon
PSFE	Program Sectoriel Forets et Environnement
PSGE	Plan Stratégique du Gabon Émergent
REDD+	Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RF	Removals Factor
RIL-C	Reduced Impact Logging for Carbon
SNC	Second National Communication of Gabon
SNORNF	Système National d'Observation des Ressources Naturelles et des Forêts
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 National context of Gabon

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.

Gabon boasts exceptional biodiversity and a large number of endemic and emblematic species. Its forests represent about 11% of the rainforest of the Congo Basin (Mayaux et al., 2013): they are home to 50% of the remaining forest elephants in Africa, as well as important global populations of primates such as gorillas, chimpanzees and mandrills. Three Global 200 priority terrestrial ecoregions are located in Gabon, including important areas of mangrove forest as well as coastal and lowland forest. Protection is afforded through a network of protected areas that includes 13 national parks, a presidential reserve, a faunal reserve, 4 hunting domains, 2 arboretums, 9 Ramsar sites, 1 World Heritage site, several cultural sites, and 20 marine protected areas. Together, these protected areas cover nearly a quarter of national territory (land and ocean), including 22% of land area (5.9 Million ha). With a per capita forest area of 15 hectares per person, population pressure is much lower than in most African countries, however illegal logging, mining and commercial hunting activities pose a threat to the country's biodiversity (Abernethy et al., 2013, 2016; Environmental Investigation Agency, 2019).

Gabon is sparsely populated, with an estimated 2.2 million inhabitants (UN DESA, 2019). Almost 90% of the population now live in urban areas (World Bank Group, 2019), with a dwindling rural population distributed in small villages along a few main roads that traverse the country. Gabon benefits from an abundance of natural resources that form the backbone of its economy- namely timber, crude oil, natural gas, manganese, uranium, magnesium, iron ore, precious metals and diamonds. Gabon is the fifth-largest oil producer in Sub-Saharan Africa and the third largest exporter of manganese worldwide: oil represents about 50% of the country's Gross Domestic Product (GDP). Ranked as an upper middle income country, it has one of the highest per capita GDPs in Sub-Saharan Africa (8,2029 USD in 2018 (World Bank Group, 2019)), however the unemployment rate is about 20% and about a third of the population lives below the national poverty line (World Bank Group, 2019).

Gabon's forests contain over 400 tree species above 50cm diameter at breast height (DBH), about 60 of which are commercially exploited (Maniatis et al., 2011). The most economically important is Okoumé, which is used to make plywood, but Gabon also produces hardwoods such as mahogany, azobé and padouk. Forestry was the country's main economic activity before crude oil surpassed it in the late 1960s. As of March 2020, 15.5 million hectares are currently allocated to about 40 logging companies (Lee, 2020), who extract about 1.7 million m^3 timber annually[1] (FRM Ingénierie, 2020). Since 2001, the forestry sector has been governed by a forestry law that demands rotation cycles of between

[1] This represents the average declared production volume for 2014-2018.

20-30 years and sustainable forest management plans[2]. In 2010, the government banned raw timber exports in an attempt to promote in-country log processing. A 59% drop in production was observed between 2007 – 2012 (FRM Ingénierie, 2020), which is likely due to a combination of the impact of the raw timber export ban (Cassagne and Diallo Follea, 2016) as well as the impact of other policy decisions that became effective from 2006 (such as the creation of the national parks in 2007 and the 2001 Forestry Code). Forest Stewardship Council (FSC) certification was first awarded in Gabon in 2008 (Precious Woods, 2020), but has only risen recently (Annex 1 Section 18.1), in response to Gabon's recent announcement that all concessions will require FSC certification by 2022 ("Discours du Chef de l'Etat. Visite de la scierie de Mevang (Rougier Gabon)," 2018). Despite a strong legislative framework for forest management, illegal logging is considered widespread in Gabon, as is the case in the wider Congo Basin region (Environmental Investigation Agency, 2019). Forestry practices in Gabon are selective (between 1-3 trees/ha are logged; Umunay et al., 2019), affecting a limited number of species, and only affecting 5-15% of biomass and canopy cover.

Gabon does not have a strong agricultural tradition, despite being endowed with arable land and suitable climatic conditions. Most farming is subsistence, with shifting cultivation of cassava, plantain, taro and yam destined mainly for self-consumption. Of the country's 26.7 million hectares of land, about 325,000 are sown representing about 1.3% of the total land area ("The World Bank Databank," 2020). Since 2012, industrial agriculture has expanded, with the establishment or strengthening of oil palm and rubber plantations that currently cover about 64,000 hectares (Olam Gabon *pers. comm.*).

Deforestation rates have historically been very low in Gabon with an annual rate persistently lower than 0.05% since 1990. The average annual change for the REDD+ activity Deforestation is: 0.03% for 1990-2000, 0.04% for 2000-2005, 0.03% for 2005-2010, 0.07% for 2010-2015 and 0.07% for 2015-2018. The relative lack of deforestation can largely be attributed to several factors: (1) historically, the country relied largely on offshore oil production, rather than intensive logging exploitation and/or industrial agriculture development, as its primary source of economic revenue[3]; (2) small-scale, slash-and-burn agriculture is relatively limited and spatially concentrated because the country is sparsely populated; and, (3) Gabon's leaders have adopted and implemented a relatively environment-friendly governance over the last two and a half decades.

Faced with a decline in its oil reserves, Gabon has shifted its economic strategy towards diversification. In 2009, the President launched a new vision for Gabon's economy- Emergent Gabon, supported by a strategic plan to operationalise it (République Gabonaise, 2012) that aims to modernize the country and become an emerging economy by 2025. Ambitious projects are under development: those that have particular implications for land-use change include a national agricultural mechanization strategy and the ambition for Gabon to become one of the largest producers of palm oil in Africa.

Nationally, deforestation appears to have increased in recent years and is currently estimated at 0.1% annually. Some controlled deforestation of low carbon degraded forest-agriculture mosaic was

[2] This law included a grace period of five years so only became effective in 2006.

[3] Oil revenues made Gabon prohibitively expensive which likely acted as a deterrent to potential investors in other economic areas such as the forestry and agriculture sector.

undertaken in 2011-2015 to establish industrial oil palm as part of the country's economic diversification. Subsistence agriculture and the expansion of infrastructures (roads, towns) are also recognized drivers of deforestation.

1.2 Relevant institutional and legislative framework

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 logging concession holders under the supervision of MINEF), 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 link between land-use and climate is complex. Land-use decisions determine the types of activities that take place in an area and, therefore, affect both the economy and the environment. For example, Gabon has long imported most of its food products: only about 1.3% of the country's surface area (approximately 350,000 ha) are currently cultivated ("The World Bank Databank," 2020). This situation, favourable to maintaining forest cover, poses problems for food security and economic diversification. Careful land-use planning can direct agricultural development towards areas with low carbon stocks and conservation value, thereby growing the economy and avoiding carbon emissions.

The Government of Gabon (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, 2015a) 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 United Nations Framework Convention on Climate Change (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 2011, Gabon initiated the establishment of the SNORNF to effectively monitor, evaluate and adapt Gabon's low emissions development activities in the Agriculture, Forestry and Other Land Use (AFOLU) 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 1.

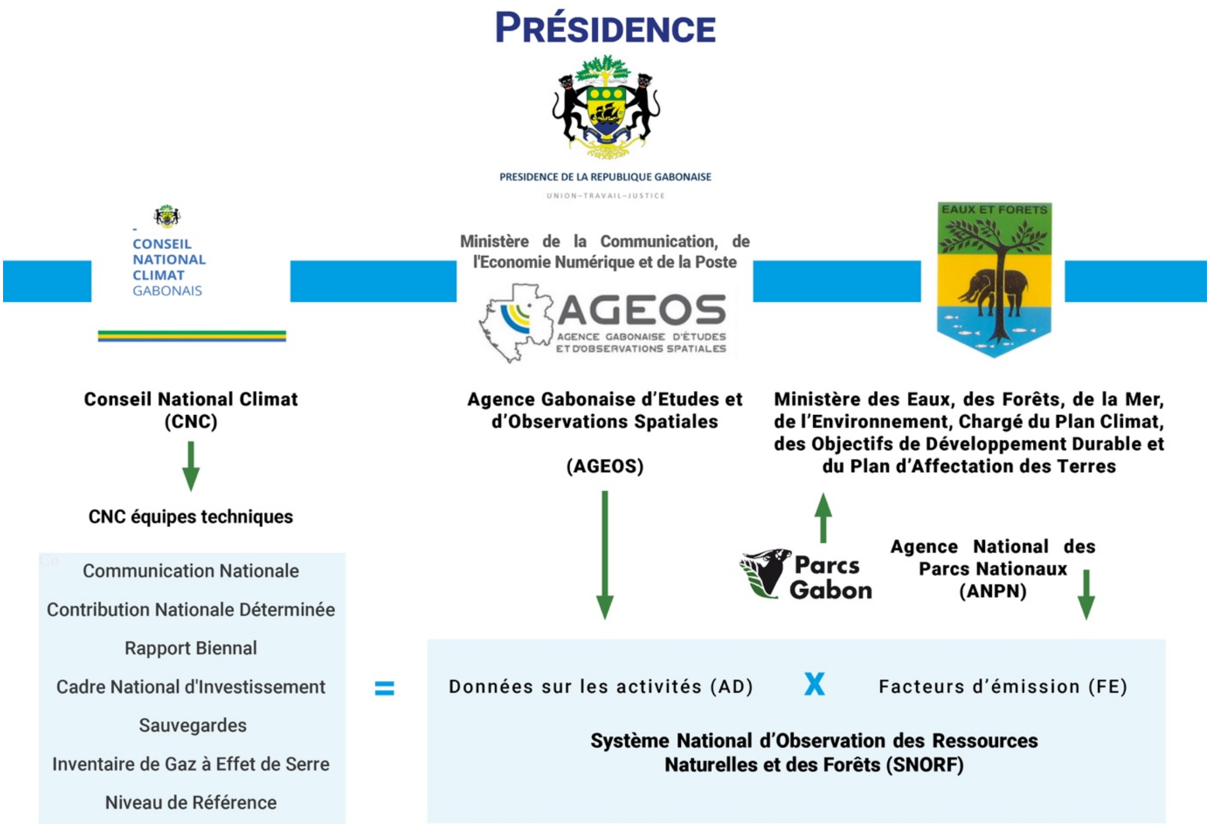

Figure 1 Institutional arrangements for data collection for the FRL and reporting to the UNFCCC.

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 a requirement for sustainable management plans for logging concessions (CFADs) to be implemented by 2006; the 2007 National Parks Law (République Gabonaise, 2007); the Environment Code of 2014 and 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.

1.2.1 Institutional arrangements for Gabon's National Forest Monitoring System

Gabon's National Forest Monitoring System (NFMS) which is presented in Figure 2 is a subset of the SNORF.

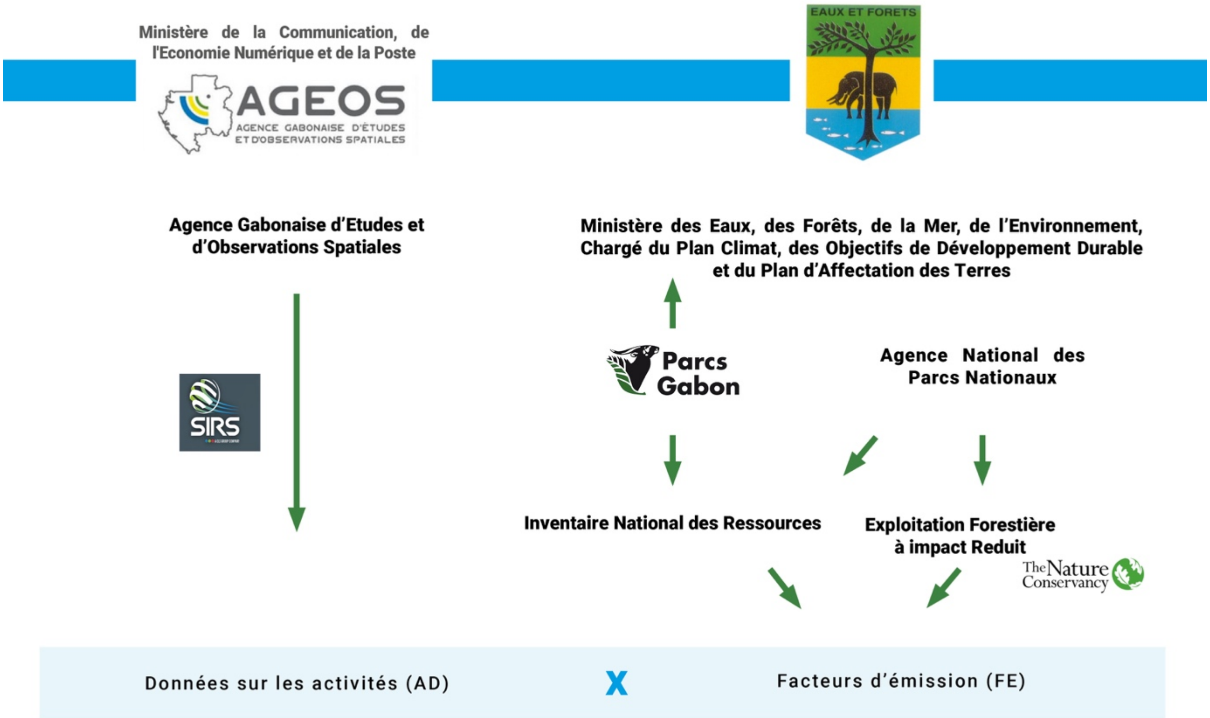

Figure 2 Institutional arrangements for Gabon's NFMS.

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.

1.3 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 LEDS builds on a history of environmental leadership spanning three decades. In 1992, President Omar Bongo Ondimba 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 the President 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 3).

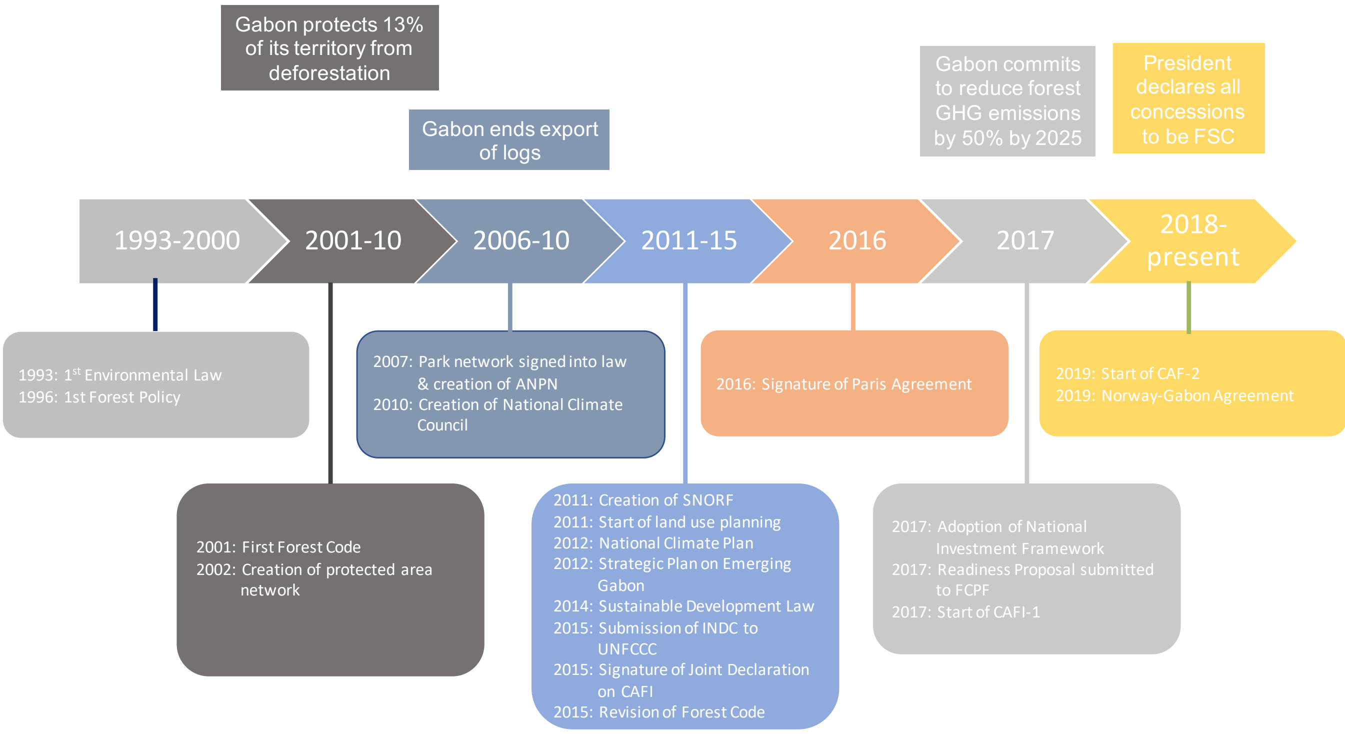

Figure 3 Timeline of Gabon's achievements related to greenhouse gas emissions reductions.

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 ANPN 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 22% of land area. This includes 3.3 million ha (11%) of fully protected National Parks and Cultural Sanctuaries; 700,000 ha (3.7%) of wildlife reserves in which limited oil exploration is allowed but no forestry; and 7.7% includes multiple uses such as extractive industries. 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% 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 4).

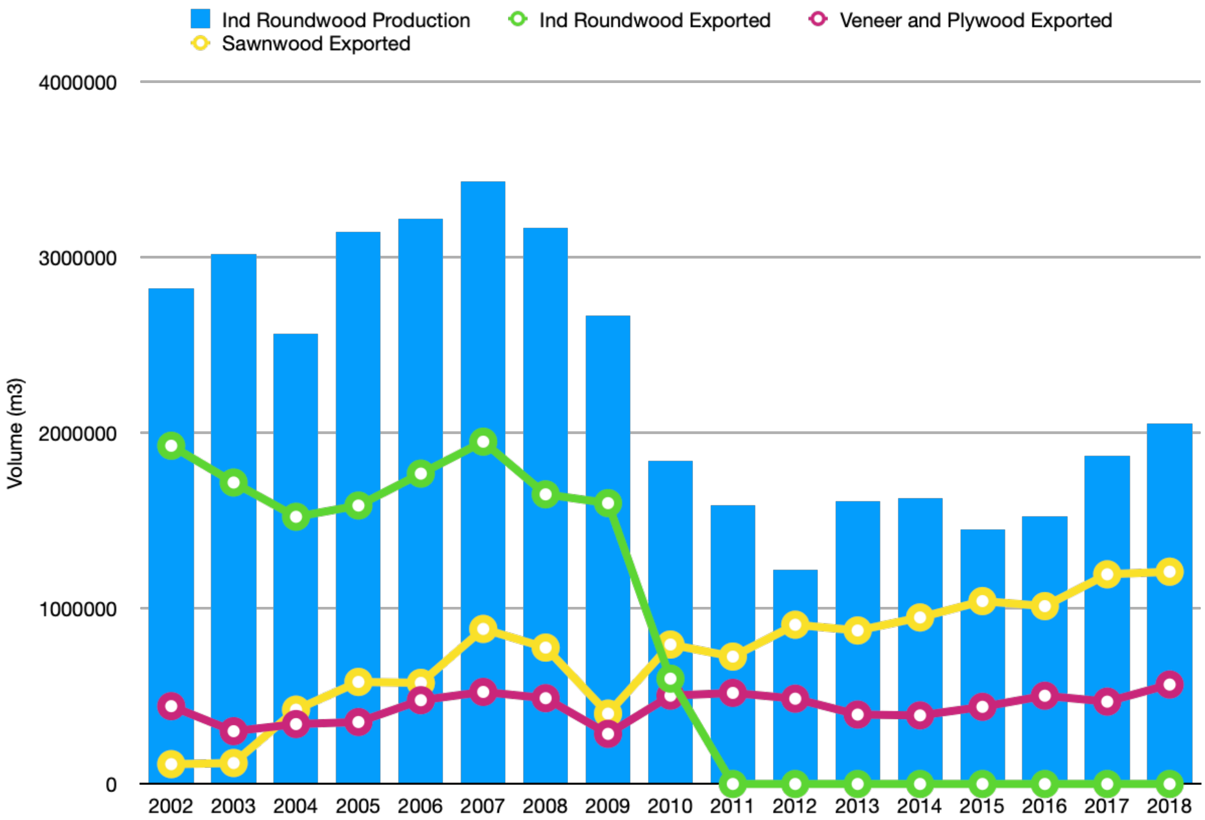

Figure 4 Impact of whole log export ban on the production and export of industrial roundwood, as well as exported sawnwood, veneer and plywood. Equivalent export volumes are presented based on data from the Tableau de Bord d'Économie (TBE) Ind = Industrial (FRM Ingénierie, 2020).

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 logging – is expected to be submitted to parliament in 2021. The new Code should help strengthen the regulatory framework for reducing emissions from AFOLU and be closely aligned with Gabon's NDC under the Paris Climate Change Agreement. With a view to reducing forest sector emissions, the Government is also reducing the surface area of forest licenses. This reduction of land area in production should automatically reduce total greenhouse gas emissions from AFOLU. A Climate Change Law is currently being prepared for adoption by parliament.

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 MINEF 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. Annex 1 (see Section 18.1) presents the companies that have obtained FSC certification in Gabon as of February 2021 (source Global FSC Certificate Database). As such, the government 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[4].

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 has established national guidelines for the "Management of the environmental and social impacts of the production of palm oil in Gabon", which will 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 they 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 increasingly strategic, targeting locations of high crop suitability and avoiding

[4] 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.

areas of high potential environmental impact, focussing on highly degraded forest-agriculture mosaics and savannah areas.

Starting in 2017, data from Gabon's NRI allowed the GoG to improve carbon maps and thereby better quantify the average carbon content of Gabonese secondary forests (Burton et al., 2017). Preliminary analyses from the NRI 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 during the Neolithic, some 2,800 years ago, just before the beginning of the Iron Age (Oslisly et al., 2013).

1.4 Gabon's relevant international commitments

Gabon submitted its first National Communication to the UNFCCC in December 2004 (République Gabonaise, 2004) and its Second National Communication (SNC) in November 2011 (République Gabonaise, 2011). For the AFOLU sector these followed the Intergovernmental Panel on Climate Change (IPCC) 1996 guidelines (IPCC, 1996) using Tier 1 methodology and FAO default data in many cases. However, the quality of these analyses was limited and neither included forest degradation, which is a significant source of emissions for Gabon.

Degradation was included in Gabon's Intended Nationally Determined Contribution (INDC) which was submitted in April 2015 (République Gabonaise, 2015b). An accompanying report detailing the sources of data and methodological approach underpinning the INDC was produced, however this was not made publicly available (République Gabonaise, 2015c). In the INDC, Gabon committed to reduce greenhouse gas emissions by 50% by 2025 compared to a business-as-usual baseline post-2005. As the AFOLU sector is responsible for more than 90% of the country's emissions, initiatives in this sector offer a high mitigation potential.

As a high percentage of Gabon's estimated emissions are from the AFOLU sector, the INDC was largely focused on sustainable management of forests and responsible land-use planning. In it, Gabon pledged to reduce emissions by at least 50% from Business as Usual (BAU) levels by 2025. Although praised for being the first African country to submit its INDC, the INDC itself received critical reviews (Climate Action Tracker, 2015; Hargita and Ruter, 2015; ICF International, 2016). These were largely based on lack of clarity in choice of methodology, source of historical data, and/or a forest reference baseline (Climate Action Tracker, 2015). The decision to include degradation but omit carbon storage was also questioned. Gabon has taken into account these critical reviews in the development of its FRL.

In 2016, Gabon signed the Paris Agreement under the UNFCCC agreeing to contribute to constraining the global average temperature rise to below 2°C. Under the Paris Agreement, each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming dealing with greenhouse-gas-emissions mitigation, adaptation, and finance.

In 2017, Gabon submitted its REDD+ Readiness Proposal (RPP) to the Forest Carbon Partnership Facility (FCPF) and engaged in a process to better understand emissions from the forestry sector and to develop technical protocols to help mitigate unnecessary forestry emissions.

In 2017, Gabon and the Central African Forest Initiative (CAFI) signed a Letter of Intent (LoI), in which Gabon pledged to reduce gross emissions by 50% below 2005 levels by 2025, implying a reduction of more than 50% in the forest sector (République Gabonaise and Central African Forest Initiative, 2017).

The 2017 LoI sets a contribution of 18 million USD, in two tranches (referred to as CAFI 1). The first tranche was disbursed to the Programme and approved in 2018 to elaborate, adopt and implement a PNAT and the SNORF. An additional 12 million USD (referred to as CAFI 2) are programmed for forest certification, creation of transboundary protected areas, land-use optimization for the intensification of crop production and technical assistance on carbon data management.

Although Gabon had previously decided not to engage in the voluntary UNFCCC REDD+ process, it reversed this decision in 2019. In September 2019, a 150 million USD, 10 year results-based payment partnership with the government of Norway, was signed as an Addendum to the 2017 LoI (referred to as CAFI 3). In this Addendum, Norway, via CAFI, pledged to pay Gabon up to 150 million USD for verified emissions reductions and removals over a ten year period between 2016 and 2025 ("Gabon: First in Africa to receive payments for preserved rainforests," 2019). A floor price of 5 USD/tCO_2 was agreed, increasing to 10 USD/tCO_2 if Gabon meets the Architecture for REDD+ Transactions REDD+ Environmental Excellence Standard (ART TREES). Prior conditions to these payments include Gabon's submission of its updated Nationally Determined Contribution (NDC), submission of a Forest Reference Emissions Level (FREL) or Forest Reference Level (FRL), and a summary of information on how REDD+ safeguards are being addressed and respected, according to relevant UNFCCC decisions. The three CAFI programmes and their institutional set up are presented in Figure 5. These three programmes also support the set-up and implementation of the REDD+ framework in Gabon and are accompanied by a National Investment Framework (NIF).

Gabon is also engaged in the FCPF readiness programme. The support of the FCPF focuses on three complementary outcomes to the CAFI programmes: a) the completion and implementation of the PNAT; b) the completion of the SNORF; and c) activities to improve emissions estimates from degradation and improve forestry practices, including examining the potential for reforestation (Gabon FCPF revised readiness preparation proposal 2018).

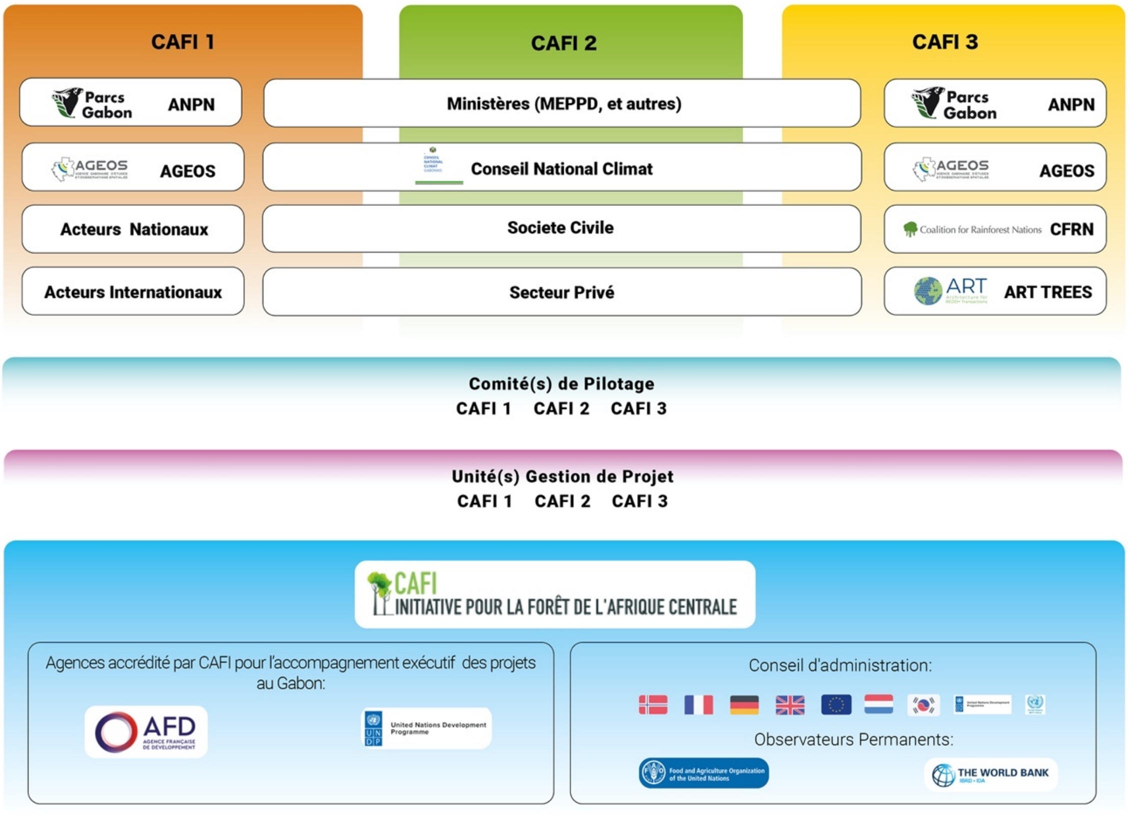

Figure 5 Gabon's three CAFI programmes and relevant institutional arrangements. MEPPD = Ministère de l'Économie, de la Prospective et de la Programmation du Développement Durable.

2 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 at maturity, 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 section 7.3).

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

3 Scale

The accounting area (26,766,700 ha) for the FRL is the land area within the political borders recognized by Gabon. Therefore, Gabon aims to address REDD+ at the national level.

4 Scope

The FRL's scope is set in terms of the REDD+ activities, the carbon pools and the greenhouse gases included in the FRL.

5 Reference periods

Gabon presents a historical reference period which include the net removals from the five REDD+ activities: 2000-2009 and 2010-2018. Gabon uses a 10-year historical period either side of 2005, from 2000-2009. This reflects Gabon's efforts to reduce emissions from deforestation, forest degradation and protect its forests (as explained in Section 1) during this decade under the leadership of President Omar Bongo Ondimba and further implemented by President Ali Bongo Ondimba from 2010 onwards.

6 Pools and Gases

6.1 Pools

Above-ground live biomass, and below-ground live biomass are included in the FRL. Carbon stocks for litter, Dead Organic Matter (DOM) and Soil Organic Carbon (SOC) are not included in emissions calculations for the following reasons.

Litter is not considered due to a lack of data. Its inclusion will also be considered in the future stepwise improvement of Gabon's FRL.

Gabon does not consider soil carbon changes in Forest Land Remaining Forest Land to be significant and adopts the IPCC assumption that for Forest Land 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 non-Forest Land-Use categories, 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. A detailed rationale for excluding soil as a carbon pool for CO_2 emissions calculations is provided in Section 18.3 (Annex 3).

Although Gabon has national data on DOM, it is not currently included as more work is required to integrate DOM in the Emissions Factors for logging emissions.

For the above reasons, Gabon would like to recall paragraph 10, of decision 12/CP.17 enabling countries to undertake the gradual improvement of their data and methods, including additional pools as appropriate.

6.2 Gases

Only CO_2 is included in Gabon's FRL as available data (although limited) indicate that the contribution of emissions of other greenhouse gases are considered to be minor (in Gabon's draft greenhouse gas inventory, 0.77% of total emissions for the AFOLU sector are estimated to be from N_20 and CH_4**,** from savannah fires and the burning of agricultural residues).

7 Land representation

Gabon's representation follows the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 3.1, Chapter 3, Volume 4 (IPCC, 2019a)

7.1 Climate

Gabon has a humid, tropical climate, with average annual high temperatures of around 25 to 27°C in the coastal plains, and 22 to 25°C inland. There is a wet season between October and May, with monthly precipitation of 200 to 250 millimetres (Conseil Climat, 2012).

Rainfall follows a biannual cycle, with two rainy seasons (March-May and October-November) punctuated by a consistent long dry season (mid-June to mid-September) and a more variable short dry season (December-February) (Bush et al., 2020). Despite low annual rainfall, forests in Gabon are thought to be maintained by extensive cloud cover during the dry season which greatly reduces water demand and maintains high humidity (Philippon et al., 2019).

Detailed ground measurements collected in Lopé National Park since the 1980's indicate that the climate is warming at a rate of +0.25°C per decade, and drying at a rate of -75mm per decade (-5.5% annual rainfall) (Bush et al., 2020). These trends are seasonally dependent, with reduced rainfall observed most prominently between March and September, and increased temperatures most pronounced between October and February (Bush et al., 2020).

7.2 Soil

There are several published sources of soil carbon stock data for Gabon (Chiti et al., 2017, 2016; Cuni-Sanchez et al., 2016; Gautam and Pietsch, 2012; Kauffman and Bhomia, 2017; Wade et al., 2019), but country-specific data on soil carbon stock changes due to land-use and management are lacking. Gabon's NRI provides the most comprehensive study of soil carbon stocks in Gabon to date (Wade et al., 2019), indicating a mean SOC stock of 163t C/ha to 2m depth, ranging from 39.3 - 655.5 tC/ha across the country. This study found that land-use type was not a reliable predictor of soil carbon, but rather lithology, local climate, and soil type exert more dominant controls (Wade et al., 2019).

7.3 Biomass / Ecological zones

Gabon's forests fall within the Global Ecological Zone of 'Tropical rainforest' (based on Figure 4.1, Chapter 4, Volume 4, of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006a)). Gabon adopts 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.

These subdivisions are further categorised by forest types for the purposes of the FRL according to current national 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, Logged Forest
Secondary forest	Young Secondary Forest, Logged Forest, Colonising Forest, Degraded Forest
Flooded forest	Flooded Forest
Mangroves	Mangrove Forest

7.3.1 IPCC land-use categories and national forest subdivisions

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

These Land-Use and land cover categories are not to be confused with the National Land Tenure classes defined in Section 7.4. The National Land Tenure classes can occur across IPCC land-use categories, and the national land-cover subdivisions can occur across the National Land Tenure classes. For example, it is possible to find both Grasslands and Croplands inside logging concessions.

Table 2 Definition of national IPCC Land-Use categories and national subdivisions adopted by Gabon.

IPCC Land-Use category	Description	National 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).
		Mangroves	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.

7.4 Management practices

7.4.1 National land tenure

In line with Gabon's National Land Allocation Plan ("*Plan National d'Affectation des Terres* – PNAT"), land in Gabon is subdivided into one of national land tenure classes (Figure 6). 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: areas that have national protection status including National Parks, Integral Nature Reserves, Presidential Reserves, Faunal Reserves, Hunting Domains, Managed Faunal Exploitation Areas, Arboretums, Cultural/historic areas[5].
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 logging concessions.
5. Community Forests: forests allocated to a village community with a view to carrying out sustainable activities under a management plan. The Forest Code adopted in 2001 initiated a process to promote and recognize community forestry[6].
6. Conservation set-aside zones: these are conservation and protection set-aside zones inside agricultural concessions and logging concessions.

Any land that is not considered as one of these six land tenure classes is considered as unallocated land. No area of land was allocated to more than one land tenure class to avoid double-counting. Furthermore, although Sustainable Development Concessions are part of the Gabon's PNAT, they are at the time of the submission of the FRL not yet operational and therefore not included.

These National Land Tenure classes are not to be confused with the IPCC Land-use categories and national subdivisions presented in Table 2.

[5] Ramsar sites were not included in this definition, because in reality they are not spatially exclusive with respect to the other identified land tenure classes, including logging 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 tenure classes identified within Ramsar sites and any other protected areas where logging is scheduled 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 logging concession.

[6] To date 53 community forests have valid management plans, another 50 are developing management plans and about 100 more are under consideration

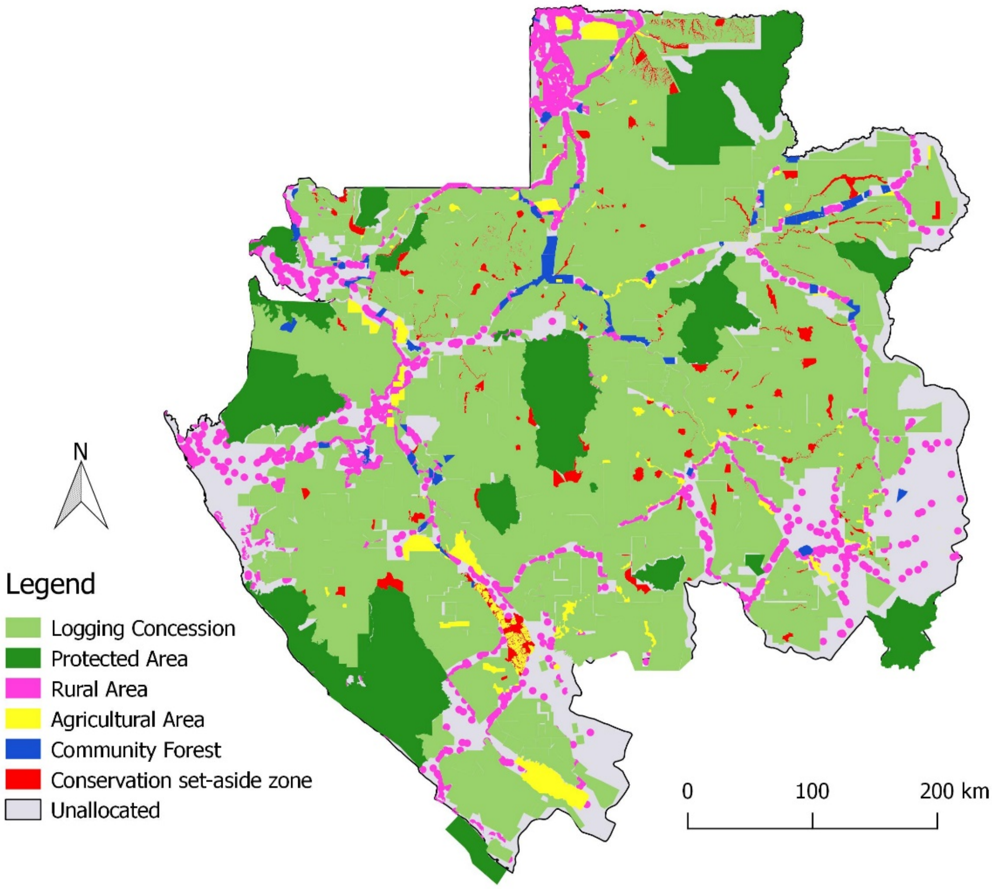

Figure 6 Map of National Land Tenure classes 2019[7].

For methodological reasons that are outlined in Section 10.1.1.4, agricultural areas and conservation set-aside zones were combined with all unallocated land into a single category: "Other Land Tenure", and community forests were combined with 'Logging Concessions'.

[7] Note an error was made in the identification of logging concessions (approximately 200,000 ha logging concessions were misallocated to the Unallocated category between 2015 and 2018) - this will be rectified as part of the improvement plan.

7.4.2 REDD+ activities

The REDD+ activities included in the FRL are:

- Deforestation,
- Forest Degradation,
- Sustainable Management of Forests (SMF),
- Conservation of Forest Carbon Stocks,
- Enhancement of Forest Carbon Stocks.

Gross emissions (from forest cover losses and logging) are accounted for separately under REDD+ Activities Deforestation, Forest Degradation, SMF and Conservation of forest carbon stocks. Gross removals are accounted for under REDD+ Activities Forest Degradation, Sustainable Management of Forests, Conservation of forest carbon stocks and Enhancement of forest carbon stocks.

REDD+ activities are organised by National Land Tenure classes and IPCC land-use categories.

7.4.2.1 Deforestation

Under the REDD+ activity 'Deforestation', carbon biomass losses due to forest cover losses (Forest Land to non-Forest Land-use categories) within the national land tenure classes Rural Areas and the Other Land Tenure are accounted for. This includes both permanent and temporary land-use change (Section 10.1.1.7).

7.4.2.2 Forest degradation

Under the REDD+ activity 'Forest Degradation', carbon biomass losses due to the degradation of forests (Forest Land remaining Forest Land) and carbon biomass gains in standing forest (Forest Land Remaining Forest Land) within the national land tenure classes Rural Areas and the Other Land Tenure are accounted for.

7.4.2.3 Sustainable Management of Forests (SMF)

Under the REDD+ activity 'SMF', carbon biomass losses due to logging activities within the national land tenure class "Logging Concessions" are accounted for. Carbon biomass gains in standing forest (Forest Land remaining Forest Land), regenerating forest and natural forest encroachment (non-Forest Land-use categories to Forest Land) are also accounted for. Community Forests are included in this category.

The default assumption is that all carbon biomass is oxidised in the year of harvest; carbon storage in harvested wood products is not calculated.

7.4.2.4 Conservation of forest carbon stocks

Under the REDD+ activity 'Conservation of forest carbon stocks', carbon biomass losses due to forest cover losses (Forest Land to non-Forest Land-use categories, both permanent and temporary) and forest degradation (Forest Land remaining Forest land) within the national land tenure class "Protected

Areas" are accounted for. Carbon biomass gains in standing forest (Forest Land remaining Forest Land), regenerating forest and natural forest encroachment (non-Forest Land-use categories to Forest Land) are also accounted for.

7.4.2.5 Enhancement of forest carbon stocks

Under the REDD+ activity 'Enhancement of forest carbon stocks', carbon biomass gains are accounted for where forests are established in previously non-Forest Land-use categories that have changed to Forest Land. This includes land which was not previously forested (natural forest encroachment), or in naturally regenerating forests which had earlier been converted from Forest Land to non-Forest Land-use categories.

7.5 Organisation of reporting

The carbon biomass losses and gains included in the FRL are measured from Forest Land converted to non-Forest Land-Use categories, non-Forest Land-Use categories converted to Forest Land, Forest Land remaining Forest Land and logging activities inside logging concessions (including Forest Land remaining Forest Land and Forest Land converted to settlement).

Emissions from forest fires are not included in the FRL as there is very little evidence of extensive forest damage due to anthropogenic fires. While savannah fires are common in Gabon, forest fires are not, and it is possible prevailing climatic conditions also prevent forests from burning. While it is recognised that shifting agriculture can result in forest burning, there is a lack of data in Gabon to accurately estimate such emissions. In order to address this, shifting agriculture is captured through distinguishing temporary from permanent land-use change (see Section 10.1.1.7).

7.5.1 Biomass Losses

In the absence of more detailed information on carbon stocks for non-Forest Land-use categories and Gabon's position to develop an accurate FRL based on national data and thereby not use IPCC Tier 1 default data, it is assumed that the carbon stocks immediately following deforestation due to permanent and temporary land-use change is zero, and carbon stocks from all pools were assumed to be committed to the atmosphere immediately at the time of deforestation.

7.5.1.1 Forest Land converted to non-Forest Land-use categories

Forest Land converted to non-Forest Land-use categories is characterised as the human-induced conversion of Forest Land to a non-Forest Land-use category. Gabon recognises two types: temporary and permanent. A change in land-use which has been observed for at least 10 years is considered by Gabon to be permanent. Gabon chooses not to follow the 20 years suggested by the IPCC (IPCC, 2006a) due to fast biomass recovery in tropical conditions. Forest Land converted to non-Forest Land-use categories 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. Temporary forest land converted to non-Forest Land-use categories in Gabon is caused by shifting agriculture.

7.5.1.2 Forest Land remaining Forest Land

Biomass losses in Forest Land remaining Forest Land are characterised as the reduction in biomass in these forests and can be described as degradation. This includes forest degradation due to shifting agriculture and other unknown forms of degradation. Forest degradation related to logging is not accounted for here.

7.5.1.3 Carbon biomass losses inside logging concessions

Carbon biomass losses inside logging concessions 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.

7.5.2 Biomass gains

Biomass gains are measured as an accumulation of biomass carbon in forests.

7.5.2.1 Non-Forest Land-use categories to Forest Land

Carbon biomass gains were calculated as the accumulation of carbon biomass from non-Forest Land-Use categories converted to Forest Land. Two types were recognised depending on the land-use conversion: natural forest regeneration following human-induced forest cover losses (observed in Cropland to Forest Land, Settlement to Forest Land and non-Forest Land-use categories to Forest Land) and natural forest encroachment into Grasslands and Wetlands (Grassland to Forest Land and Wetland to Forest Land).

7.5.2.2 Forest Land remaining Forest Land

Carbon biomass gains in Forest Land remaining Forest Land were calculated as carbon biomass accumulation in standing forest.

7.5.2.3 Carbon biomass gains inside logging concessions

Carbon biomass gains inside logging concessions were calculated as carbon biomass accumulation in Forest Land remaining Forest Land (standing forest), and the accumulation of carbon biomass from non-Forest Land-use categories converted to Forest Land (including both natural forest regeneration following human-induced forest cover losses and natural forest encroachment into Grasslands and Wetlands).

7.5.3 Summary of reporting organisation

Table 3 below summarizes the organisation of the emissions reporting by REDD+ activity.

Table 3 Organisation of the emissions reporting by REDD+ activity.

REDD+ Activity	National Land Tenure	Losses	Gains
Deforestation	Rural Area	Forest Land to non-Forest Land-use Categories • Temporary land-use change • Permanent land-use change	None
	Other Land Tenure		
Forest Degradation	Rural Area	Forest Land remaining Forest Land • Degradation	Forest Land remaining Forest Land • Standing forest
	Other Land Tenure		
Conservation of forest carbon stocks	Protected Areas	Forest Land remaining Forest Land • Degradation	Forest Land remaining Forest Land • Standing forest
		Forest Land to non-Forest Land-use Categories • Temporary land-use change • Permanent land-use change	Non-Forest Land-use Categories to Forest Land • Natural Regeneration • Natural Encroachment
SMF	Logging Concessions	Forest Land remaining Forest Land • Logging (timber production)	Forest Land remaining Forest Land • Standing forest
		Forest Land to non-Forest Land-use Categories • Implicitly included in logging (timber production)	Non-Forest Land-use Categories to Forest Land • Natural Regeneration • Natural Encroachment
Enhancement of forest carbon stocks	Rural Area	None	Non-Forest Land-use Categories to Forest Land • Natural Regeneration • Natural Encroachment
	Other Land Tenure		

8 Upwards adjustment

In accordance with relevant decisions of the COP, Gabon's FRL are established transparently taking into account historic data and is adjusted for national circumstances (paragraphs 7 and 9 decisions 4/CP.15 and 12/CP.17 respectively).

Gabon takes note of the limits proposed by the Green Climate Fund (GCF) REDD+ Results-Based Payments Pilot Programme and associated scorecard (Green Climate Fund, 2017) and the Forest Carbon Partnership Facility Carbon Fund Methodological Framework (FCPF, 2016) for HFLD countries. The GCF terms of reference for the pilot programme for REDD+ RBPs allows an upward adjustment that does not exceed 0.1% of the carbon stock over the eligibility period spread over the results reporting period and does not exceed 10% of the FRL (Green Climate Fund, 2017). The FCPF Methodological Framework allows a HFLD country to apply an annual upward adjustment of 0.1 % of the total forest carbon stock over their average annual historical emissions (FCPF, 2016), providing this does not exceed 10% of the FRL.

As an HFLD country and given its national circumstances (see Section 1.1 and Section 12.1), Gabon will apply a maximum permitted upward adjustment that is the equivalent of 10% of the FRL spread over the results reporting periods.

9 Compliance with IPCC Guidance and Guidelines

The annex of Decision 12/CP.17 (Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels as referred to in decision 1/CP.16) (UNFCCC, 2011) states that information used to develop a reference level should be guided by the most recent IPCC guidance and guidelines. Therefore, the IPCC 2006 Guidelines for National Greenhouse Gas Inventories: Agriculture, Forestry and Other Land-use (IPCC, 2006a) and the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019a) were used as a technical framework for the formulation of the FRL.

9.1 Good practice

Paragraph (b) of the annex of decision 12/CP.17 (Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels) (UNFCCC, 2011) states that the information provided by countries during the FRL submission should be transparent, complete, consistent and accurate. Gabon has followed this as outlined below.

- **Transparency:** Gabon's FRL information is openly available online[8]. Gabon is currently working on publishing relevant spatially explicit and non-spatial information through the open-access geoportal of the SNORF (currently under construction). The PNAT is accessible through this interactive platform. The data on the National Resources Inventory are published (Carlson et al., 2017; Poulsen et al., 2020; Wade et al., 2019).
- **Completeness:** as per the annex of decision 13/CP.19 (Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels) (UNFCCC, 2013), all data, methodologies, procedures used are presented and shared to allow for the independent reconstruction of the FRL.
- **Consistency:** The methodologies and data used are consistent with the guidance provided in the relevant UNFCCC decisions. The net removals are estimated in a way that is consistent and will remain functionally consistent as Gabon implements its various national policies and measures. The FRL is established maintaining consistency with anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks as will be contained in Gabon's updated greenhouse gas inventory.
- **Accuracy:** Estimates of emissions and removals are accurate and include estimates of uncertainty represented at the 95% confidence interval.

9.2 Tiers and approaches

Regarding the estimation of emissions and removals from Forest Land, the IPCC has released extensive Guidance and Guidelines (IPCC, 2019a, 2006a, 2003), that Gabon takes into account for the development of its FRL.

Gabon is mainly collecting information at Tier 2 and Approach 3 level. In terms of Emissions Factors, national data-sets include carbon stock data from Gabon's NRI which currently consists of a series of 104 permanent 1 ha plots (see Section 10.2.1.1) and logging Emissions Factors collected from twelve logging concessions as part of three separate studies (Ellis et al., 2019; Medjibe et al., 2013, 2011) (see Section 10.2.3) and logging Emissions Factors collected from twelve logging concessions as part of three separate studies (Ellis et al., 2019; Medjibe et al., 2013, 2011) (see Section 10.2.310.2.2).

In terms of Removals Factors data are collated for old-growth forest from a national network of 134 permanent 'research' plots which are regularly re-measured, part of the Afritron network (www.forestplots.net) and have been widely published. Newly collected re-measures from a subset of plots from the NRI and from previously studied logging concessions are also included to provide preliminary estimates of sequestration in logged and secondary forests. Gabon intends to take steps to improve Tier 2 data by completing re-measures in all 104 NRI plots, and to increase the robustness of the NRI inventory by establishing a total of 500 plots.

In terms of Activity Data, national remote sensing data-sets collected and compiled by SIRS are used to provide information to calculate all emissions and removals with the exception of logging emissions.

[8] Accessible here: https://www.dropbox.com/sh/0bk6j8zhhnf1go1/AABtfmpJpjwHfAHzhHc---cFa?dl=0

For logging emissions, national timber harvest production data are used, which have been nationally validated (Conseil National Climat, 2020). Other data concerning forestry management and national land tenure are sourced from national archives and government sources.

9.3 Consistency with the national greenhouse gas inventory

The FRL and the national greenhouse gas inventory are currently inconsistent. The data used for the development of the FRL are an improvement to the existing greenhouse gas inventory and will be integrated in upcoming submissions of the national greenhouse gas inventory and NDC. As part of the improvement plan of the FRL (see Section 15), the FRL will be aligned with any development of the greenhouse gas inventory to maintain consistency between the two systems.

10 Information used to construct the FRL

10.1 Activity Data

10.1.1 Activity Data derived from remote sensing

The Activity Data for all forest cover change – with the exception of logging activities (see Section 10.1.2) - were derived from remote sensing products generated by SIRS in these methods. The semi-random sampling method described by (Sannier et al., 2014) was used. This approach is considered advantageous in that it:

- provides a means of collecting reliable baseline data to assess the accuracy of the wall-to-wall maps (such as the ones produced by AGEOS),
- can be used independently of the forest cover maps to produce national estimates of forest cover using the direct expansion method,
- can produce rapid and efficient national forest cover area estimates,
- can be used to produce national land-use and change matrices.

Initially, the semi-random sampling method was used to assess accuracy and uncertainty in wall-to-wall forest cover and change maps produced by AGEOS for 1990, 2000, 2010 and 2015 (SIRS, 2019). In the context of the FRL, additional forest cover area and change statistics including the national IPCC Land-Use categories and national subdivisions described in Table 2 were then specifically produced for intervening years 2005 and 2018. Data for 1990 was added directly from the results from Sannier et al. (2014) with no re-analysis, therefore differences between the assessment for the 1990-2000 period and the other periods exist.

10.1.1.1 Sampling design

Some of the assessment years (1990, 2000, 2010, 2015 and 2018) had already been addressed in previous studies (SIRS, 2019, 2013). However, for 1990, 2000 and 2010 only 2 classes (Forest and Non-forest) were identified. For 2015-2018 the full set of IPCC land-use classes had been identified: these data were slightly updated for the FRL in order to ensure complete coherence with the other assessment years (i.e. 2000, 2010, 2015 and 2018 were updated to reflect the IPCC land-use categories, 1990 was not updated due to a lack of satellite imagery). The definition of forest was the same as the one adopted by Gabon.

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 two-stage sampling approach was implemented by selecting Secondary Sampling Units (SSUs) of 30mx30m within the PSUs (Figure 7). 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 total 665 PSUs of 400 ha were distributed across the country.

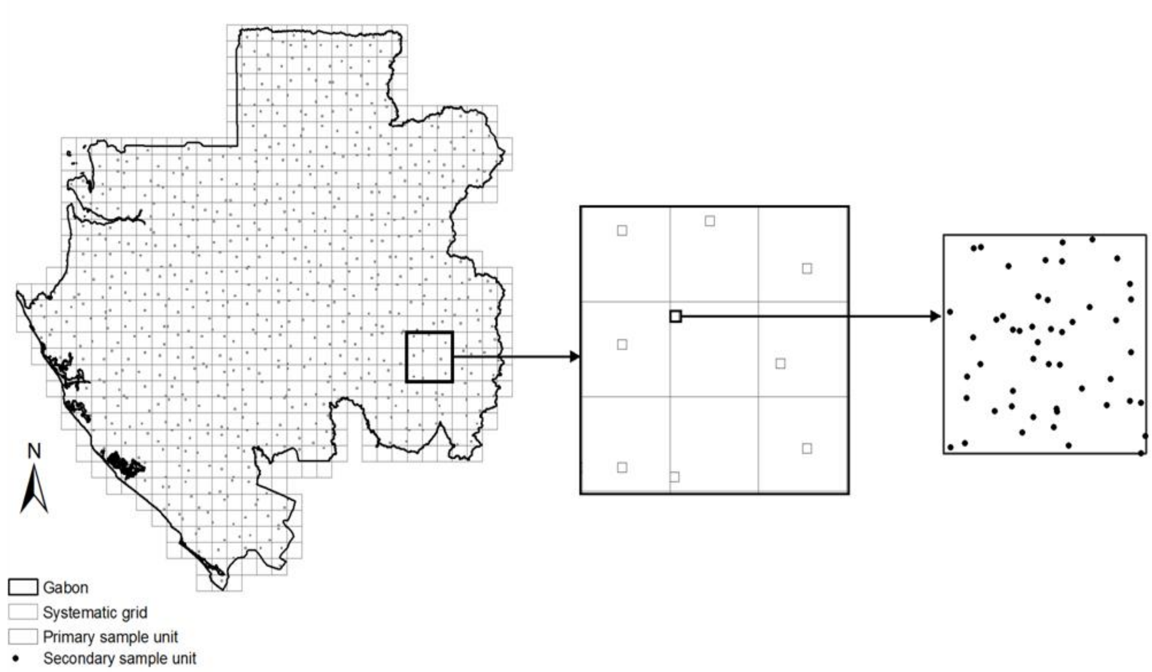

Figure 7 Sampling approach using a systematic grid, primary and secondary sample units (from SIRS, 2013).

The estimates are based on the direct expansion method (Sannier et al., 2014) which produces forest cover and forest cover change estimates based on samples alone. Area estimates can be derived directly from the sample data alone using the so-called direct expansion method as long as the data has been collected based on a probabilistic sample. The estimate of proportion (y) of class (c) and its variance are given by (Equation 1):

$$\bar{y}_c = \frac{1}{n} y_i$$

and

$$var\ (\bar{y}_c) = \left(1 - \frac{n}{N}\right) \frac{1}{n(n-1)} \sum_{i-1}^{n} (y_i - \bar{y}_c)^2$$

Equation 1

where:

y_i is the proportion of segment *i* covered by class *c*,
N is total number of segments in the region,
n is number of segments in the sample.

The proportion of the study region sampled (*n/N*) is the sample fraction.

The estimate of class area (*Z*) and variance in study area (*D*) are as follows (Equation 2):

$$\hat{Z}_c = D * \bar{y}_c$$

and

$$var\ (\hat{Z}_c) = D^2 * var\ (\bar{y}_c)$$

Equation 2

where *D* is the area of the region.

Analyses first focussed at a national level on the detection of:

- forest cover loss according to the national definition of forest,
- partial loss of forest-cover that was detected within a minimal surface area of 1ha with a tree cover that was equal to or greater than 30% (e.g. selective logging that may appear as degradation),
- forest regeneration,
- land-use and land-use changes.

Freely available Landsat TM 4 / TM 5 (1990) and Landsat 7/8 images (2000 to 2015), SPOT7 (2015) and Sentinel2 (2015 to 2019) were used for the analyses: however, the analysis of optical satellite imagery is particularly difficult in Gabon given it is one of the cloudiest countries in the world (http://www.acgeospatial.co.uk/the-cloudiest-place/). To facilitate the task a set of free online environmental monitoring tools were used (Open Foris: http://www.openforis.org/home.html). This made it possible to visualize the segments and the Landsat 7 / 8 and Sentinel 2 directly without having to download them, then to digitize the land-use /land cover in the PSUs and finally to generate statistics allowing to generate land-use and land cover change matrices (full details in (SIRS, 2019)).

Digitization was done using GIS software. The shapefile containing the 665 PSUs was updated with the analyses for each assessment year. An attribute field was added for each of these years so that a final, single attribute field per year was created containing the corresponding land cover and land-use code.

10.1.1.2 Identification of land cover and land-use types

To ensure complete consistency with other national processes, the land-use classes and national subdivisions described in Table 2 were used. The following steps were carried out to distinguish the different IPCC land-use categories and subcategories.

First, the validation that SIRS conducted in 2020 on the national land-use and land-cover map produced by AGEOS for the year 2015 (SIRS, 2020a) was used to assign different land-use (e.g. Cropland, Grassland, etc.) and land-cover codes to the 665 PSUs for the year 2015.

Second, in order to distinguish the different types of land-use and land-cover categories, the following rules for interpretation were used (especially for Landsat 7/8 images), supported by the time-series and shapefiles produced by (Lee, 2020):

- when an area is seen as "bare soil" for several consecutive years, and specially around a road, it is most of the time considered as the IPCC land-use category of "Settlements",
- when an area is seen as "bare soil" for a year, is regular in shape, and changes in appearance across years, this is classified as "shifting agriculture" and therefore forest degradation (Forest Land remaining Forest Land),
- when an area is seen as "bare soil" for a year and nearby there is a village or a road, this is considered as an agricultural area and therefore usually classified as the IPCC land-use category of "Cropland",
- when an area has a low vegetation cover (smoother texture) and that no human activity is observed, it is usually classified as the IPCC land-use category of "Grassland" (this also includes savannahs).

10.1.1.3 Rules for distinguishing between different forest cover change events

Once the digitalization was complete, rules to distinguish permanent from temporary land-use change, forest degradation, forest regeneration and stable forest cover were defined. 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 due to a lack of suitable satellite imagery. 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 4):

- **Permanent land-use change**: 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 by the remote sensing method was 'deforestation'.
- **Temporary land-use change**: 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 was identified by the remote sensing method as 'degradation'. Note however, that for Gabon's FRL this was not reported under REDD+ activity degradation, but under REDD+ activity deforestation.
- **Degradation** was 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 4). (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 Land) from Colonising Forest as the result of natural forest encroachment into savannahs (e.g. Grassland becomes Forest Land) - see Section 10.1.3.6).
- **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 4 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 deforestation[9]
Non-Forest	Secondary Forest	Secondary Forest	Regeneration at Year + 5, then stable

[9] 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.

The attribution of the areas of each land cover and land-use type and the change between assessment years were compiled into matrices (see Annex 2 in section 18.2), 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 10 national sub-categories. The exception was 1990, which was not reanalysed. Therefore, the 1990-2000 analysis only distinguishes forest and non-forest.

10.1.1.4 Analysis by National Land Tenure

The second phase of the work involved cross-referencing the PSUs with national data provided by MINEF, enhanced with historical data from the literature (Lee, 2020). From these datasets, shapefiles for the remote sensing assessment years spanning the two historical reference periods were generated for the six discrete National Land Tenure classes identified in Section 7.4 (in line with the PNAT). These were: logging concessions, protected areas, rural areas, agricultural areas, community forests and conservation set-aside zones (see Section 7.4.1 and Figure 6).

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 National Land Tenure classes (see Section 7.4.1) into one category "Other Land Tenure". Community Forests were combined with logging concessions. The surface areas for each of these National Land Tenure classes is indicated in Table 5.

Table 5 Area in hectares of the four different National Land Tenure classes retained for remote sensing analyses.

Year	Rural Area	Forestry Concession	Protected Area	Other Land Tenure	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, individual matrices were generated to allow land cover and land-use changes to be quantified for each National Land Tenure class, and for the Activity Data for emissions and removals calculations to be derived for each of the REDD+ activities.

10.1.1.5 Discrepancies between the "start" and "end" years for each assessment period

To generate land-use change matrices for each National Land Tenure class, a method was required to allow cross-checking between the PSUs and the National Land Tenure shapefiles, which changed in size and shape between the start and end of each assessment period due to the historical administrative changes in National Land Tenure. Thus, the number of PSUs selected for land-use change analysis was made based on the size and shape of the shapefile at the end of each assessment period. This meant the number of PSU's that were retained within a National Land Tenure shapefile at the beginning of each assessment period differed to the number at the end of the previous assessment period, because they were all selected on the basis of the shapefile at the end of each assessment period (and there was no complete overlap between them) (Figure 8). This difference meant that the estimated total forested areas within each National Land Tenure class differed between the end and start of each assessment period. This discrepancy had no incidence on the Activity Data derived for biomass losses, since the calculations for biomass losses took into consideration the annual average change in forest cover area as detected between each assessment period. However, this discrepancy affected the Activity Data for removals, as the interpolation of estimated total forested area was made between assessment years, so the forest state at both the start and end of each assessment period needed to be considered. This will be addressed as part of the improvement plan.

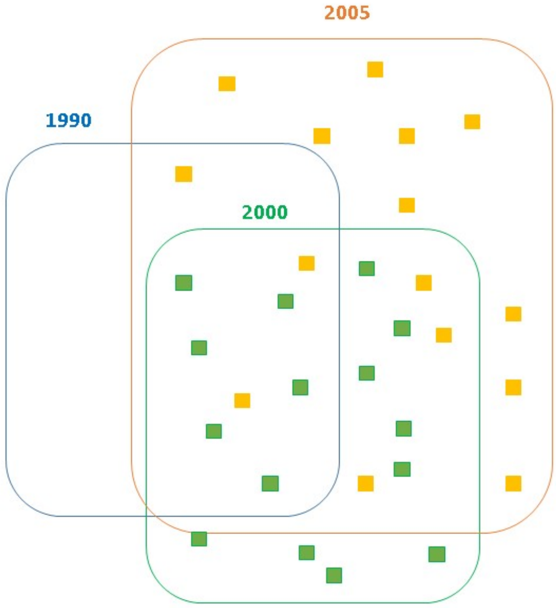

Figure 8 Example of difference in PSU placement in National Land Tenure shapefiles at the 'start' and 'end' of assessment periods. Here, the blue polygon represents a land tenure shapefile at the start of the 1990-2000 assessment period. The PSUs for land-use change analysis (green squares) are selected based upon the shapefile area in 2000 (green polygon). For the 2000-2005 analysis, the PSU's (yellow squares) are selected based on the shapefile area in 2005 (yellow polygon). Therefore, for year 2000, at the 'end' of the 1990-2000 period, and the 'start' of the 2000-2005 period, the sampling effort within the shapefile (PSU placement) is different.

10.1.1.6 Forest cover and change statistics for Gabon

Initial analysis conducted at a national scale (not stratified by National Land Tenure), provide the following forest cover statistics for Gabon (Table 6). These data are considered the most accurate and precise for overall forest cover statistics for the country.

Table 6 Forest cover, 95% CI and uncertainty for each assessment year (from the national-level analysis).

	Forest Cover		
Year	Area (ha)	95% CI (ha)	Uncertainty
1990	23,663,312	532,580	2.3%
2000	23,589,451	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%

The data illustrate the consistently high forest cover Gabon has maintained over the last three decades. Total forested area has barely changed: 88.4% forest cover in 1990, 87.8% in 2018.

Note that the FRL only uses data from the analysis conducted at the 'National Land Tenure Level': i.e. for each of the National Land Tenure classes. When summed, discrepancies between these results and the national scale analysis are observed (Section18.4 Annex 4). All observed differences in forest cover are small and fall within the 95% CI of the national level estimates.

The areas of forest within each National Land Tenure class are shown in Table 7. They have changed considerably as a function of the administrative changes in National Land Tenure over time. Significant increases are observed in logging concessions and protected areas as more have been created, whereas forested land under Other Land Tenure has reduced in size.

Table 7 Area of forest for each National Land Tenure class.

Year	Rural Area		Logging Concession		Protected Area		Other Land Tenure		Total Forest	
	Area (ha)	U	Area (ha)	U	Area (ha)	U	Area (ha)	U	Area (ha)	U
1990	1,881,019	N/A	6,561,557	N/A	784,801	N/A	14,489,730	N/A	23,717,107	N/A
2000	1,972,718	8.2%	13,210,040	1.1%	1,707,571	5.3%	6,754,510	6.3%	23,644,840	2.1%
2005	1,920,438	8.5%	14,079,723	0.9%	1,729,738	7.0%	6,016,450	6.6%	23,746,349	1.9%
2010	1,956,286	8.4%	13,175,402	1.0%	3,230,610	6.1%	5,361,776	7.0%	23,724,074	2.0%
2015	1,628,915	12.5%	14,190,984	0.7%	3,334,691	5.9%	4,514,799	8.2%	23,669,389	2.0%
2018	1,369,047	11.2%	15,374,043	0.9%	3,336,167	5.9%	3,639,528	9.1%	23,718,785	1.9%

Forest cover change statistics (Table 8 and Table 9) indicate low rates of forest cover loss that have largely been offset by natural forest regeneration. Permanent land-use change from Forest Land to non-Forest Land use categories did not exceed 0.05% even with the onset of several key industrial development initiatives in the 2010's. Annual rates of permanent forest cover losses, however, appear to have doubled in the last three years (2015-2018).

Table 8 Extent of forest cover change detected as either temporary or permanent land-use change, degradation or regeneration for each assessment period. U = Uncertainty.

Assessment Period	Permanent land-use change		Temporary land-use change		Degradation		Regeneration	
	Area (ha)	U	Area (ha)	U	Area (ha)	U	Area (ha)	U
1990-2000	79,648	50.8%	44,837	83.8%	0	0.0%	52,217	24.8%
2000-2005	28,643	40.5%	41,193	43.1%	9,496	80.6%	59,084	54.7%
2005-2010	38,530	44.5%	29,333	33.2%	18,432	88.1%	60,298	22.7%
2010-2015	60,956	65.2%	38,457	41.2%	5,997	157.5%	47,333	26.7%
2015-2018	69,017	18.4%	13,570	54.9%	14,520	180.7%	59,566	27.3%
Total	**276,794**	**22.3%**	**167,390**	**27.6%**	**48,445**	**68.5%**	**278,498**	**15.3%**

Table 9 Percentage forest cover change detected, as a proportion of the total forested area from the start of each assessment period.

Assessment Period	Permanent land-use change		Temporary land-use change		Degradation		Regeneration	
	% forest change	annual % change	% forest change	annual % change	% forest change	annual % change	% forest change	annual % change
1990-2000	0.3%	0.03%	0.2%	0.02%	0.0%	0.00%	0.2%	0.02%
2000-2005	0.1%	0.02%	0.2%	0.03%	0.0%	0.01%	0.2%	0.05%
2005-2010	0.2%	0.03%	0.1%	0.02%	0.1%	0.02%	0.3%	0.05%
2010-2015	0.3%	0.05%	0.2%	0.03%	0.0%	0.01%	0.2%	0.04%
2015-2018	0.3%	0.10%	0.1%	0.02%	0.1%	0.02%	0.3%	0.08%
Total	**1.2%**	**0.04%**	**0.7%**	**0.03%**	**0.2%**	**0.01%**	**1.2%**	**0.04%**

However, it is important to remember the following points when interpreting the most recent forest cover change statistics:

- Sentinel 2 images were used in the 2015-2018 analysis, which have a higher spatial resolution than the previously used Landsat images, and capable of detecting more forest cover disturbance.
- The method used for distinguishing forest cover losses resulting in land-use change (either permanent or temporary) relies on knowledge of a future state. For earlier assessment years, five-year periods were used to detect forest cover losses (e.g. the status in 2015 was used to identify

forest cover losses observed between 2005 and 2010), whereas for 2015-2018 it was only possible to compare against the status in 2019. Therefore, forest cover loss between 2015 and 2018, which remains non-forest in 2019 would be categorised as deforestation, but if it recovers by 2020 or 2025 would not be detected as such. Therefore, permanent land-use change may have been overestimated in 2015-2018, and as a result it is expected that part of the allocation of forest cover loss may shift from permanent to temporary land-use change during future analyses.

The historically low levels of forest cover losses have been partially offset by natural regeneration (Table 8 and Figure 9), much of which is expected to be due to shifting agriculture and forest disturbance recovery in logging concessions. Overall, forest cover losses due to temporary and permanent land-use change have occurred at 1.6 times the rate of forest gains.

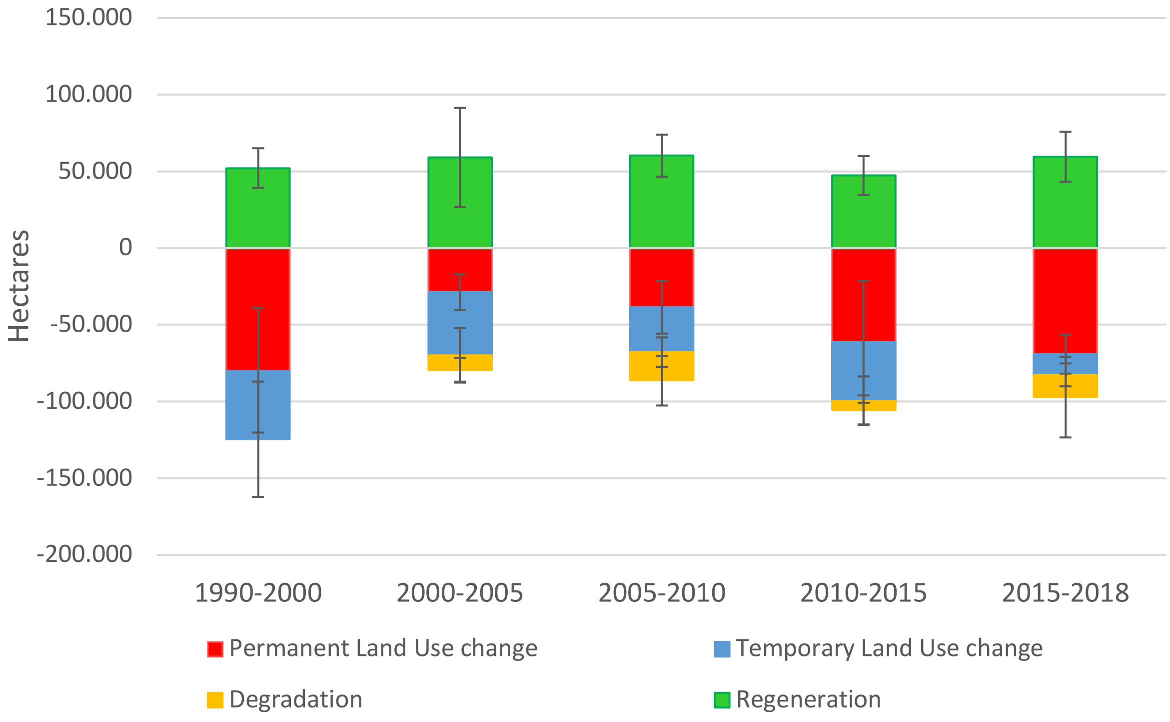

Figure 9 Total forest cover change detected in Gabon for five assessment periods between 1990 and 2018, with 95% CIs. Forest losses are plotted as negative values, forest gains are plotted as positive values.

10.1.1.7 Activity Data for Biomass losses from Forest Land converted to non-Forest Land-use Categories

Data for both permanent and temporary land-use change (Forest land to non-Forest Land-use categories) from the remote sensing matrices were extracted and reorganised into tables. All data were organised by National Land Tenure, IPCC land-use category, duration of land-use change (temporary or permanent), REDD+ Activity and Forest Type lost.

Data were allocated to a REDD+ activity according to National Land Tenure (Table 10).

Table 10 Organisation of Land Tenure for reporting biomass losses from Forest Land converted to non-Forest Land-use categories under different REDD+ Activities.

National Land Tenure	REDD+ Activity
Rural Area	Deforestation
Other Land Tenure	Deforestation
Protected Areas	Conservation

Note that remote sensing data for forest cover losses inside logging concessions were excluded, for the reasons outlined below (Section 10.1.1.7.1).

In order to ensure consistency with the removals calculations and the application of the most appropriate Emissions Factor, the forest types lost as detected by remote sensing method were interpreted according to current ecological knowledge of Gabonese forests (Table 11). Forest cover losses were detected in Dense, Flooded and Secondary forest but none in mangroves, therefore mangroves were not retained as a forest type for calculation of emissions.

Table 11 Interpretation of forest types identified by the remote sensing method for application of appropriate Emissions Factors for carbon biomass losses (RS = remote sensing).

Forest type lost as designated in RS method	Interpretation	Justification	Most appropriate Emissions Factor to apply
Dense and Flooded Forest	Old growth, Old Secondary Forest and Older Logged Forest.	Old Secondary Forest, old growth and older selectively logged forest are likely to appear identical with RS, therefore 'dense' forest is likely to contain all types. Flooded forest is included in the same category here, as already included in the Emissions Factor	Mean carbon stocks measured from the NRI for Old Growth, Secondary and Logged Forest.
Secondary forest	Secondary Forest	Secondary forest that is lost to deforestation would have been detected as either stable secondary forest in the previous assessment period or as dense forest degraded to 'secondary' forest. It is therefore likely to be a mixture of Young Secondary Forest and Degraded Forest.	The mean carbon stock for secondary forest is applied here, derived from the NRI.

The total area of forest cover losses were recorded for each assessment period, with 95% CI and uncertainty values. The average annual area of forest cover loss was then derived from the totals recorded for each assessment period: these yearly averages constituted the annual Activity Data for biomass losses from Forest Land converted to non-Forest Land-Use categories: an example is presented in Table 12. The full Activity Data for biomass losses from Forest Land converted to non-Forest Land-use Categories - reported under REDD+ activities Deforestation and Conservation is presented in Sections 18.5 Annex 5 and 18.6 and Annex 6.

10.1.1.7.1 Justification for excluding data on forest cover losses detected by remote sensing from logging concessions

Biomass losses from Forest Land converted to non-Forest Land-use Categories and Forest Land remaining Forest Land, as detected by the remote sensing method within logging concessions were excluded from emissions calculations. This is because it was considered that the vast majority of this is likely to be linked to forestry activities, such as the creation of haul roads and log yards, which are already included in the Emissions Factors for logging emissions. Between 2000 and 2018, 72% of the forest cover losses detected within logging concessions by the remote sensing method were attributed to the creation of roads and "Settlements" (here, the term "Settlement" follows the IPCC definition), most of which are likely to be haul roads and log yards. The rest was attributed to the creation of Cropland and Grassland, part of which may include some shifting agriculture but may also include other cleared areas where grasses have subsequently established. While it is recognised that the exclusion of all forest cover losses from within logging concessions may have resulted in the exclusion of some Activity Data not related to selective timber harvesting (e.g. shifting agriculture), it is also recognised that any illegal logging detected outside of logging concessions as forest cover loss or degradation has almost certainly been double-counted due to the fact that the Activity Data for logging emissions includes illegally harvested timber.

While a more detailed analysis is required to disentangle the true extent of these factors, it was considered a reasonable approximation to assume that the inclusion of all forest cover loss data outside of logging concessions (thereby potentially double-counting illegal logging) offsets the exclusion of all forest cover loss data inside logging concessions (thereby potentially excluding some shifting agriculture).

Table 12 Example of the organisation of remote sensing data to derive Activity Data for Forest Land converted to non-Forest Land-use categories (permanent land-use change). Presented here are the Activity Data for Rural Area, assessment period 2010-2015, reported under REDD+ Activity Deforestation (RS = remote sensing; LUC = Land-Use Change category; CI= Confidence Interval, U = Uncertainty).

National Land Tenure	IPCC LUC	Forest type lost (RS)	Interpretation	Total area changes per assessment period (ha)			Activity Data: Yearly change (ha):	
				2010-2015			2010-2015	
				Total (ha)	95% CI (ha)	U	Total (ha)	U
Rural Area	Forest Land to Cropland	Dense + flooded	Old growth, old secondary, older logged	2,070	2,221	107.3%	414	107.3%
		Secondary	Secondary	3,706	3,264	88.1%	741	88.1%
	Forest Land to Grassland	Dense + flooded	Old growth, old secondary, older logged	96	188	196.0%	19	196.0%
		Secondary forest	Secondary	0	0	0.0%	0	0.0%
	Forest Land to Wetland	Dense + flooded	Old growth, old secondary, older logged	531	1,041	196.0%	106	196.0%
		Secondary forest	Secondary	0	0	0.0%	0	0.0%
	Forest Land to Settlement (including roads)	Dense + flooded	Old growth, old secondary, older logged	480	897	187.1%	96	187.1%
		Secondary forest	Secondary	213	275	128.8%	43	128.8%
	Forest Land to Other Land	Dense + flooded	Old growth, old secondary, older logged	1,552	3,041	196.0%	310	196.0%
		Secondary forest	Secondary	972	1,905	196.0%	194	196.0%
			Total Rural Area	9,620	8,863	92.1%	1,924	92.1%

10.1.1.8 Activity Data derived for biomass losses in Forest Land remaining Forest Land

Degradation data (where Forest Land Remains Forest Land) from the remote sensing matrices were extracted and reorganised into tables. All data were organised by National Land Tenure, IPCC land-use category, REDD+ Activity and Forest Type degraded.

Data were allocated to a REDD+ activity according to National Land Tenure (Table 13).

Degradation identified by the remote sensing method that occurred inside logging concessions were excluded from the analyses, because logging degradation is already included in the calculations for selective timber harvesting (See section 10.1.2).

Table 13 Organisation of Land Tenure for reporting biomass losses from Forest Land Remaining Forest Land under different REDD+ Activities.

National Land Tenure	REDD+ Activity
Rural Area	Degradation
Other Land Tenure	Degradation
Protected Areas	Conservation

In order to ensure consistency with the removals calculations and the application of the most appropriate Emissions Factor, the Degraded Forest types as detected by remote sensing were interpreted according to current ecological knowledge of Gabonese forests (Table 11). The remote sensing analyses identified degradation in Dense, Flooded and Secondary forest but none in mangroves, therefore mangroves were not retained as a forest type for calculation of emissions from degradation.

The total area lost to degradation was recorded for each assessment period, with 95% CI and uncertainty values. The average annual area lost to degradation was then derived from the totals recorded for each assessment period.

An example of the Activity Data for Degradation is presented in Table 14 and the full Activity Data for Degradation reported under REDD+ activities Degradation and Conservation is presented in Annex 7, Section 18.7.

Table 14 Example of the organisation of remote sensing data to derive Activity Data for degradation. Presented here are the Activity Data for Other Land Tenure, assessment period 2000-2005, reported under REDD+ Activity Degradation (RS = remote sensing; LUC = Land-Use Change category; CI = Confidence Interval, U = Uncertainty).

National Land Tenure	IPCC LUC	Forest type degraded (RS)	Interpretation	Total area changes per assessment period (ha)			Yearly change (ha): Activity Data for Degradation	
				2000-2005			2000-2005	
				Total (ha)	95% CI (ha)	U	Total (ha)	U
Rural Area	Forest Land remains Forest Land	Dense + flooded Forest	Old growth, old secondary, older logged	4,727	5,627	119.0%	945	119.0%
Protected Areas	Forest Land remains Forest Land	Dense + flooded Forest	Old growth, old secondary, older logged	0	0	0%	0	0%
Other Land Tenure	Forest Land remains Forest Land	Dense + flooded Forest	Old growth, old secondary, older logged	**1,538**	**2,434**	**158.2%**	**308**	**158.2%**

10.1.2 Activity Data derived from volume estimates for logging

10.1.2.1 Considerations for obtaining the most accurate source of Activity Data for logging emissions

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. These are discussed below.

- *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*. Section 10.1.1 describes the remote sensing method used to derive Activity Data for the FRL, from which the area of forest cover loss was measured within 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.

10.1.2.2 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 Ingénierie, 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 10 and FRM Ingénierie, 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 10) (FRM Ingénierie, 2020).

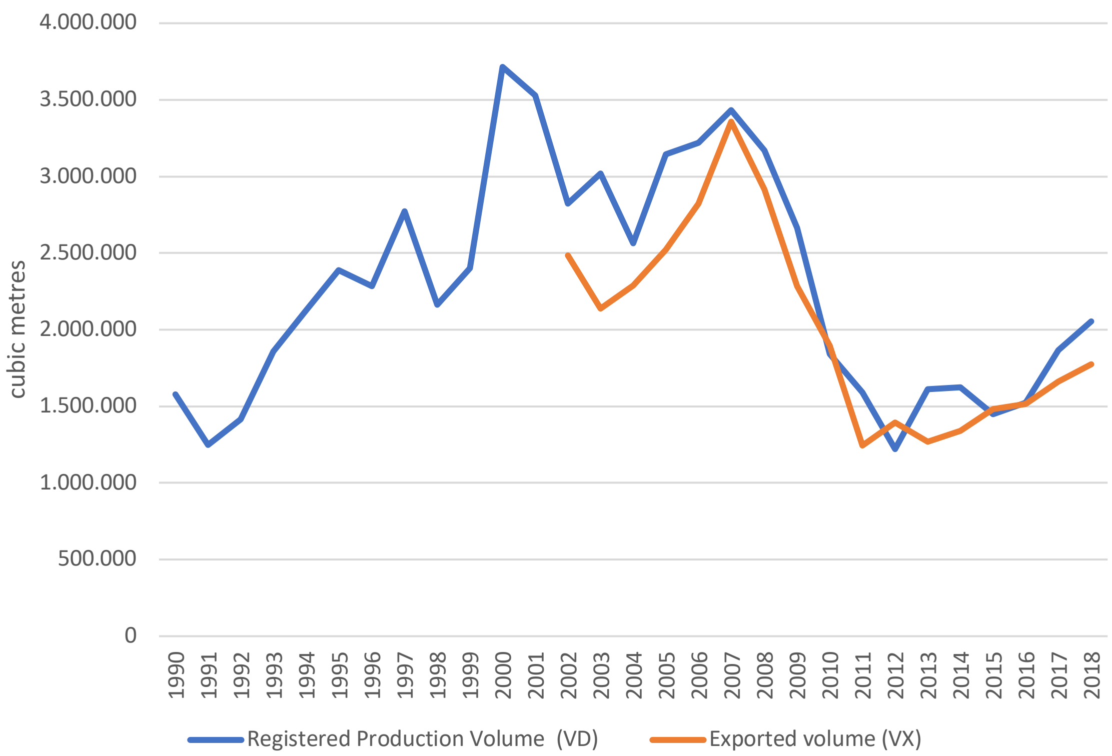

Figure 10 Comparison of registered production volume (V_D, blue line) and exported volume (V_X, red line).

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 11).

Furthermore, the analysis of the declared timber production volume and export volume illustrates that 'illegal logging' is captured as part of that information (FRM Ingénierie, 2020). Illegal logging can include a variety of elements such as logging in the wrong area, logging smaller diameters, logging the wrong species, logging beyond the authorised volume etc.

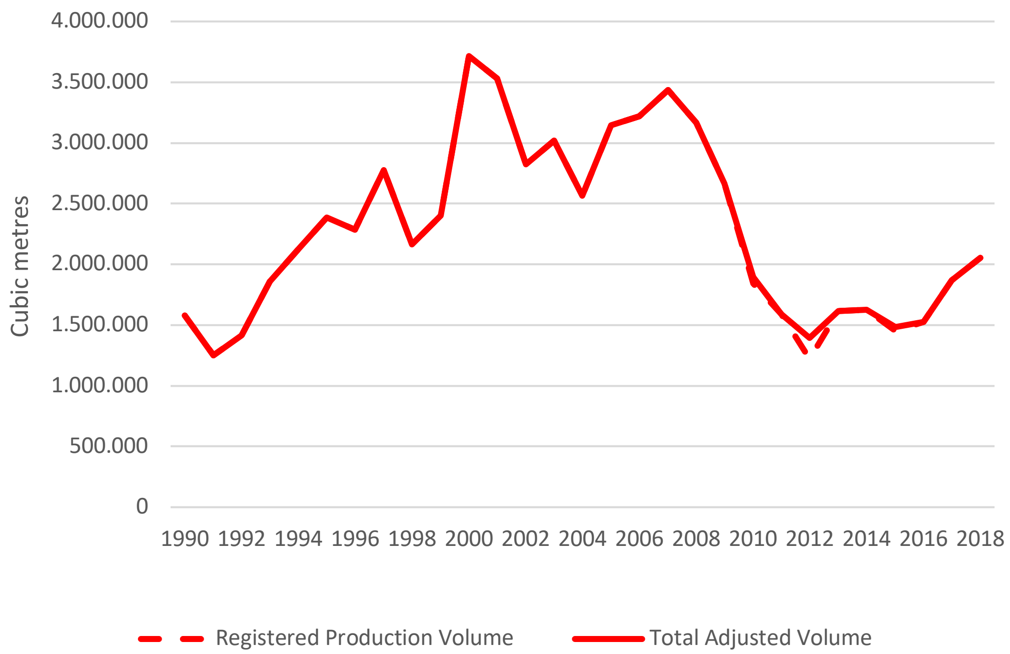

Figure 11 Adjusted, conservative production volume data (solid red line), retained as the Activity Data, 1990-2018.

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

10.1.2.3 Activity Data derived for logging emissions.

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 15). The approach taken to derive Uncertainty is described in Section 13.

Table 15 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%
Mean (1990-2018)	**2,295,476**	
95%CI	**268,957**	

10.1.3 Activity Data for Biomass Gains

The Activity Data for carbon biomass gains was derived from a combination of the remote sensing data (Section 10.1.1) and Activity Data used to calculate logging emissions (Section 10.1.2).This approach was taken to enable the estimation and inclusion of the area of Logged Forest as it was considered to better represent Logged Forests.

10.1.3.1 Step 1. Organisation of forest regeneration data

Data for forest regeneration (Non-Forest Land-use Categories to Forest Land) from the remote sensing matrices were extracted and reorganised into tables. All data were organised by National Land Tenure, IPCC land-use category, REDD+ Activity and Forest Type regenerated. The remote sensing method identified all regenerated forest within an assessment period as 'secondary' forest. As a further step, Gabon interpreted this according to the type of land-use conversion observed: regenerating forest from Cropland, Settlement or Other Land to Forest Land was considered to be following human-induced forest-cover losses. This type of regeneration was identified as Young Secondary Forest. However, regenerating forest from Grassland or Wetland to Forest Land was considered to be part of natural forest encroachment into previously non-forested areas that is observed throughout the country (Delegue et al., 2001; Jeffery et al., 2014; Mitchard and Flintrop, 2013). This type of regeneration was identified as Colonising Forest.

The total area of forest cover gains were recorded for each assessment period, with 95% CI and uncertainty values. The average annual area of forest cover gains was then derived from the totals recorded for each assessment period.

10.1.3.2 Step 2. Creation of Forest Cover matrices

Forest cover matrices were generated that combined annual change data for regenerating forest (Step 1) with the area of standing forest (Stable and Degraded forest in Forest Land remaining Forest Land) in order to construct the Activity Data for biomass gains.

Matrices were organised by National Land Tenure, IPCC land-use change category, Forest state (Stable, Degraded or Regenerating) and Forest type.

First, data for each assessment year were extracted from the remote sensing matrices and inserted into the tables. Here, data were taken from both the start and end of each assessment period. This was necessary, because, due to the nature of remote sensing method (the PSU sampling approach combined with changes in the size and shape of the National Land Tenure classes between assessment years) the total forested areas within each Land Tenure class at the end of each assessment period did not exactly match the areas at the start of the subsequent period (Section 10.1.1.5). For Forest Remaining Forest Land, the area of each forest type at the end of each assessment period differed to the area at the start of the subsequent period. For Non-Forest Land-use Categories to Forest Land (Regenerating forest), the area at the start of each assessment period was zero.

10.1.3.3 Step 3. Interpolation of data to create annual time series

For Forest Land Remaining Forest Land (which included Stable and Degraded Forest), the areas of each forest type (Dense + Flooded, Secondary and Mangrove) between the start and end of each assessment period were interpolated by taking the average annual difference between the two years and summing them to the area of the previous year.

For non-Forest Land-use Categories to Forest Land (which included regenerating forest), the annual area of forest cover gains for each assessment period (derived in Step 1) was taken.

In order to ensure that the total forest areas across each forest sub-category summed correctly, the annual area of newly regenerated forest needed to be 'retired' each year from the "Non-Forest Land-use Categories to Forest Land" category to 'Forest Land Remaining Forest Land'. Therefore, two new forest subcategories were created in 'Forest Land Remaining Forest Land': Young Secondary Forest and Colonising Forest. These represented the total (cumulative) area of regenerated forest between any two assessment years. This was computed for each year by summing the area of annual regenerated forest to the total (cumulative) area for the previous year.

The total Forested area in each National Land Tenure class was interpolated between the start and end of each assessment period by taking the average annual difference between the two years and summing them to the area of the previous year. The sum of the derived data for each forest sub-category was then double-checked against the interpolated totals, to ensure they matched exactly.

10.1.3.4 Step 4. Estimation of the area of Logged Forest

To better represent the estimates of the area of Logged Forest and to ensure methodological consistency with the logging emissions calculations, the area of Logged Forest was derived from the Activity Data used to calculate logging emissions (timber production volume data, see Section 10.1.2). 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 15) were converted to Equivalent Harvested Areas (A_{EH}) using Equation 3 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 3

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 interpolated 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 4:

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

Equation 4

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 5):

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

Equation 5

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. The area of Logged Forest (LF_{10} and LF_{25}) over time is indicated in Figure 12.

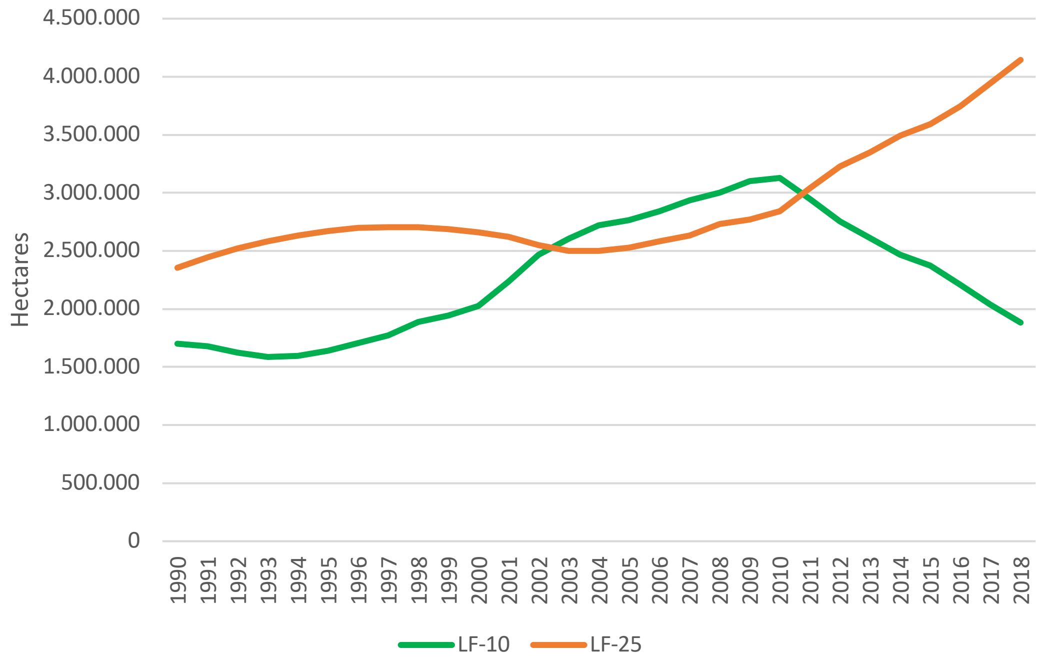

Figure 12 Estimated area of Logged Forest (LF-10 = forest logged 1-10 years earlier; LF-25 = forest logged 11-25 years earlier), 1990-2018.

10.1.3.4.1 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.

10.1.3.4.2 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}.

10.1.3.5 Step 5. Integration of Logged Forest into the forest cover matrices.

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.

First, a second forest cover matrix was created, that linked to the data in the first set. Here, the assessment years at the 'start' of each assessment period were excluded (with the exception of 1990, which was the first assessment year), in order to generate an annual time series with only 1 set of values per year.

To integrate the Logged Forest data, the assumption was made that all forest identified in the category Young secondary and Degraded Forest (see Table 16) 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, Table 16) within logging concessions and protected areas, to ensure the total forested areas were correct.

The Adjustment to the Activity Data was made as follows:

1. Sum of two Logged Forest categories: (LF_{10} + LF_{25})
2. Sum of two secondary forest categories (Degraded + Stable)
3. Deduct area of secondary forest from Logged Forest (Logged - Secondary)
4. Deduct the remaining area from the area of 'Dense' forest ('Dense' – Remaining Logged)

This resulted in the final annual time-series of forested areas in hectares disaggregated by National Land Tenure, IPCC land-use category, REDD+ Activity and forest type (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 17). All data sum to the total forested area for Gabon for each year.

10.1.3.6 Step 6. Interpretation of forest types to apply removals factors.

The designation of different forest types, as identified by the remote sensing method, were interpreted according to current ecological knowledge of Gabonese forests to (a) ensure consistency with the approach taken for biomass losses, and (b) to ensure application of the most appropriate removals factors. The approach taken and reasoning is detailed in Table 16.

Table 16 Interpretation of forest types identified by the remote sensing method for the application of Removals Factors.

Type of Forest cover change between assessment years	Forest type as designated by Remote Sensing method	Interpretation	Justification	Most appropriate removals factor to apply (see Table 25)
-Dense forest remains dense -Flooded forest remains flooded	Dense and Flooded Forest	Old growth, Old Secondary Forest and Older Logged Forest.	Old Secondary Forest, old growth and selectively Logged Forest are likely to appear identical with RS, therefore 'dense' forest is likely to contain all types. Flooded forest is included in the same category here, as no separate removals factor is available	Mean value for old growth and Old Secondary Forest
-Secondary forest remains secondary -Dense forest is degraded to secondary	Secondary forest	Secondary	Stable secondary forest that is detected by RS is likely to be Young Secondary Forest. Forest that is identified by RS as degraded from dense forest to secondary is likely to be heavily degraded, through shifting agriculture or heavy logging. They are included in the same category at this stage.	Mean value for Old Secondary and Young Secondary
Cropland, Settlement and Other Land becomes Forest Land	Secondary Forest	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.	Young Secondary Forest
Grassland and Wetland becomes Forest Land	Secondary forest	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	Colonising Forest
Mangrove Forest remains mangrove	Mangrove Forest	Mangrove Forest	No change in forest classification required. Note that no regenerating Mangrove Forest was identified by the RS analysis.	Mangrove Forest
Forest remains forest (1990-2000)	Unidentified forest	Unidentified forest	1990-2000 only. No forest types were distinguished. Likely to be majority Old Growth, Old Secondary and Logged Forest	Mean value for old growth and Old Secondary Forest
Non-forest becomes forest (1990-2000)	Secondary Forest	Young Secondary Forest	Regenerating forest detected in 1990-2000 period assumed to be Young Secondary Forest	Young Secondary Forest

Table 17 Example of the Activity Data derived for removals calculations. Presented here are the Activity Data for logging concessions, 2010-2018, reported under REDD+ activity SMF.

REDD+ Activity	SMF												
National Land Tenure	Logging Concessions												
IPCC LUC	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Cropland becomes Forest Land	Grassland becomes Forest Land	Wetland becomes Forest Land	Settlement becomes Forest Land	Other Land becomes Forest Land
Forest State	Stable	Stable	Degraded	Stable	Stable	Stable	Stable	Stable	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating
Forest Type	Old growth, old secondary, older logged	Secondary	Secondary	Mangrove	Young Secondary	Colonising	Logged (1-10)	Logged (11-25)	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary
2010	7,691,852	0	0	13,552	22,259	523	2,953,183	2,488,339	911	131	0	4,653	0
2011	6,621,407	0	0	0	0	0	2,802,092	2,684,187	1,372	166	0	1,871	0
2012	7,121,152	0	0	0	3,243	166	2,635,507	2,867,590	1,372	166	0	1,871	0
2013	7,637,792	0	0	0	6,485	332	2,513,416	2,989,605	1,372	166	0	1,871	0
2014	8,129,633	0	0	0	9,728	498	2,394,898	3,132,847	1,372	166	0	1,871	0
2015	8,617,473	0	0	0	12,970	664	2,320,992	3,235,477	1,372	166	0	1,871	0
2016	9,000,508	0	0	0	0	0	2,170,982	3,400,320	2,899	24	0	4,400	0
2017	9,344,269	0	0	0	7,299	24	2,017,983	3,599,690	2,899	24	0	4,400	0
2018	9,668,375	0	0	0	14,598	48	1,882,538	3,801,161	2,899	24	0	4,400	0

10.1.3.7 Distribution of Forest types in Gabon

Steps 1-4 above resulted in a detailed time series of forest cover by type and their distribution across the main National Land Tenure classes (Table 18 and Figure 13). The data illustrate the importance of logging concessions for the bulk (57%) of Gabon's 'dense' (old growth, old secondary and older logged) forest. However, about one fifth (19.5%) of this forest type is found in the 'Other Land Tenure' category, which includes areas of industrial agriculture. It should be noted that for the young secondary and Colonising Forest the values only represent the areas of new forest growth (regeneration) between 1990 and 2018, not the total expected areas of these forest types (for which a baseline would be required).

Table 18 Distribution of forest cover (in hectares) by forest type and National Land Tenure, for the most recent assessment year 2018.

	National Land Tenure				
Forest subdivision	Logging Concessions	Other Land Tenure	Protected Areas	Rural Area	Total
Old growth, old secondary, older logged	9,668,375	3,315,611	2,912,359	1,073,476	**16,969,821**
Secondary	0	231,632	0	278,702	**510,334**
Logged (1-10)	1,882,538	0	0	0	**1,882,538**
Logged (11-25)	3,801,161	0	348,673	0	**4,144,834**
Mangrove	0	73,582	78,110	0	**151,692**
Young Secondary	21,897	18,487	2,025	15,396	**57,804**
Colonising	72	217	0	1,474	**1,762**
Total	**15,374,043**	**3,639,528**	**3,336,167**	**1,369,047**	**23,718,785**

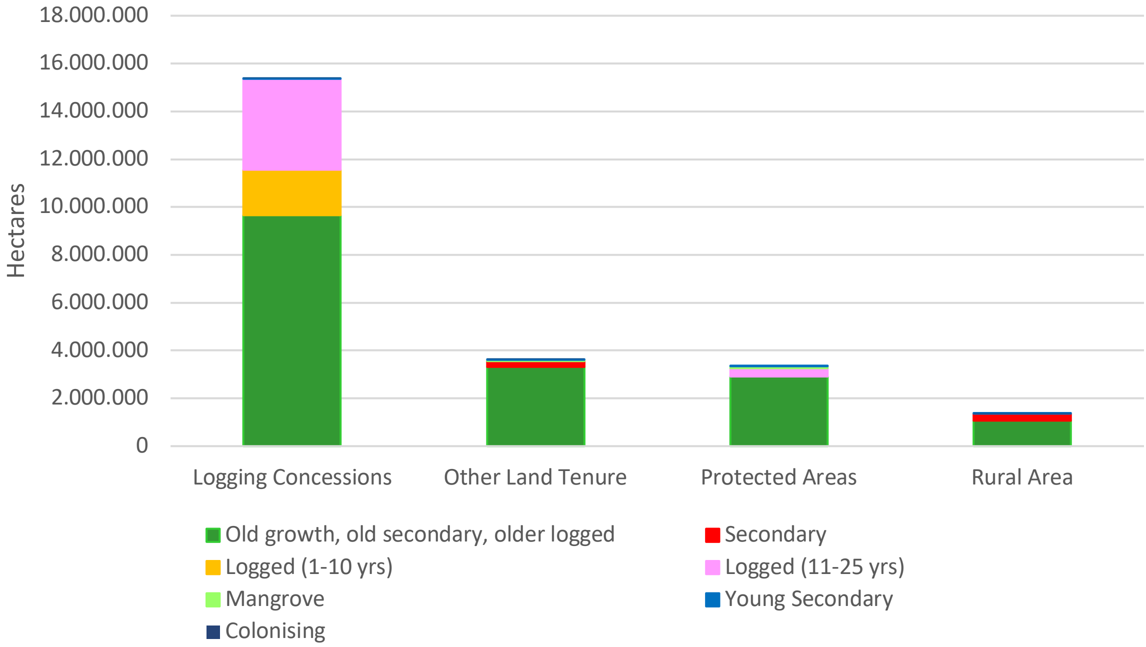

Figure 13 Distribution of forest types for each National Land Tenure class, 2018.

10.2 Emissions Factors

For all Emissions and Removals Factors, the following treatment was applied:

Data were partitioned into above-ground (AGB) and below-ground (BGB) portions using the shoot-root ratio of 0.235 at the stand level for moist tropical forests >125 t/ha (Mokany et al., 2006), following Equation 6:

$$BGB = AGB * 0.235$$

Equation 6

- To convert biomass to carbon the most recent carbon conversion factor for tropical forests of 0.456 was applied (Martin et al., 2018), following Equation 7:

$$Carbon = dry\ biomass * 0.456$$

Equation 7

- Carbon stock values were converted to tCO_2eq following Equation 8:

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

Equation 8

10.2.1 Emissions Factors for biomass losses for Forest Land converted to non-Forest Land-use categories

National-level carbon stock data for forests in Gabon have been sourced for all major carbon pools. Emissions Factors retained for the FRL are compiled from the Gabonese government's National Resource Inventory (NRI; Poulsen et al., 2020). Several independent research studies were additionally sourced to provide data for reporting carbon stocks in forest types and carbon pools not considered for emissions in this version of the FRL.

10.2.1.1 Methods to estimate Emission Factors for old growth, secondary and Logged Forest

Carbon stocks for Old Growth, Secondary and Logged Forest are sourced from Gabon's NRI (Poulsen et al., 2020). The NRI currently consists of a series of 104 permanent 1-ha plots (with plans to increase it to 500 permanent plots) established across Gabon using a semi-systematic design (Poulsen et al., 2020). A stratified sampling design was considered but rejected for the following reasons (Poulsen, 2013): (a) attempts at stratification proved complex and unreliable, due to the high heterogeneity of Gabon's forests and a lack of confidence in the quality of data available for defining strata; (b) there were concerns that many potentially important environmental variables would be excluded; (c) sampling would be prohibitively expensive and time-consuming. The semi-systematic sampling approach was considered advantageous in that it reduces bias in the location of plots, captures spatial variability in forest structure and composition and allows for additional sample plots to be included without disturbing the overall statistical integrity of samples. The sampling approach used the Reverse Randomized Quadrant-Recursive Raster (RRQRR) algorithm in GIS to develop random samples within a 50 km x 50 km grid over the entire country. The only source of stratification in the survey design was the use of a forest map derived from a combination of MODIS landcover and MODIS Vegetation Continuous Field (VCF) to identify forest and reduce the probability of sampling in non-forested landscapes. Future iterations of the NRI will sample all lands.

Each inventory site consists of one 1-ha (100 x 100 m) plot plus four 0.16-ha (40 x 40 m) satellite plots. The winged design was employed to improve validation of remote sensing data. For the FRL here, carbon stocks derived from the 1-ha plots only were used. Field data were collected following the RAINFOR standard protocols for plot establishment and measurement (Phillips et al., 2009).

Forest types were *a posteriori* classed by disturbance history as well as by edaphic type. Disturbance history types were Old Growth (undisturbed), Secondary Forest (of indeterminate age) and Logged Forest (time since disturbance unknown) (Figure 14). Data were collected for above-ground live biomass in all plots, and for above-ground dead wood (standing and downed wood) and soil carbon to 2m in a subset of plots. All data are published in Carlson et al., 2017; Poulsen et al., 2020 and Wade et al., 2019. Below-ground carbon was extrapolated for the FRL for both live and dead biomass using standard shoot-root ratios. Methods are summarised in Box 1.

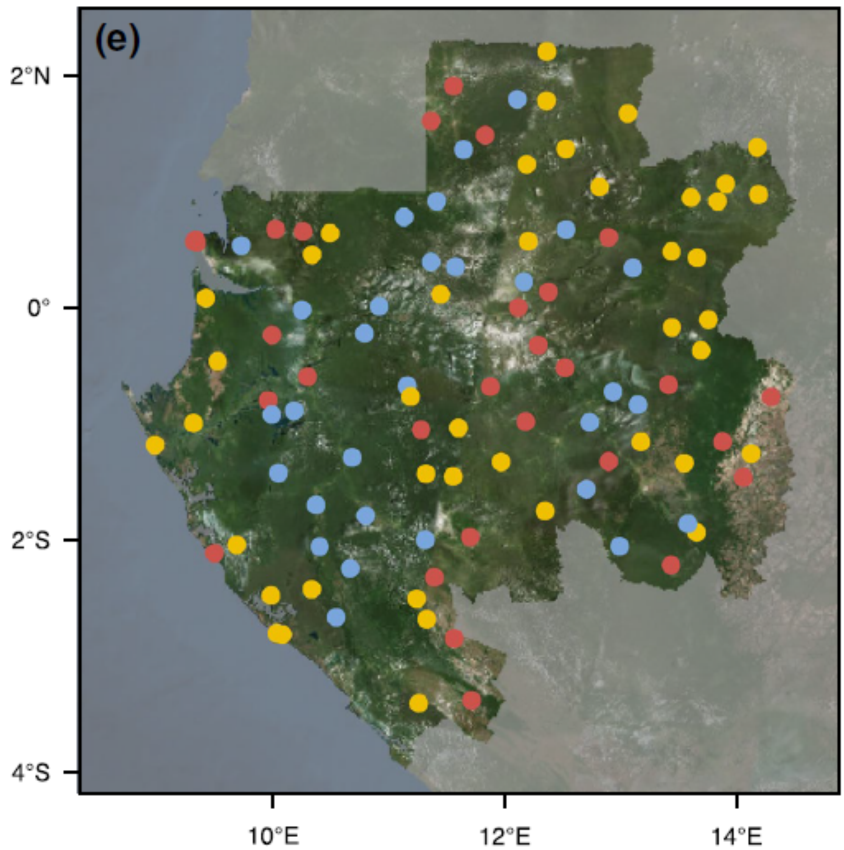

Figure 14 Location of plots measured for the National Resource inventory (NRI) using a semi-systematic sampling design. Yellow = old growth, Blue = Logged Forest, red = secondary forest (source: Poulsen et al., 2020).

Box 1 Methods employed to estimate biomass carbon stocks for each carbon pool in Old Growth, Secondary and Logged Forest.

Above-ground Biomass

Trees ≥10 cm DBH were measured at a height of 1.3m from the ground or 50 cm above any buttresses, stilt roots, or deformities in 104 plots and identified to species-level whenever possible. Samples of unidentified trees were taken for identification at Gabon's National Herbarium. Of 67,466 trees, 80.9% were identified to species and 99.4% to genus-level; of 1572 large trees, 92.1% were identified to species and 99.6% to genus-level. Tree heights (H) were measured with a laser hypsometer. Technicians took three height measurements of 55 randomly selected trees per site with 10 trees from each of 5 DBH subclasses (10-20 cm, 21-30 cm, 31-40 cm, 41-50 cm, >50 cm) and the five largest trees. With tree height measurements, a series of diameter-height (D:H) regression models (linear, quadratic and polynomial) were built for each plot to predict the heights of the unmeasured trees (Beirne et al., 2019). For plots without height measurements, a national D:H model was fitted to all the NRI data:

$$\hat{H} = 43.98 - 35.38 \times e^{-0.019D}$$

Equation 9

Wood density values (ρ) were derived from the Global Wood Density Database (Zanne et al., 2009). Diameter (D) of individual trees was converted to AGB using the most recent pantropical allometric equation (Chave et al., 2014) for moist forests (1500-3500 mm precipitation yr^{-1}) where :

$$AGB_{est} = 0.0673 \times (\rho D^2 H)^{0.976}$$

Equation 10

Note that a Gabon-specific allometric model (Ngomanda et al., 2014) was not used as it is based on a limited sample from a single site. The general equation was considered more appropriate to the nationwide dataset. Full methodological details are provided in (Poulsen, 2013; Poulsen et al., 2020).

Dead Wood

Necromass in standing and lying dead wood was measured in transects set up in a subset of 47 of the NRI plots. Total deadwood volume was estimated by measuring the diameters of both fallen and standing deadwood ≥10 cm DBH, using a three-decay class system (Chao et al., 2008). The volume (m^3) of standing deadwood was estimated using Smalian's Formula (Harmon et al., 1986), and the volume of fallen deadwood was estimated following Van Wagner (1968). Necromass (t/ha) for each transect and decay class was calculated by multiplying the volume of deadwood per ha by the wood density for the appropriate decay class and edaphic type combination. Full methodological details are provided in (Carlson et al., 2017).

Below-ground Biomass

Below-ground biomass (BGB) was determined at the stand level by multiplying live AGB and standing dead wood by the mean root:shoot ratio of 0.235 (SE= 0.011) for tropical moist forests >125 t/ha (Mokany et al., 2006), using Equation 6.

Soil

Soil was sampled in a subset of 57 of the NRI plots (27% old growth, 39% secondary, 31% logged). In each plot 3 soil pits were dug, and samples collected at 7 depth intervals to 2m, passed through a 2mm sieve, and analyzed for total carbon by dry combustion. Bulk density was sampled across the first five soil depth

increments (0–10 cm, 10–30 cm, 30–50 cm, 50–75 cm, and 75–100 cm)[10], using a 200 cm^3 volume core and averaged from three replicates for each depth. Carbon stocks were estimated using the equation: $$CM = CF \times BD \times V$$ Equation 11 where CM is total carbon by mass (tha^{-1}), CF is the fraction of carbon, BD is the fine-fraction (< 2-mm) soil bulk density and V is the volume in the soil layer (m^3/ha). Full methodological details are provided in (Wade et al., 2019).
Carbon Fraction of dry matter
The IPCC-recommended default value of 0.47 carbon fraction of dry matter was not used, instead the more recent estimate of 0.456 for tropical forests (Martin et al., 2018) was used (Equation 7).

As soil carbon emissions are not accounted for in the FRL (see Annex 3 in Section 18.3), soil carbon stocks were not retained as an Emissions Factor for deforestation and degradation, however, for the purposes of reporting total carbon stocks for the country the data are included here.

10.2.1.2 Methods to estimate Emission Factors for mangroves

For Mangrove Forests, carbon stocks are taken from a research study (Kauffman and Bhomia, 2017) conducted as part of the CIFOR-USDA Forest Service Sustainable Wetlands Adaptation and Mitigation Program (SWAMP). SWAMP protocols for measuring mangrove carbon stocks were followed (Kauffman and Donato, 2012). Seventeen sites were sampled, 10 in Akanda National Park (Northern Gabon) and 7 in the Ndougou Lagoon (Southern Gabon). Full methodological details are provided in (Kauffman and Bhomia, 2017; Kauffman and Donato, 2012) and are summarised in Box 2.

Following (Kauffman and Donato, 2012), data were compiled into Downed wood, Vegetation (including standing dead wood, live AGB and BGB), and soil. Raw data are publicly available at CIFOR (https://data.cifor.org/dataverse/swamp). For the FRL, raw data were re-organised into Live Biomass (Above ground and below ground), Necromass (Above-ground: standing and downed wood, below-ground) and soil to 1m[11].

As no Mangrove Forest cover losses were detected in the Activity Data (see Section 10.1.1), mangrove carbon stocks were not retained as an Emissions Factor for deforestation and degradation, however, for the purposes of reporting total carbon stocks for the country they are included here.

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[10] Mineral soil carbon stocks were collected to 2m (Wade et al., 2019) but not at all plot locations.

[11] Mangrove soil carbon stocks below 100cm are reported in Kauffman and Bhomia, (2017), but the raw data are not available on the CIFOR Dataverse. As a conservative approach, soil carbon stocks to 100cm only are reported for all forest types.

Box 2 Methods employed to estimate biomass carbon stocks for each carbon pool in Mangrove Forest (taken from (Kauffman and Bhomia, 2017).

Above-ground Biomass
At each site, tree diameter (D) for trees >1.3 m in height were measured at 30 cm above the highest prop root in a series of 6 x 7 m circular plots along a 100 m transect. AGB was calculated using species-specific allometric equations (Fromard et al. 1998), where: for *Avicennia germinans*, AGB (kg) = $0.14 \times D^{2.4}$ Equation 12 for *Rhizophora racemosa* AGB (kg) = $0.1282 \times D^{2.6}$ Equation 13
Dead Wood
For dead wood, standing dead trees were separated into three decay classes, where biomass was estimated to be either 97.5%, 80% or 50% of a live tree respectively. For downed wood the planar intersect technique adapted for mangroves was used to calculate mass of dead and downed wood with 2 decay class categories.
Below-ground Biomass
Below-ground biomass was estimated from both live and dead AGB with the general mangrove equation (Komiyama et al. 2008), where D= diameter and ρ = wood density: BGB (kg) = $0.199 \times (\rho^{0.899} \times D^{2.22})$ Equation 14 Wood density values were taken from the Global Wood Density Database (Zanne et al., 2009)
Soil
Soil samples were taken at each of the six subplots per sampling site, by auger at depth intervals of 0-15, 15-30, 30-50 and 50-100. Soil of a known volume was extracted, and bulk density was determined in laboratory after drying. The dry combustion method was used to measure carbon concentrations. Bulk density and carbon concentration were combined with plot-specific soil depth measurements to determine soil carbon stocks.
Carbon Fraction of dry matter
Biomass of trees and downed wood debris was converted to carbon mass using specific carbon fractions of 0.47 for aboveground C and 0.39 for belowground C, following (Kauffman and Donato, 2012). As these fractions are part of standard mangrove carbon protocols, these conversions are retained here.

10.2.1.3 Other sources of carbon stock data

While not included as Emissions Factors, national carbon stock values can be reported for Colonising Forest, where forest losses were not detected but forest gains were. Carbon stock values for colonising forest are taken from (Cuni-Sanchez et al., 2016) for above-ground biomass (most recent measures are reported): below-ground biomass was extrapolated using Equation 6. In this study, soil carbon was only reported to 30cm. Because of this, soil carbon stock values to 1m are taken from another study (Chiti et al., 2018) conducted at the same site. Note however, that DOM stocks are not available for this forest type.

Carbon stocks for secondary forests where the disturbance history is unknown from Gabon's NRI (Poulsen et al., 2020), were used to calculate the emissions from secondary forest (interpreted as Young Secondary and Degraded Forest) (see Table 11). This is considered a conservative estimate for this forest type.

10.2.1.4 Carbon stock data for Gabon's forests

Carbon stock values for the major carbon pools and forest types identified in the FRL are summarised in Table 19. Note that the data for "Forest avg" represents the arithmetic mean value for Old-Growth, Logged and Secondary Forest, as measured as part of the NRI.

Multiplying the most appropriate total vegetation and total ecosystem carbon stocks by the most recent forest cover estimates for each forest type (the area of forest cover by forest type is also summarised in Table 18) indicates Gabon stocks approximately 8.1 billion tonnes of carbon in its forests (Table 20).

Table 19 Average carbon stocks in tonnes of carbon (tC) per hectare per pool per forest type measured. U = Uncertainty.

Forest type	Disturbance history	Above ground: Trees >10cm DBH		Below ground: Living roots	Dead Organic Matter: Total DOM		Soil carbon: 0-100 cm		Above and below-ground		Total Ecosystem		Source
		Mean	U	Mean	Mean	U	Mean	U	Mean	U	Mean	U	
Old-growth	Undisturbed	151.6	12%	35.6	21.4	29%	161.3	76%	187.2	10%	369.9	33%	NRI (Poulsen et al., 2020)
Logged	Undetermined	172.8	11%	40.6	40.7	26%	127.1	18%	213.4	9%	381.2	8%	NRI (Poulsen et al., 2020)
Secondary	Undetermined	95.6	22%	22.5	24.7	56%	98.3	12%	118.0	18%	241.1	12%	NRI (Poulsen et al., 2020)
Forest (average old growth, logged, secondary)	Undetermined	141.7	9%	33.3	30.1	21%	125.1	28%	175.0	8%	330.2	12%	NRI (Poulsen et al., 2020)
Mangrove	Undisturbed	111.8	36%	37.0	18.9	33%	254.6	20%	148.8	29%	422.3	18%	(Kauffman and Bhomia, 2017) https://data.cifor.org/dataverse/swamp
Colonising	Undisturbed	47.2	30%	11.1	data not available		72.3	3%	58.3	25%	130.6	11%	(Chiti et al., 2018; Cuni-Sanchez et al., 2016)

Table 20 Estimated total carbon stocks for Gabon, 2018, per forest type recognised in the FRL.

Forest type	Area (ha)	Carbon stock value to apply (tC/ha)			Total Carbon stock (tC)	
		Forest type	AGB+ BGB	Ecosystem	AGB+ BGB	Ecosystem
Old growth, old secondary, older logged	16,969,821	Forest (average)	175.05	330.24	2,970,497,746	5,604,138,896
Secondary	510,334	Secondary	118.01	241.09	60,225,766	123,033,975
Logged (1-10 and 11-25 combined)	6,027,372	Logged (unknown disturbance history)	213.43	381.19	1,286,403,300	2,297,603,557
Mangrove	151,692	Mangrove	148.78	422.32	22,568,847	64,062,165
Young Secondary	57,804	Secondary (undetermined)	118.01	241.09	6,821,629	13,935,766
Colonising	1,762	Colonising	58.34	130.64	102,807	230,208
Total	**23,718,785**				**4,346,620,095**	**8,103,004,566**

10.2.1.5 Emissions factors for biomass losses from Forest Land converted to non-Forest Land-use categories

Carbon stock values calculated in Table 19 were used to derive the Emissions Factors for biomass losses from Forest Land converted to non-Forest Land-use categories. Carbon stock values in tC/ha were converted to tCO_2eq/ha using Equation 8.

Emissions Factors retained for calculations of biomass losses from forest land converted to non-forest land-use categories (including both permanent and temporary land-use change) are presented in Table 21. Only two were retained: secondary forest (EF1), and the arithmetic mean of carbon stocks for old growth, logged and secondary forest (EF2), as these were considered the most appropriate to apply to the forest types identified in the Activity Data (Table 11).

10.2.2 Emissions Factors for biomass losses in Forest Land remaining Forest Land

The Activity Data retained for Biomass losses in Forest Land remaining Forest Land consists of the area of Degraded Forest identified by the remote sensing method, outside of logging concessions. This was forest degraded from "dense" to "secondary" forest. The Emissions Factor applied (EF3) is the difference between the Forest Average (EF2) and the Secondary Forest (EF1) Emissions Factors (Table 21).

Table 21 Emissions Factors applied for Biomass losses in Forest Land converted to non-Forest Land-use categories and in Forest Land remaining Forest Land.

Emissions Factor No.	Forest Type	Living Biomass			Total Above and Below Ground		Applied to
		Above-Ground		Below Ground			
		EF	U	EF	EF	U	
EF1	Secondary Forest	350.4	21.6%	82.3	432.7	21.7%	Forest Land converted to non-Forest Land-use categories
EF2	Average Forest (Old Growth, Logged, Secondary)	519.7	8.8%	122.1	641.8	8.9%	Forest Land converted to non-Forest Land-use categories
EF3	Difference (Average Forest – Secondary)	169.3	52.2%	39.8	209.1	52.2%	Degradation in Forest land remaining Forest Land

10.2.3 Emissions Factors for logging

To determine Emissions Factors 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 (four CFADs, three CFADs with FSC certification and two '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 (coarse woody debris) is not included, according to RIL-C methodology.

Logging emissions expressed in tC/m^3 were calculated using the following basic equations:

$$E = H + S + F$$

Equation 15

Where:

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

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

Equation 16

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 (tC/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 Equation 6.
- 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 17) were applied to the original (total) Emissions Factors in order to partition the data into AGB and BGB in the correct proportions according to Equation 6:

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

Equation 17

- Biomass was converted to carbon with Equation 7;
- Data were reorganised into GOFC-GOLD recommended equivalent logging emission categories, following (Pearson et al., 2014), according to Equation 18 and Table 22:

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

Equation 18

Where:

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

Table 22 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)

Logging Emissions Factors for each of the 12 concessions, by carbon pool and emissions category are detailed in Annex 9 in Section 18.9.

Values in tC/m^3 were converted to tCO_2 eq/m^3 using Equation 8.

Logging Emissions Factors by carbon pool and emissions category are presented in Table 23. 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 23 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%**

10.3 Removal Factors

10.3.1 Removal Factors for different forest types

Removals Factors were derived from available sequestration data collected from different studies in different forest types in Gabon, including: Logged Forest, Secondary Forest, Colonising Forest, Old Growth Forest and Mangrove Forest. These will be updated and refined as part of the stepwise improvement plan.

For the purposes of the FRL, the sequestration data were organised as described below.

10.3.1.1 Logged Forest

Data were collected from 18 plots in Gabon in forests logged 9 - 10 years prior to sampling, giving a mean AGB change of 6.35 t/ha/year (U= 34.9%) (Medjibe, 2020). This was considered the sequestration rate for **Logged Forest**, **1-10 years since disturbance** (LF_{10}). For sequestration rates in Logged Forest 11-25 years since disturbance, no national data are available. Instead supplementary data from a post-logging recovery study conducted in the Central African Republic (CAR) (Gourlet-Fleury et al., 2013) was used. Here, forests logged 10 years prior to sampling had a mean AGB change of 6.69 t/ha/year (U=16.3%) (Gourlet-Fleury, *pers.comm*), which is very similar to the Gabon value. At 24 years post-logging the mean AGB change observed in the CAR study was 4.82t/ha/year (U= 15.7%) (Gourlet-Fleury et al., 2013). This means, in the CAR study forests logged 11-24 years previously can be derived as (((4.82*24)-(6.69*10))/14)= 3.48 t/ha/year, which is 52% of the value for forests logged 1-10 years previously. This percentage was applied to derive the equivalent sequestration rate for Gabon's forests from 11-25 years since disturbance. Therefore, a mean AGB change of (6.35 * 0.52) = 3.30 t/ha/year (U = 34.9%) was considered the sequestration rate for **Logged Forest**, **11-25 years since disturbance** (LF_{25}).

10.3.1.2 Secondary Forest

Data were collected in eight of the NRI plots located in secondary forest: these were all confirmed to be Old Secondary Forest (20-100 years since disturbance, (Medjibe, 2020)). The mean AGB change of these plots was 2.83 t/ha/year (U = 55.5%). This was considered the sequestration rate for **Old Secondary Forest** (20-100 years since disturbance).

There were no national data available for sequestration rates in Young Secondary Forest (0-20 years since disturbance). Instead, new default values for IPCC were used, following (Requena Suarez et al., 2019). The mean AGB change value given for Young Secondary Forest in African tropical rainforest is 7.60 t/ha/year (U= 39.5%). This was considered the sequestration rate for **Young Secondary Forest** (0-20 years since disturbance).

10.3.1.3 Colonising Forest

The sequestration rate for Colonising Forest was taken from a study that analysed 5 plots in Lopé National Park (Cuni-Sanchez et al., 2016). The mean AGB change value given is 3.1 t/ha/year (U = 42.4%). This was considered the sequestration rate for **Colonising Forest**.

10.3.1.4 Old Growth Forest

A re-analysis of 45 plots from undisturbed, old-growth forest in Gabon was conducted from the data published in Hubau et al., (2020). The mean AGB change value (a four-decade average from 1980-2015) is 1.69 t/ha/year (U = 38.3%). This was considered the sequestration rate for **Old-Growth Forest**.

10.3.1.5 Mangrove Forest

No national data are available for sequestration in Mangrove Forests, here the IPCC default value is assumed (IPCC, 2014, Chapter 4: Coastal Wetlands, Tables 4.2-4.4). The mean AGB change value given is 9.9 t/ha/year (U = 5.1%). This was considered the sequestration rate for **Mangrove Forest**.

10.3.1.6 Average: Old Growth and Old Secondary Forest

In order to provide a sequestration rate for undetermined forest types (1990-2000 remote sensing data) and for Old Growth, Old Secondary and Older Logged Forest, a mean value was taken from Old Growth and Old Secondary Forest (no sequestration rates are available for Older Logged Forest, so this is considered as conservative). The mean AGB change value is 2.26 t/ha/year (U= 33.7%). This was considered the sequestration rate for **undetermined forest types** and for **Old Growth, Old Secondary and Older Logged Forest**.

10.3.1.7 Summary of Removal Factors

Equation 6-8 were used to convert biomass to carbon, to estimate below-ground carbon from above-ground carbon and to convert carbon to CO_2 eq. Sequestration rates for each forest type are presented in Table 24 and final Removal Factors retained for removals calculations in $tCO_2eq/ha/yr$ are presented in Table 25.

Table 24 Sequestration rates (t C/ha/year) for different forest types in Gabon. U = Uncertainty.

Forest type	Years since disturbance	Δ Above ground Carbon		Δ Below ground Carbon	Δ Total Carbon	
		Mean	U	Mean	Mean	U
Logged (LF-10)	1-10	2.89	34.9%	0.68	3.57	35.0%
Logged (LF-25)	11-25	1.51	34.9%	0.35	1.86	35.0%
Young Secondary	<20	3.47	39.5%	0.81	4.28	39.5%
Old Secondary	20-100	1.29	55.5%	0.30	1.59	55.5%
Old growth	undisturbed	0.77	38.3%	0.18	0.95	38.4%
Colonising	undisturbed	1.41	42.4%	0.33	1.75	42.4%
Mangrove	undisturbed	4.51	5.1%	1.06	5.58	5.3%
Average: Old growth, Old Secondary	unknown	1.03	37.6%	0.24	1.27	37.6%

Table 25 Removals factors retained for removals calculations under all REDD+ activities, $tCO_2eq/ha/yr$.

Removals Factor No.	Forest Type	$tCO_2/ha/yr$				
		Δ Above ground		Δ Below ground	Total	
		Mean	U	Mean	Mean	U
RF1	Logged (1-10 years)	10.61	34.9%	2.49	13.10	35.0%
RF2	Logged (11-25 years)	5.53	34.9%	1.30	6.82	35.0%
RF3	Young secondary	12.71	39.5%	2.99	15.69	39.5%
RF4	Colonising	5.18	42.4%	1.22	6.40	42.4%
RF5	Mangrove	16.55	5.1%	3.89	20.44	5.3%
RF6	Old growth, old secondary, old logged	3.78	37.6%	0.89	4.67	37.6%
RF7	Secondary	4.73	55.5%	1.11	5.85	55.5%

11 Gross emissions, gross removals and net removals per REDD+ activity

11.1 Gross emissions

For each REDD+ activity (Deforestation, Forest Degradation, SMF and Conservation), carbon biomass losses (emissions) were determined following the basic IPCC equation (IPCC, 2006b):

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

Equation 19

Where:

E = Emissions in tCO_2eq/yr
AD = Activity Data (in ha/yr or m^3/yr)
EF = Emissions Factor (in tCO_2eq/ha or tCO_2 eq/m^3)

Emissions were calculated annually, and data were organised by National Land Tenure class, IPCC land-use category, forest type and carbon pool.

11.1.1 Deforestation

Gross Emissions for REDD+ activity Deforestation were calculated using Equation 19, the Activity Data in Sections 18.4 Annex 4 and 18.6 Annex 5 (expressed in ha/yr) and the Emissions Factors in Table 21 (expressed in tCO_2eq/ha).

Here, all biomass losses from Forest Land converted to non-Forest Land-use categories within Rural Areas and Other Land Tenure is accounted for and includes agricultural concessions. Total annual gross emissions are shown in Figure 15, averaging 5.6 million tCO_2eq/year over the 1990-2018 period (4.4 million tCO_2eq/year 2000-2009, 8.0 million tCO_2eq/year 2010-2018). Emissions have increased notably since 2010 (coinciding with industrial agricultural development, in line with Emergent Gabon's development goals). However, historically 43% of land-use change has been temporary, suggesting that much of this is due to shifting agriculture. Since 2010, 65% of Forest Land converted to non-Forest Land-use categories is permanent deforestation.

However, recent increases may be adjusted downwards during the next assessment period according to the remote sensing methodology (see Section 10.1.1.6) as new data becomes available. Estimates for the most recent assessment period (2016-2018), including the relative proportions of temporary and permanent land-use changes may change during future analyses due to the nature of the methodological approach (see Section 10.1.1.6).

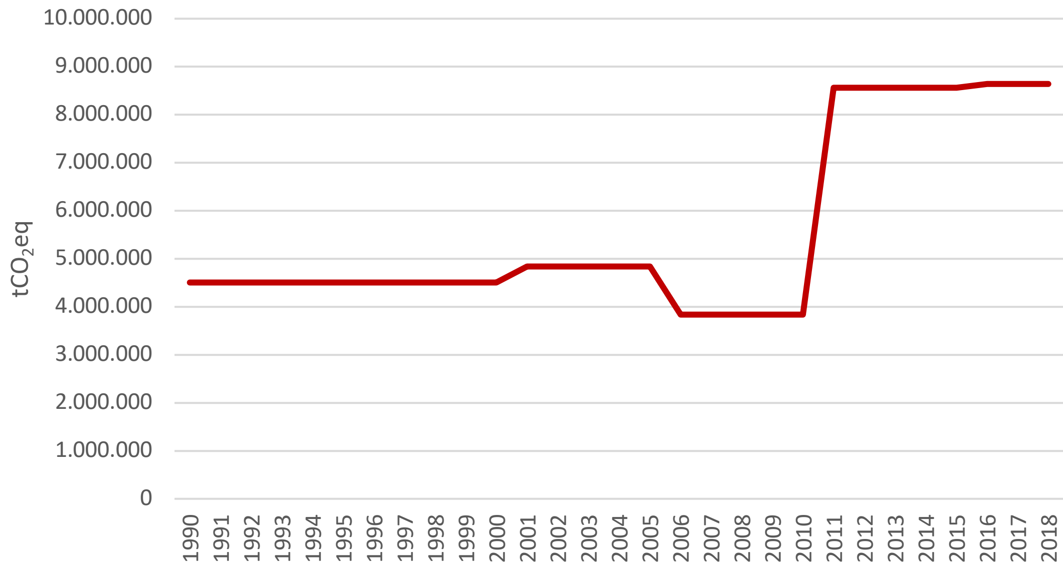

Figure 15 Total gross emissions under REDD+ Activity 'Deforestation'.

11.1.2 Forest Degradation

Gross Emissions for REDD+ activity Forest Degradation were calculated using Equation 19, the Activity Data in Section 18.7 Annex 7 (expressed in ha/yr) and the Emissions Factors in Table 21 (expressed in tCO_2eq/ha).

Here, all biomass losses from Forest Land Remaining Forest Land within Rural Areas and Other Land Tenure is accounted for and includes agricultural concessions. Total annual gross emissions are shown in Figure 16, averaging 157,104 tCO_2eq/year over the 1990-2018 period (349,169 tCO_2eq/year 2000-2009, 118,259 tCO2eq/year 2010-2018). Estimates for the most recent assessment period (2016-2018) may change during future analyses due to the nature of the methodological approach (see Section 10.1.1.6). Although not possible to quantify with the current methodology, it is likely most of these emissions are due to shifting agriculture (see Section 10.1.1.8).

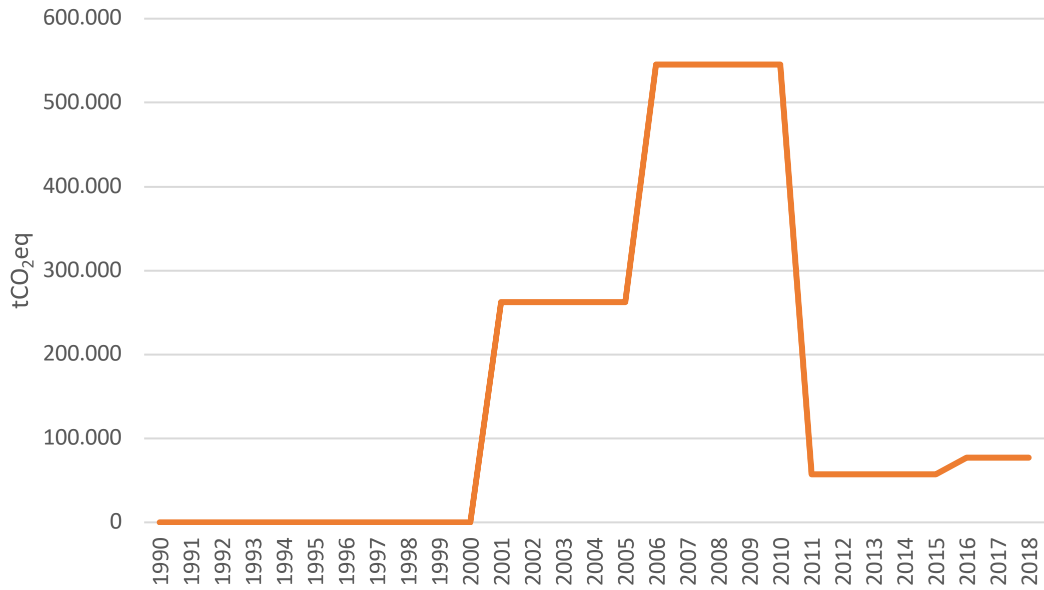

Figure 16 Gross emissions under REDD+ activity 'Degradation'.

11.1.3 Sustainable Management of Forests (SMF)

Gross Emissions for REDD+ activity SMF were calculated using Equation 19, the Activity Data in Table 15 (expressed in m^3/yr) and the Emissions Factors in Table 23 (expressed in tCO_2eq/m^3).

Here, all biomass losses from logging activities inside logging concessions is accounted for. Total annual gross emissions are shown in Figure 17, averaging 21.6 million tCO_2eq/year over the 1990-2018 period (29.5 million tCO_2eq/year 2000-2009, 15.8 million tCO_2eq/year 2010-2018). Decreases observed since 2007 coincide with SMF policies that came into force from 2006 onwards, including the implementation of the new forestry code, the creation of national parks and the 2010 raw timber export ban. Although timber production and therefore emissions have started to increase in recent years, they are still below levels observed in the 2000s. Emissions due to selective timber harvesting are estimated to currently stand at around 19.3 million tCO_2eq/year.

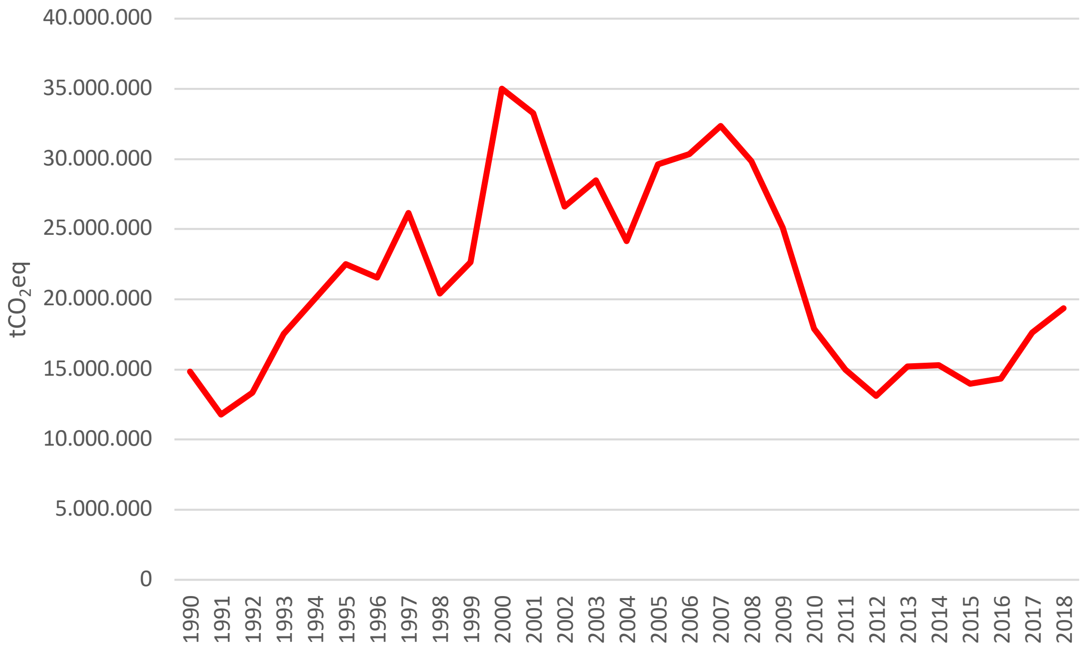

Figure 17 Gross emissions under REDD+ activity SMF.

11.1.4 Conservation

Gross Emissions for REDD+ activity Conservation were calculated using Equation 19, the Activity Data in 18.5 Annex 5 and 18.7 Annex 6 (expressed in ha/yr) and the Emissions Factors in Table 21 (expressed in tCO_2eq/ha).

Here, all biomass losses from Forest Land converted to non-Forest Land-use categories (permanent and temporary) and in Forest Land Remaining Forest Land (degradation) within Protected Areas is accounted for. Overall, gross emissions are very low within protected areas, and no degradation was observed: all biomass losses are attributed to either permanent or temporary land-use change.

Total annual gross emissions are shown in Figure 18, averaging just 51,344 tCO_2/year over the 1990-2018 period (11,581 tCO_2eq/year 2000-2009, 79,136 tCO_2eq/year 2010-2018).

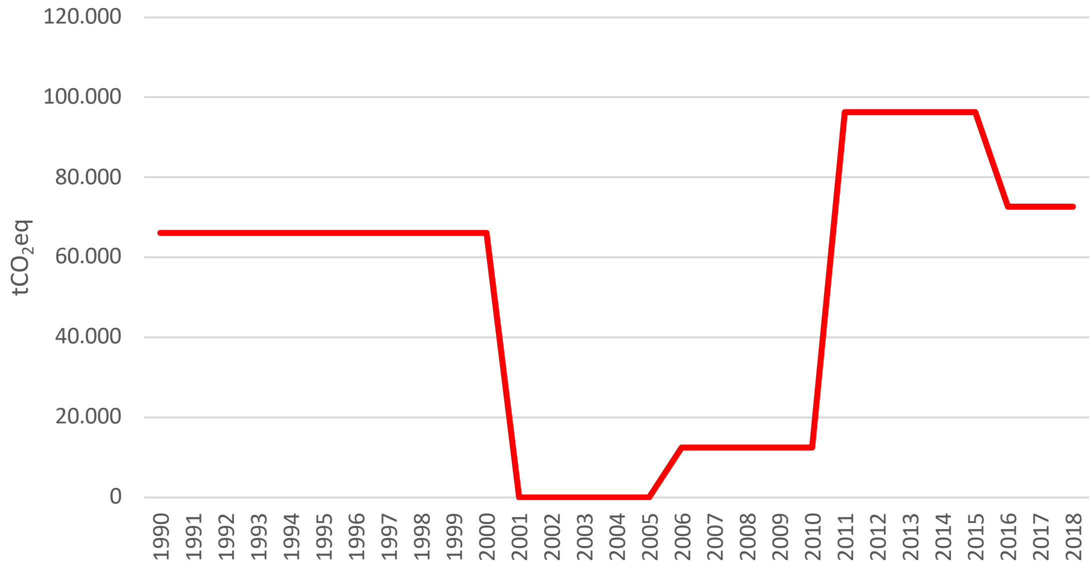

Figure 18 Gross emissions under REDD+ activity Conservation.

11.2 Gross removals

Removals, are defined as removals of greenhouse gases, in this case CO_2, from the atmosphere by a sink, following the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019a).

For each REDD+ activity (Enhancement, Forest Degradation, SMF and Conservation) carbon gains (removals) were determined following the basic IPCC equation (IPCC, 2006b):

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

Equation 20

Where:

R = Removals in tCO_2eq/yr
AD = Activity Data in ha/yr
RF = Removals Factor in $tCO_2eq/ha/yr$

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 by applying the Removals Factors in Table 25.

11.2.1 Forest Degradation

Biomass gains for REDD+ activity Forest Degradation were calculated using Equation 19, the Activity Data in Section 18.8 Annex 8 (expressed in ha/yr) and the Emissions Factors in Table 25 (expressed in $tCO_2eq/ha/yr$).

Here, all biomass gains from Forest Land Remaining Forest Land in Rural Areas and Other Land Tenure is accounted for. This includes sequestration in standing forest. Total annual biomass gains are shown in Figure 19 averaging 46.2 million $tCO_2eq/year$ over the 1990-2018 period (43.8 million $tCO_2eq/year$ 2000-2009, 32.9 million $tCO_2eq/year$ 2010-2018).

The decrease over time reflects the overall reduction in surface area of Other Land Tenure, as more land was allocated to logging concessions and protected areas. The staccato pattern observed in the graph is a methodological artefact of the remote sensing method (whereby the data for the "end" of one assessment period and the "start" of the next do not exactly match). This will be addressed as part of the improvement plan.

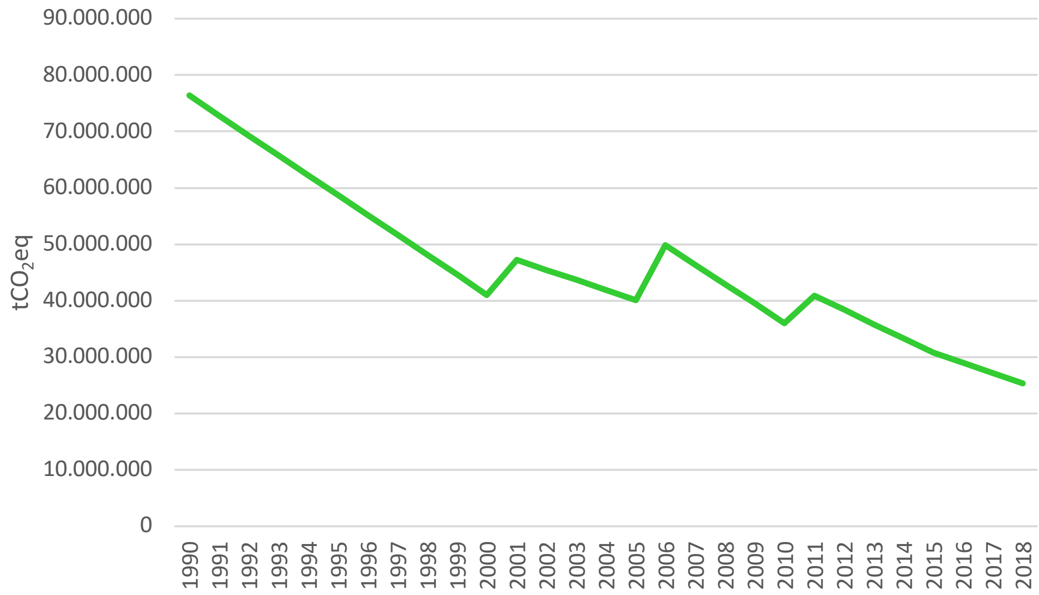

Figure 19 Biomass gains for REDD+ Activity Forest Degradation.

11.2.2 Sustainable Management of Forests (SMF)

Biomass gains for REDD+ activity SMF were calculated using Equation 19, the Activity Data in Section 18.8 Annex 8 (expressed in ha/yr) and the Emissions Factors in Table 25 (expressed in tCO_2eq/ha/yr).

Here, all biomass gains from non-Forest Land-use categories converted to Forest Land and Forest Land Remaining Forest Land in Logging Concessions is accounted for. This includes naturally regenerating forest following human disturbance, naturally encroaching forest into Grasslands and Wetlands and sequestration in standing forest. Total annual biomass gains are shown in Figure 20 averaging 81.0 million tCO_2eq/year over the 1990-2018 period (87.9 million tCO_2eq/year 2000-2009, 91.5 million tCO_2eq/year 2010-2018). The trend is increasing over time and can principally be explained by increases in the surface area of the logging concessions (See Annex 10 Section 18.10), as well as the overall increase in Logged Forest (which has a higher sequestration rate (See Figure 12). Logging concessions constitute the biggest contribution for CO_2 removals of any land tenure in Gabon.

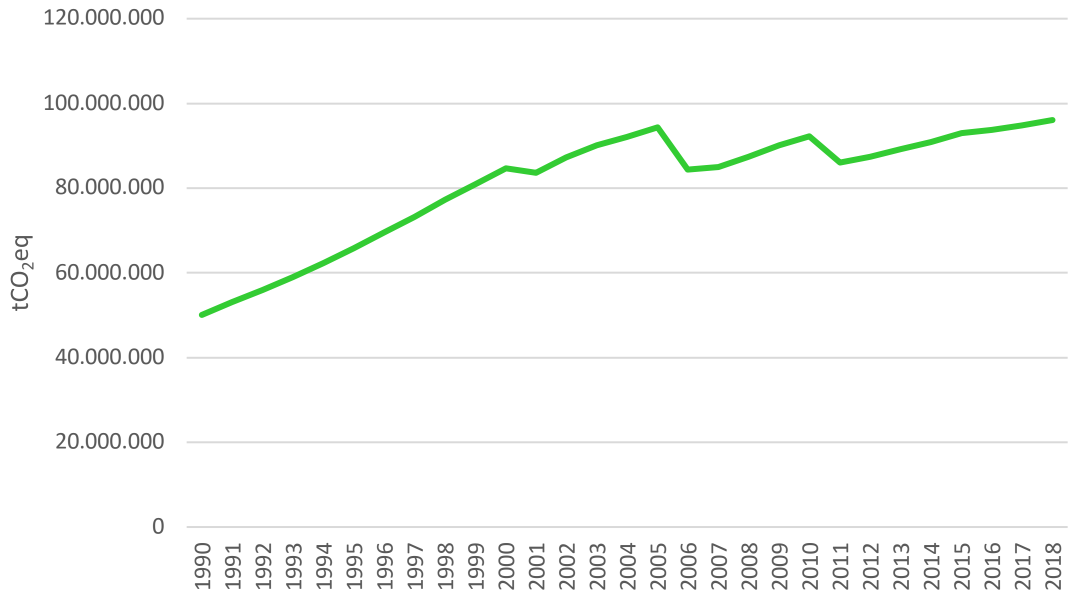

Figure 20 Gross removals under REDD+ activity SMF.

11.2.3 Conservation

Biomass gains for REDD+ activity Conservation were calculated using Equation 19, the Activity Data in Section 18.8 Annex 8 (expressed in ha/yr) and the Emissions Factors in Table 25 (expressed in tCO_2eq/ha/yr).

Here, all biomass gains from non-Forest Land-use categories converted to Forest Land and Forest Land Remaining Forest Land in Protected Areas is accounted for. This includes naturally regenerating forest following human disturbance, naturally encroaching forest into Grasslands and Wetlands and sequestration in standing forest. Total annual biomass gains are shown in Figure 21 averaging 11.1 million tCO_2eq/year over the 1990-2018 period (10.3 million tCO_2eq/year 2000-2009, 18.1 million tCO_2eq/year 2010-2018). The trend is increasing over time, and the patterns are broadly explained by the increase in protected areas over time, such as the creation of the national parks in 2007. The slight decrease observed since 2010 is explained by the diminishing area of Logged Forest contained within the national parks since they were created.

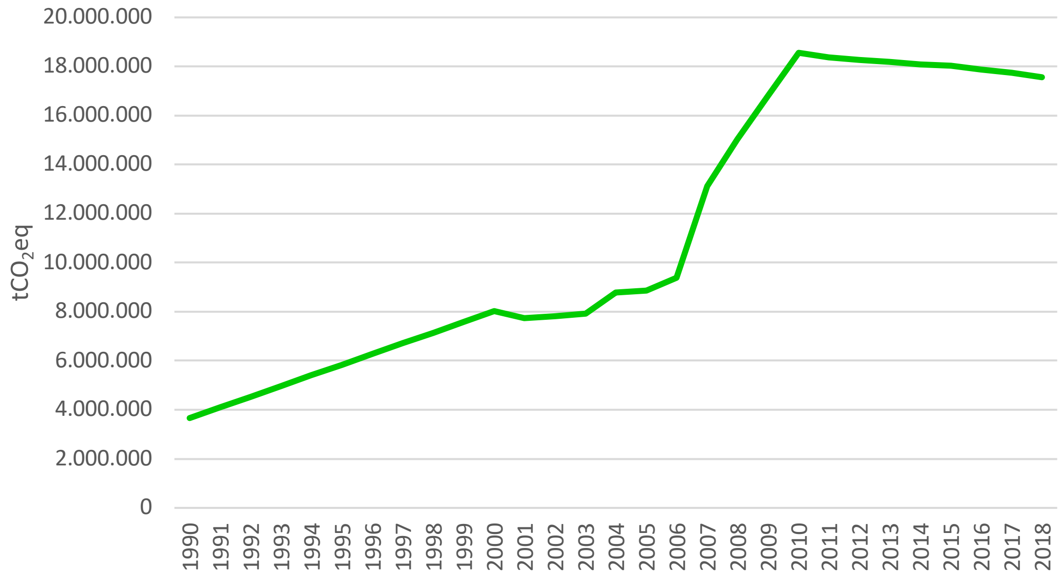

Figure 21 Gross removals under REDD+ Activity Conservation.

11.2.4 Enhancement

Biomass gains for REDD+ activity Enhancement were calculated using Equation 19, the Activity Data in Section 18.8 Annex 8 (expressed in ha/yr) and the removals factors in Table 25 (expressed in tCO_2eq/ha/yr).

Here, all biomass gains from non-Forest Land-use categories converted to Forest Land within Rural Areas and Other Land Tenure is accounted for. This includes naturally regenerating forest following human disturbance and naturally encroaching forest into Grasslands and Wetlands. Total annual biomass gains are shown in Figure 22, averaging 79,345 tCO_2eq/year over the 1990-2018 period (79,352 tCO_2eq/year 2000-2009, 115,761 tCO_2eq/year 2010-2018).

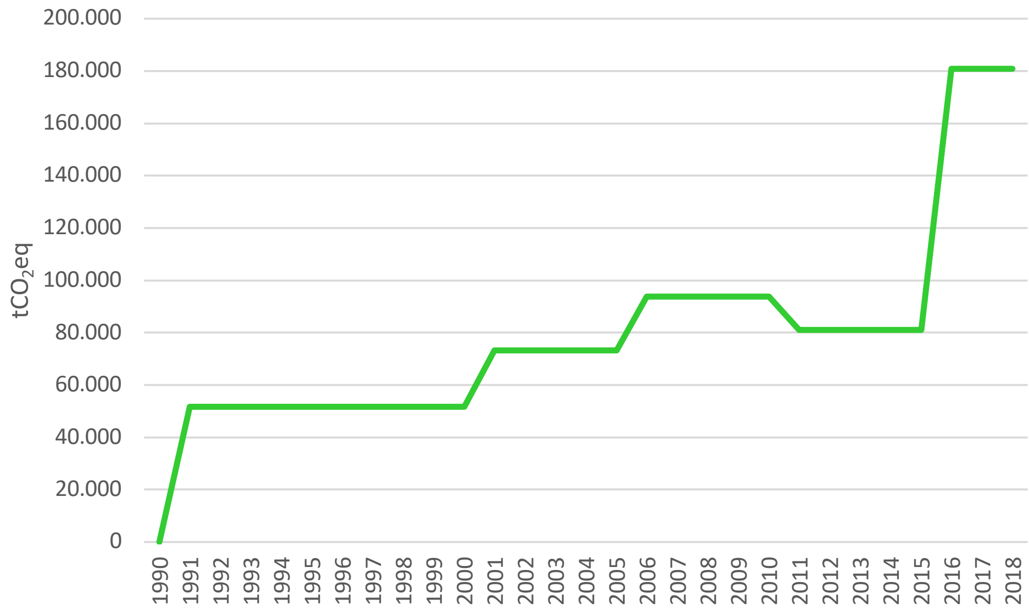

Figure 22 Gross removals for REDD+ activity Enhancement.

11.3 Net removals per REDD+ activity

Net removals were calculated following the IPCC equation 2.4 Gain-Loss Method (IPCC, 2006a) (Equation 21):

$$\Delta CB = \Delta CG - \Delta CL$$

Equation 21

Where:

ΔCB is annual carbon stock change in a pool
ΔCG is the annual gain of carbon
ΔCL is the annual loss of carbon

As gains are much greater than losses, nearly all net removals are positive, indicating that Gabon's forests are a net carbon sink.

11.3.1 Deforestation

No biomass gains were reported under REDD+ activity Deforestation (zero gains), therefore net removals are equal to the negative gross emissions for this REDD+ activity (Section 11.1.1).

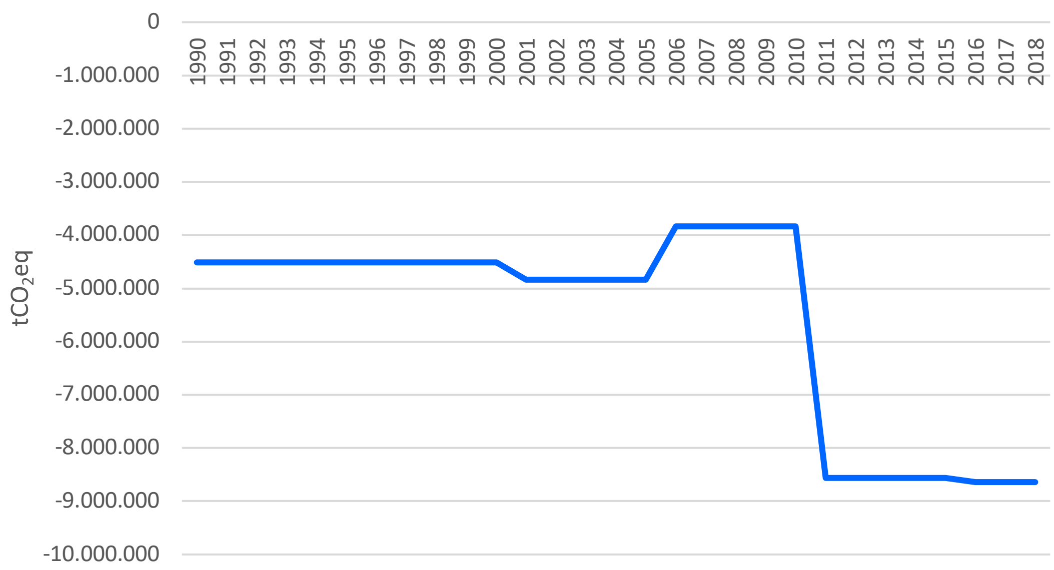

Figure 23 Net removals under REDD+ Activity Forest Deforestation.

11.3.2 Forest Degradation

Net removals under REDD+ activity Forest Degradation (Rural Areas and Other Land Tenure) are shown in Figure 24. Net removals remain positive but have decreased over time. The average net removals is 46 million tCO_2/year over the 1990-2018 period (43.4 million tCO_2eq/year 2000-2009, 32.8 million tCO_2eq/year 2010-2018).

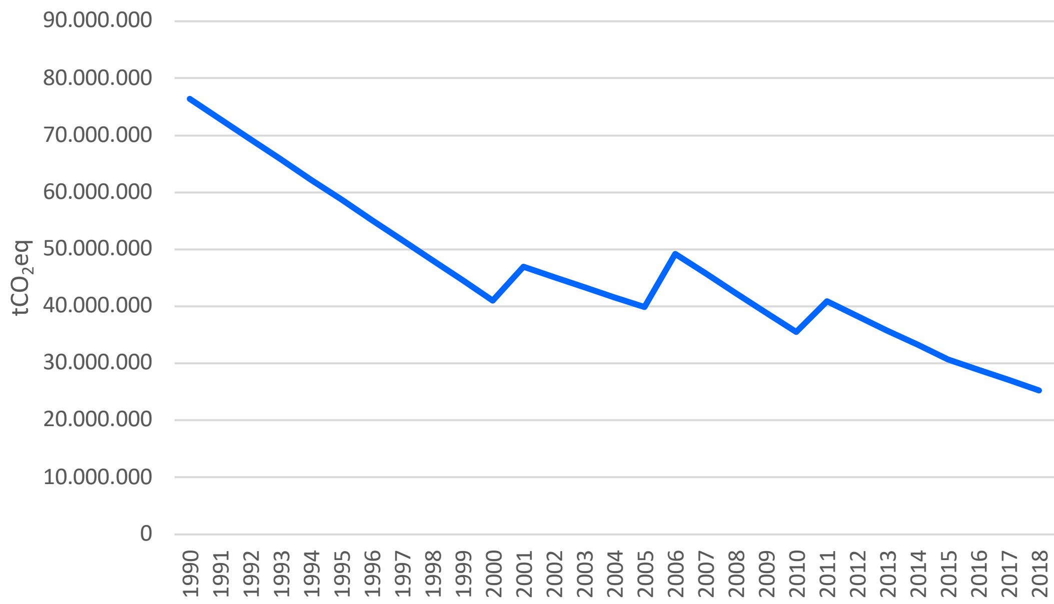

Figure 24 Net removals under REDD+ Activity Forest Degradation.

11.3.3 Sustainable Management of Forests (SMF)

Net removals under REDD+ activity SMF (Logging Concessions) are shown in Figure 25. Net removals have increased over time. The average net removals is 59.4 million tCO_2/year over the 1990-2018 period (58.4 million tCO_2eq/year 2000-2009, 75.7 million tCO_2eq/year 2010-2018).

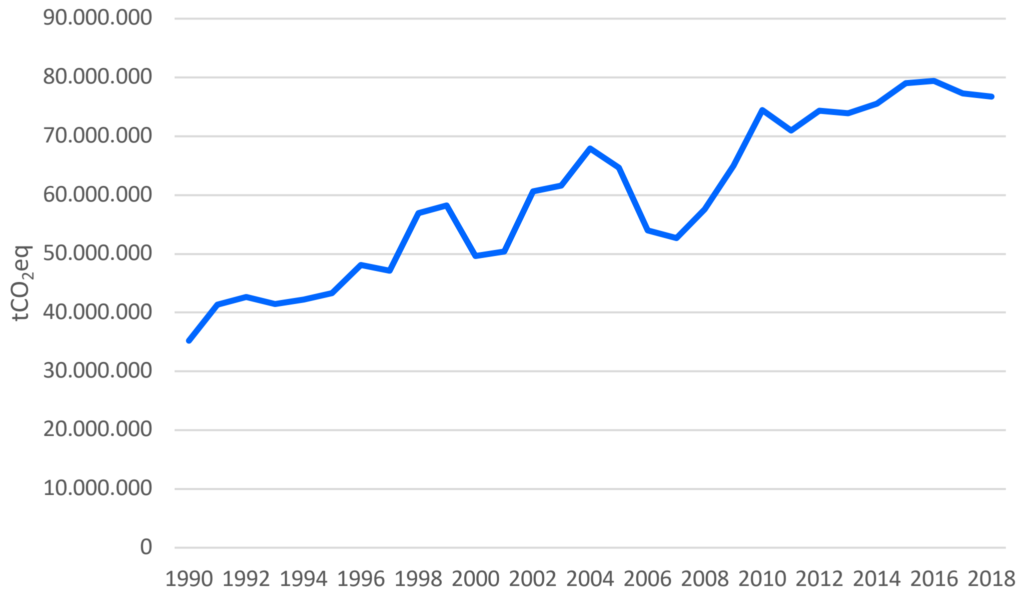

Figure 25 Net removals under REDD+ Activity SMF.

11.3.4 Conservation

Net removals under REDD+ activity Conservation (Protected Areas) are shown in Figure 26.Net removals have increased over time, with a slight decrease since 2010. The average net removals is 11.1 million tCO_2/year over the 1990-2018 period (10.3 million tCO_2eq/year 2000-2009, 18.0 million tCO_2eq/year 2010-2018).

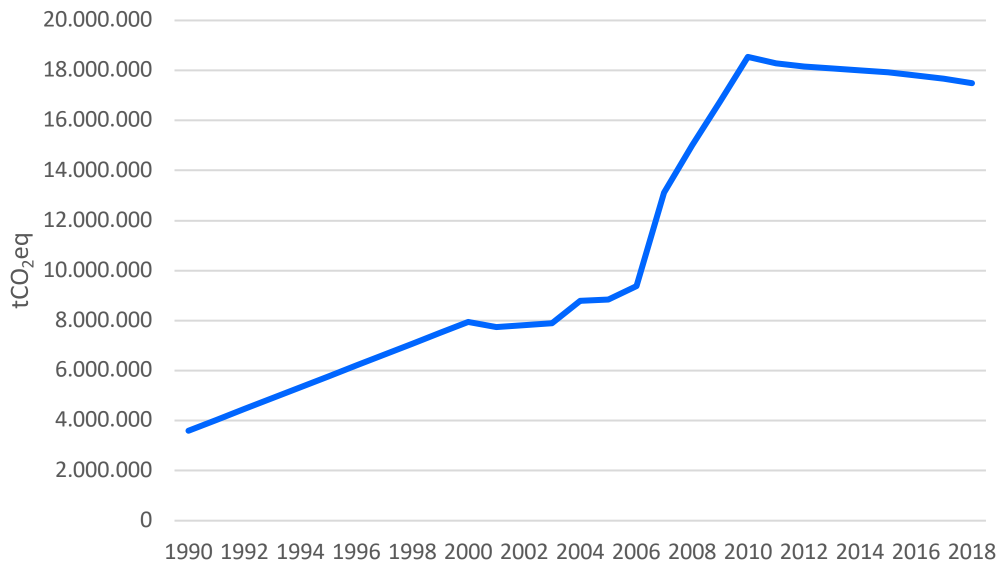

Figure 26 Net Removals under REDD+ Activity Conservation.

11.3.5 Enhancement

As no biomass losses were reported under REDD+ activity Enhancement (zero losses), the net removals are therefore equivalent to the gross removals for this REDD+ activity (Section 11.2.4).

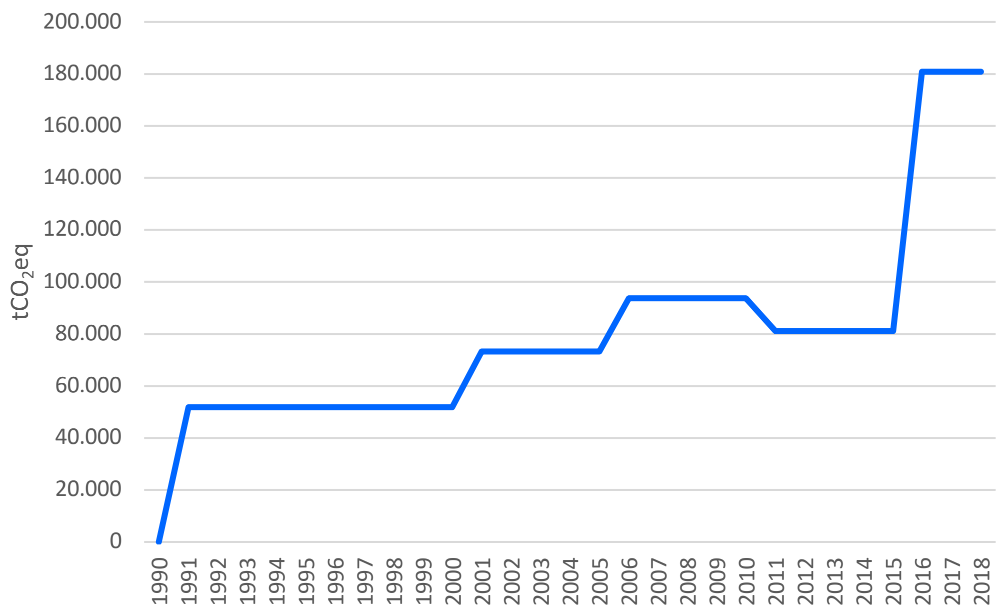

Figure 27 Net removals under REDD+ Activity Enhancement.

11.4 Summary of emissions and removals per REDD+ activity

The historical emissions and removals per REDD+ activity are presented here as an overview. Figure 28 presents the gross total emissions reported under each REDD+ activity in Gabon from 1990-2018. Total gross emissions for the period 1990-2018 are 795.0 million tCO_2eq, averaging 27.4 million tons per year (34.2 million tCO_2eq/year 2000-2009, 24.0 million tCO_2eq/year 2010-2018).

The data illustrate the important contribution of selective timber harvesting to emissions. Logging concessions (reported under SMF) contribute 79% of all forest related CO_2eq emissions. Rural Areas and Other Land Tenure (which includes agricultural concessions, as reported under REDD+ Activities Deforestation and Degradation) contribute 21% forest-related emissions (20% from forest cover losses and 1% from degradation). Protected areas (reported under Conservation) contribute only 0.2% forest-related emissions.

The data indicate decadal trends that coincide with government policies: low but increasing emissions in the 1990s (pre-forestry reform), higher emissions in the early 2000s that decrease from 2007 onwards following the implementation of several key national policies (national park creation, operationality of the 2001 forestry law and the raw timber export ban). It should be noted that gross emissions decreased by 40% between 2007 and 2012 and remained stable and low for most of the 2010s. This historical pattern of gross emissions reduction, evidenced from 2007 onwards, demonstrates Gabon's early commitment to sustainable forestry management practices.

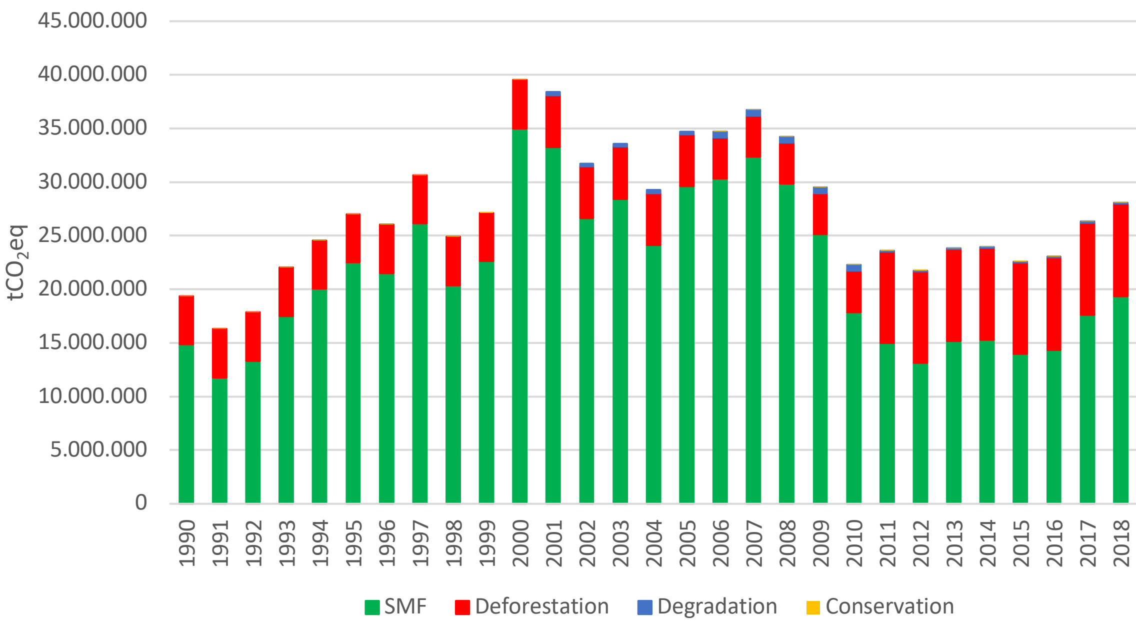

Figure 28 Gross total emissions from each REDD+ activity in Gabon, in tCO_2 from 1990-2018.

Gross removals contribute a significant amount to Gabon's forest carbon balance. Gross removals for each REDD+ activity for 1990-2018 are shown in Figure 29. They total 4.0 billion tCO_2eq over the 1990-

2018 period, with an average of 138.4 million tCO_2eq/year (142.1 million tCO_2eq/year 2000-2009, 142.6 million tCO_2eq/year 2010-2018).

Gabon's estimates indicate that the country's forests are removing about 139 million tCO_2eq/year from the atmosphere. Figure 29 shows how removals in logging concessions and protected areas have become more important over the years. Overall, logging concessions are responsible for 58% of all removals and protected areas 8%. However, the contribution of Rural Areas and Other Land Tenure is also significant, responsible for 34% of removals.

It should be noted that total removals in Gabon appear to be decreasing gradually since 2010 due to decreases in the cumulative area subject to logging during the previous decade, as a consequence of reduced harvest following the log-export ban. This trend is influenced by the contribution of removals in Logged Forest. The Activity Data for Logged Forest are derived directly from the production volume data: as the area of Logged Forest for any given year is a cumulative total over a previous 25-year period, historical changes in timber production are reflected in the respective area of Logged Forest for the subsequent 25 years. This relationship has implications for Gabon's ability to demonstrate results for both emissions reductions and increased removals against a recent historical baseline. Because logged forests have higher sequestration rates than unlogged forests, reduced emissions as evidenced through the capping or reduction of timber production will also have the effect of lowering removals, especially if the reduction is maintained over time.

Furthermore, preliminary data indicate that implementing RIL-C reduces not only emissions but also sequestration rates post-logging. Therefore, RIL-C implementation as a national policy would be expected to reduce removals in Logged Forests over time. As more data are collected as part of the improvement plan, future work will endeavour to integrate post-logging RIL-C sequestration rates into the model. By committing to significant reductions in logging-related emissions through sustainable forestry practices, it will become increasingly difficult to simultaneously demonstrate increased removals in standing forest against a recent historical baseline.

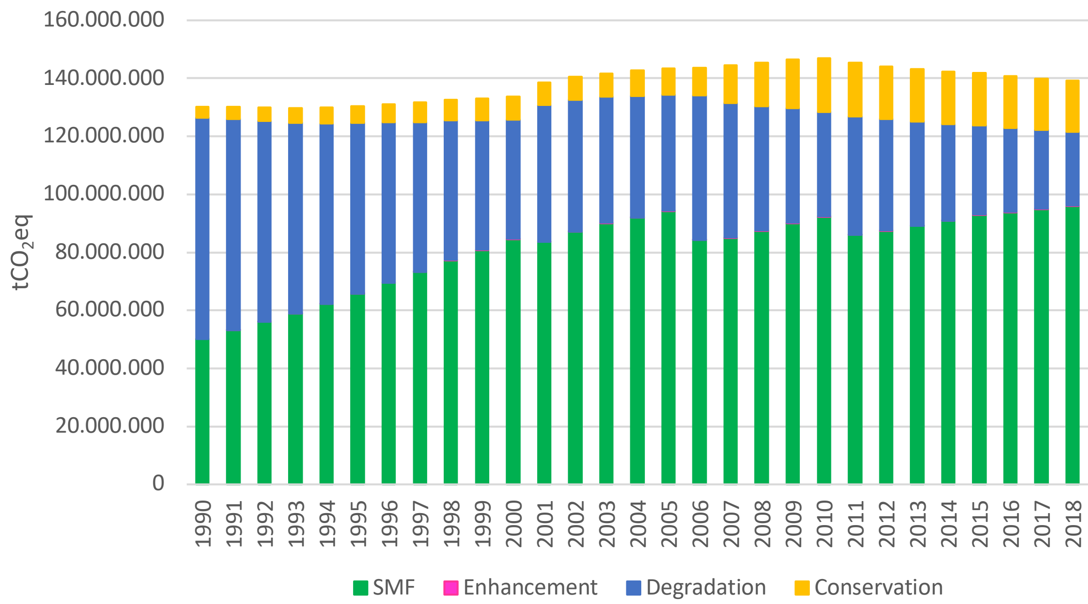

Figure 29 Gross Removals for each REDD+ activity in Gabon, in tCO_2 from 1990-2018.

Total net removals for each REDD+ activity are shown in Figure 30. Total net removals are 3.2 billion tCO_2eq sequestered over the 1990-2018 period, or an average of 111.0 million tCO_2eq/year (107.8 million tCO_2eq/year 2000-2009, 118.6 million tCO_2eq/year 2010-2018). Considering emissions levels from other sectors as reported in the 1st and 2nd national communications (République Gabonaise, 2011, 2004), Gabon's net emissions for the 1990-2018 period are in excess of 2.75 billion tCO_2eq.

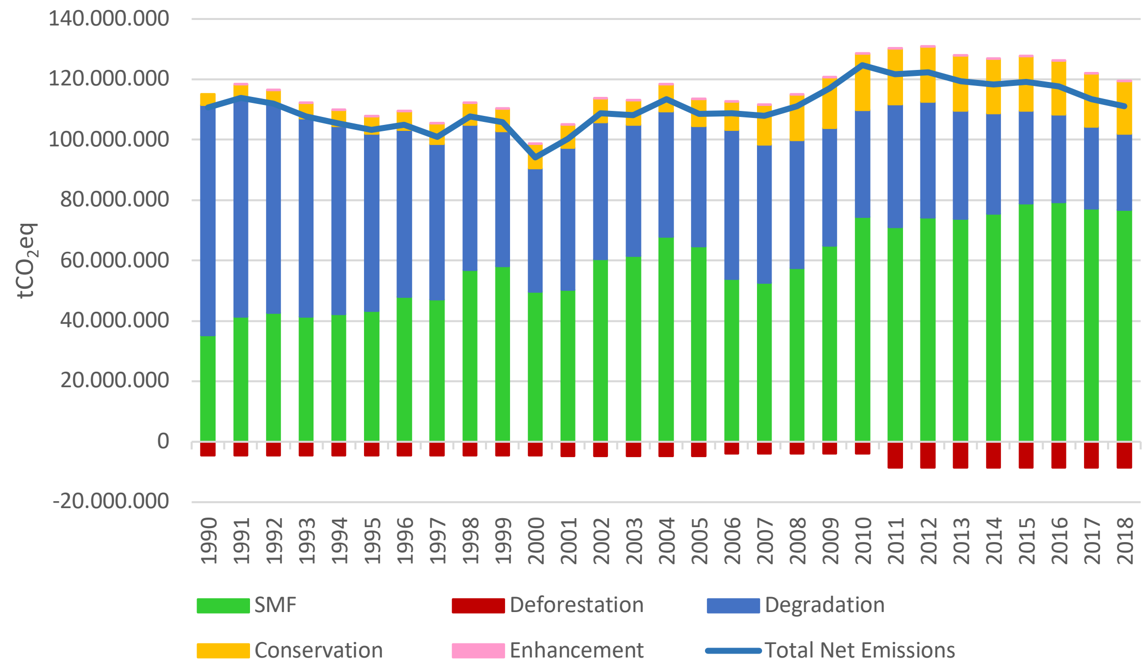

Figure 30 Net removals for each REDD+ activity in Gabon, in tCO_2 from 1990-2018. The solid blue line shows the total net removals.

12 Construction approach of the FRL

Gabon proposes a national adjusted FRL for the period 2010-2018.

12.1 Upwards adjustment

As an HFLD country, the GCF REDD+ RBP pilot programme guidelines allow an upward adjustment of 0.1 % of the total forest carbon stock spread over the results reporting period (GCF, 2017). This states: "*For countries that have consistently maintained high forest cover and low deforestation rates an adjustment that does not exceed 0.1% of the carbon stock over the eligibility period in the relevant national or subnational area, and does not exceed 10% of the FREL/FRL may be applied to the average annual historical emissions*". Section 18.11 Annex 11 details the calculation of the mean carbon stocks for Gabon over the GCF-eligible results reporting period of 2013-2018. Table 26 indicates that 10% of the mean net removals is lower than 0.1% of the carbon stocks for the FRL. This maximum upwards adjustment was made to the net average removals during the historical reference period 2000-2009 (applied to Gabon's FRL for 2010-2018) (Table 27).

Table 26 Calculation of 0.1% mean carbon stocks during the eligibility period.

Eligibility Period	Mean C stocks (tC)	Mean C stocks (tCO_2eq)	0.1% mean C stocks (tCO_2eq)
2013-2018	4,341,044,837	15,917,164,404	15,917,164

Table 27 Calculation of the upwards adjustment to the FRL.

Historical reference period	Mean net removals (tCO_2eq)	10% mean net removals (tCO_2eq)	10% FRL as a % of C stocks	Max. upwards adjustment allowed (tCO_2eq)	FRL + adjustment (tCO_2eq)
2000-2009	107,839,499	10,783,950	0.0678%	10,783,950	97,055,549

12.2 National FRL

For 2000-2009, the total average annual net removals from Deforestation, Forest Degradation, Sustainable Management of Forests, Conservation of Forest Carbon Stocks and Enhancement of Forest Carbon stocks is 107,839,499 tCO_2eq /year (Table 28). The proposed national adjusted FRL is 97,055,549 tCO_2eq, as calculated in Table 27.

Table 28 Summary of the average historical gross and net removals for Gabon (2000-2009) by REDD+ activity.

	Biomass Losses (Emissions)		Biomass Gains (Removals)		Gains-Losses (Net Removals)	
	Mean	U	Mean	U	Mean	U
REDD+ Activity	tCO_2eq/yr	%	tCO_2eq/yr	%	tCO_2eq/yr	%
Deforestation	4,405,851	14.4%	0	0.0%	-4,405,851	14.4%
Degradation	349,169	43.1%	43,787,662	0.7%	43,438,493	0.8%
SFM	29,480,629	9.6%	87,873,617	0.6%	58,392,988	4.9%
Conservation	11,581	12.6%	10,346,096	0.9%	10,334,516	0.9%
Enhancement	0	0.0%	79,352	17.3%	79,352	17.3%
Total	**34,247,229**	**2.6%**	**142,086,728**	**0.5%**	**107,839,499**	**2.8%**

Gabon's FRL is presented in Figure 31. It indicates the average historical net removals for 2000-2009 which is applied to the upwards adjusted FRL for 2010-2018.

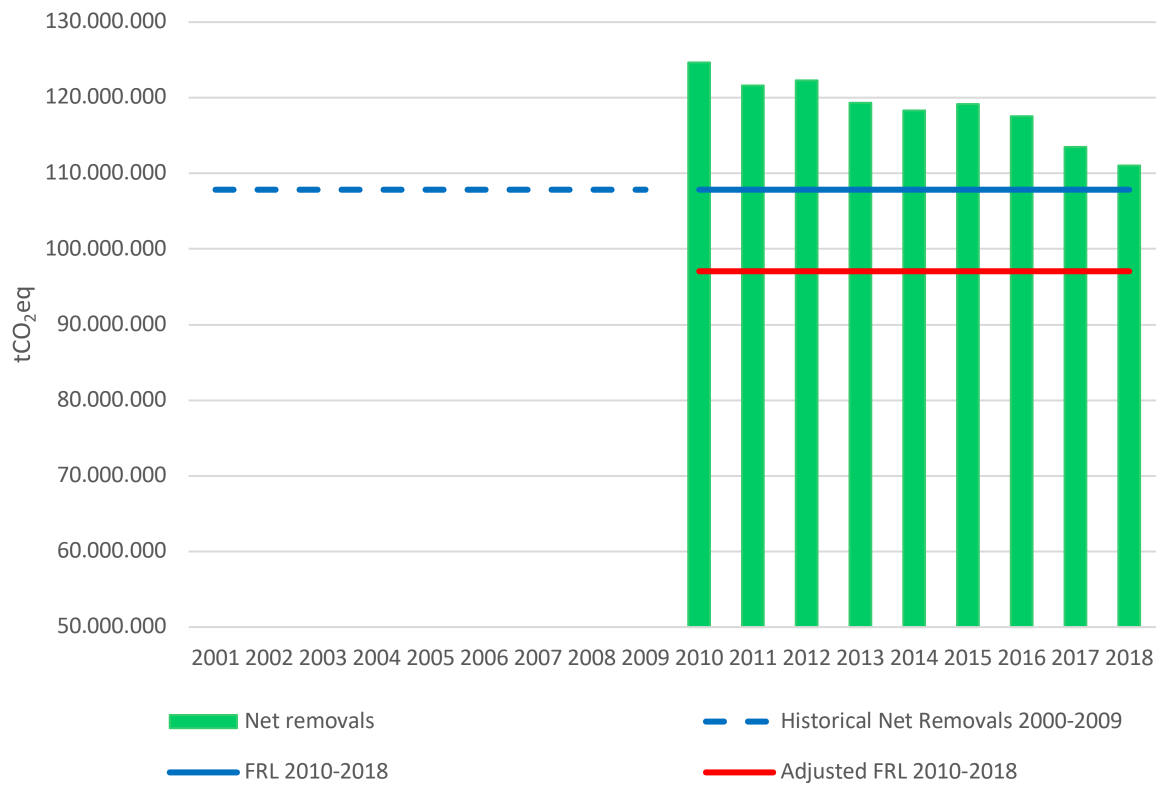

Figure 31 Gabon's proposed FRL. The FRL indicates the average historical net removals for 2000-2009 which is applied to the upwards adjusted FRL for 2010-2018.

13 Uncertainty

Uncertainties are indicated throughout the document. They were calculated at 95% Confidence Intervals as:

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

Equation 22

For remote sensing data, U was calculated as:

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

Equation 23

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

Where quantities were combined by addition across categories, U was calculated using IPCC equation 3.2 for combining uncertainties (IPCC, 2019b) (Equation 24). This equation was also applied where quantities were combined by average.

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

Equation 24

Where quantities were combined by subtraction, a variant of IPCC equation 3.2 was used (Equation 25).

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

Equation 25

Where quantities were combined by multiplication across categories, U was calculated using IPCC equation 3.1 for combining uncertainties (IPCC, 2019b) (Equation 26).

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

Equation 26

13.1 Uncertainty for Emissions and Removals Factors

For above-ground biomass, uncertainty was computed for each emissions and removals factor using Equation 22. For EF3, which was derived as a subtraction of two separate Emissions Factors, the uncertainty was computed using Equation 25. For RF6, which was derived as the average value of two separate sequestration rates, the uncertainty was computed using Equation 26.

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[12].

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). It is assumed that the value 1.235 is the sum of the certain value 1 and the uncertain value 0.235 with U 9.17%.

Therefore, uncertainty for the quantity 1.235 was computed with the formula:

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

Equation 27

The uncertainty of total carbon biomass (AGB+BGB) was then computed using IPCC equation 3.1 for multiplication (Equation 26), combining uncertainty for the quantity 1.235 with uncertainty for AG 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 29). 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 included 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

[12] 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.

(e.g. for Colonising Forest) are sourced from only a few measurements, and indicate quite high uncertainty values. This dataset represents the best available data at the time of analysis.

Table 29 Summary of Uncertainties for all Emissions and Removals Factors. U = Uncertainty.

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	tCO_2eq/ha	432.71	21.7%
EF2	Average forest carbon stocks (old growth, logged, secondary)	NRI- field measurements	104	tCO_2eq/ha	641.84	8.9%
EF3	Difference: Average Forest - Secondary carbon stocks	Derived	-	tCO_2eq/ha	209.12	52.2%
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	$tCO_2eq/ha/yr$	13.10	35.0%
RF2	Logged Forest- (11-25)	Derived	-	$tCO_2eq/ha/yr$	6.82	35.0%
RF3	Young Secondary	IPCC default value	15	$tCO_2eq/ha/yr$	15.69	39.5%
RF4	Colonising	Field measurements	5	$tCO_2eq/ha/yr$	6.40	42.4%
RF5	Mangrove	IPCC default value		$tCO_2eq/ha/yr$	20.44	5.3%
RF6	Average: Old growth, Old Secondary	Derived	-	$tCO_2eq/ha/yr$	4.67	37.6%
RF7	Secondary (20-100 yrs)	NRI- field measurements	8	$tCO_2eq/ha/yr$	5.85	55.5%

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. The IPCC recommends a 3% uncertainty for official statistics, however, here a more conservative approach was taken. In the analysis conducted by (FRM Ingénierie, 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, a fixed uncertainty of **11.5%** per year was applied to each year of Activity Data 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 total forest cover

The remote sensing method had high accuracy and precision for estimating forest cover. Uncertainty values for forest cover (calculated using Equation 23) were between **2.2 and 2.3%** for each assessment year (Table 6).

13.4 Uncertainty for Activity Data for forest cover losses from remote sensing

The forest cover loss data derived from remote sensing was used to estimate biomass losses from Forest Land to non-Forest Land-use categories (permanent and temporary land-use change) and Forest Land Remaining Forest Land (Degradation). Using Equation 23, uncertainties were first calculated for individual forest cover change event for each assessment period, which was organised by National Land Tenure, IPCC land-use category, REDD+ Activity and forest type.

Then, 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 was assumed to be the same (no change to uncertainty values when dividing a number). This provided uncertainty values at their most disaggregated level. As the areas involved at this level of disaggregation were very small and variable (mean 152 ha, range 5 - 4,479 ha), the associated uncertainties were also high and variable, ranging from 41.3-196% for temporary land-use change, 44.4 - 196% for permanent land-use change and 119- 196% for degradation. However, when aggregated using the IPCC Approach 1 (see below), the overall uncertainties decreased considerably.

13.5 Uncertainty for AD for removals

The AD for removals was a mixture of remote sensing data, interpolated data, estimated data derived from timber harvest and adjusted data. Therefore, the approach for computing uncertainty was more complicated than for emissions. A step-wise approach was taken, as described below.

13.5.1 Uncertainty for remote sensing data

For each National Land Tenure class, for the 'end' assessment years 2000, 2005, 2010, 2015 and 2018, Equation 22 was applied to calculate Uncertainty from the 95% CIs provided by the remote sensing analyses for each forest subcategory. Uncertainty values were not available for the 'start' assessment year (but these were not used in the FRL).

13.5.2 Uncertainty for interpolated data

The IPCC approach 1 does not provide equations to compute uncertainty for interpolated data. Therefore, a novel approach was developed. The following equations were applied:

$$U(ADint_i) = \frac{1.96 \times \sqrt{var(ADint_i)}}{ADint_i} \times 100$$

Equation 28

$$var(ADint_i) = var(AD_i)$$

Equation 29

$$var(AD_i) = \left(\frac{AD_i \times U_{AD_i}}{1.96 \times 100}\right)^2$$

Equation 30

Where:

$ADint_i$ is the interpolated Activity Data for year *i* (interpolated between assessment years *a* and *b*)

AD_i is the Activity Data for assessment year *b*

Further explanation of the reasoning behind these equations is provided in Annex 11.

13.5.3 Uncertainty for the cumulative areas of regenerated forest

The total (cumulative) area of regenerated forest between any two assessment years was computed for each year by summing the area of annual regenerated forest to the total (cumulative) area for the previous year (see Section 10.1.3.3). The uncertainty around these data was computed by applying Equation 24 (IPCC equation 3.2 for addition).

13.5.4 Uncertainty for Logged Forest

The area of Logged Forest was derived from timber production data (see Section 10.1.3.4). First, the Uncertainty of the Equivalent Harvested Areas (A_{EH}, Equation 3) was computed by applying Equation 26 (IPCC equation 3.1 for multiplication), where U_1= U of V_{AD} and U_2 = U of HI. This gave a constant value of 34% for all years. For the derived values of A_{EH} prior to 1990 (Equation 4 and Equation 5), in the absence of uncertainty values associated with logging concession area data (A_C), the same uncertainty value of 34% was assumed.

Equation 24 (IPCC equation 3.2 for addition) was then applied to derive the uncertainty of the summed (cumulative) totals respectively for LF_{10} and LF_{25} for each year.

The uncertainty of the proportion of Logged Forest within protected areas or logging concessions respectively (see Sections 10.1.3.4.1 and 10.1.3.4.2) was assumed to be the same as the total area of Logged Forest (LF_{10} and LF_{25} respectively) given that it is a proportion and therefore directly dependent.

13.5.5 Uncertainty for adjusted forest categories (replacement of remote sensing data with Logged Forest data)

The uncertainty of the adjusted forest categories within Protected Areas and logging concessions (where the area of 'dense' and 'unidentified' forest was partially replaced by the area of Logged Forest, and the area of secondary forest was totally replaced by the area of Logged Forest; Section 10.1.3.5), the following steps were applied:

- Area of secondary forest becomes zero, uncertainty = 0%.
- Value X1: Sum of the two Logged Forest categories: (LF_{10} + LF_{25}): Uncertainty of X1 computed with IPCC equation 3.2.
- Value X2: Sum of the two secondary forest categories (Degraded + Stable): Uncertainty of X2 computed with IPCC equation 3.2.
- Value X3: Subtraction of area of secondary forest from Logged Forest (X2 – X1): Uncertainty of X3 computed with IPCC equation 3.2.
- Value X4: Area of 'dense' forest, uncertainty already computed.
- Value X5: Subtraction of area of remaining Logged Forest from area of dense forest (X4 – X3): Uncertainty of X5 computed with IPCC equation 3.2.
- For years 1990-2000 (within logging concessions), Value X6 = area 'unidentified' forest, value X7 is the subtraction of the area of Logged Forest from the area 'unidentified' forest (X6 – X1); Uncertainty of X7 is computed with IPCC equation 3.2.

13.6 Uncertainty for Total Biomass losses and gains (Emissions and Removals)

For each sub-category of data (organised by National Land Tenure, IPCC land-use category, REDD+ Activity and forest type), uncertainty for emissions and removals (AGB + BGB combined) was calculated for each year using Equation 26 (IPCC equation 3.1 for multiplication), where U_1= U of AD and U_2 = U of EF or RF.

Using IPCC Approach 1, overall uncertainty for each REDD+ Activity was then calculated per year by applying Equation 24 (IPCC equation 3.2 for addition).

Then, for each REDD+ Activity, the overall uncertainty for each of three historical periods (1990-2018, 2000-2009 and 2010-2018 respectively) was computed using Equation 24, where $(x_i \times U_i)^2$ was computed annually and summed for years (1990-2018, 2000-2009 and 2010-2018 respectively), and x = AD.

To compute the Uncertainty for total emissions, the yearly Uncertainties for each REDD+ Activity were combined to provide the total uncertainty per year, applying Equation 24 (IPCC equation 3.2 for addition). Then, the overall Uncertainty for each of three historical periods (1990-2018, 2000-2009 and 2010-2018 respectively) was computed using Equation 24, where $(x_i \times U_i)^2$ was calculated for years 2000-2009 and summed, and x = AD.

The overall uncertainties for each REDD+ Activity are presented in Table 28. The overall uncertainty for net removals is 1.33% for 1990-2018, 2.8% for 2000-2009 and 1.9% for 2010-2018.

13.7 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 National Land Tenure classes, 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 U 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 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 Ingénerie, 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 document took place by the Coalition for Rainforest Nations that are supporting the National Climate Council to ensure consistency between the data of the FRL document and the national greenhouse gas inventory. Furthermore, the FRL document underwent an informal QA by two experts of the UNFCCC roster that do formal FRL/FREL reviews before it was submitted to the UNFCCC. The verification process for the NRR and the informal QA for the FRL document took place in parallel.

15 Proposed stepwise improvements to the FRL

Gabon's FRL 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 are described below.

15.1 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 greenhouse gas inventory 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.

15.2 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.

16 Expected total projected net removals

Expected projected net removals were estimated from 2019-2030, based on assumptions made in line with Gabon's various policies. They are considered both conservative and achievable, and are as follows:

a) Timber production volume increases by 20% by 2030,
b) RIL-C is implemented, resulting in a 30% reduction in logging-related emissions by 2025, 50% by 2030,
c) 300,000 ha Eucalyptus plantation forest are planted in savannahs, at a rate of 60,000 ha/year and starting with 15,000 ha in 2020 (applying a sequestration rate from young Eucalyptus stands in Cameroon (Noiha Noumi et al., 2017),
d) Annual rates of deforestation and forest degradation continue at rates observed between 2015 and 2019.

Expected net projected emissions (2019-2030, dashed green line) are plotted with Historical net removals (1990-2018, solid green line) in Figure 32.

A retrospective and forward-looking "Business-As-Usual" (BAU) scenario was also modelled, to highlight the impact of Gabon's past and existing efforts to reduce emissions. This is an update of the BAU scenario indicated in Gabon's INDC and aims to simulate a historical scenario in the absence of Gabon's forestry sector policies that came into play from 2000 onwards. Under this scenario, the following assumptions were made:

a) No revised forestry law was introduced in 2001, so no forestry management plans, or certification (CFAD, FSC) were introduced. All concessions operated under conventional logging regimes with a harvest cycle of 17.5 years (this is the weighted mean harvest cycle of all concessions under conventional logging),
b) No National Parks were created, meaning 1,030,589 ha logging concession were not cancelled in 2004-2006 (7% of the forestry estate),
c) No limit was placed on the allocation of logging concession permits: the areas allocated to logging increased at rates observed between 1990 and 2000,
d) 10,000 ha forest /year were converted to cropland (industrial agriculture) from 2010 onwards, with no application of the 118t C/ha threshold for HCV forests).

The BAU scenario is plotted in Figure 32 (orange line).

Finally, to illustrate the impact of Gabon's historically low rates of deforestation, a hypothetical scenario was modelled whereby emissions from 1990-2030 were estimated using a deforestation rate equivalent to the average for tropical countries. The annual deforestation rate used was 0.497% for 1990-2000 and 0.494% for 2000-2010 (applied to years 2000-2030), from Achard et al., (2014). Net removals with an average deforestation rate for tropical countries are plotted in Figure 32 (solid and dashed blue lines, representing net removals including and excluding those due to selective timber harvesting).

The data presented in Figure 32 show that, if achieved, projected net removals will be 117.8 million tCO_2eq/year by 2025. This is a difference of 9.2 million tCO_2eq compared to 2005 levels (108.6 million tCO_2eq: dotted green line), an increase of 8.5%. Gabon's pledge made in 2017 (République Gabonaise and Central African Forest Initiative, 2017) was to reduce 2005 gross emissions by at least 50% by 2025. Under this projected scenario, Gabon's gross emissions are expected to be 23.8 million t/CO_2e by 2025, a reduction of 31% compared to 2005 levels. This is expected to increase to a 41% emissions reduction by 2030 (20.3 million t/CO_2e).

When interpreting these results, it is important to consider the following points:

- The CAFI pledge was made on the basis of the INDC, which was based on 50% reduction in emissions compared to a BAU model and which contained the best available data at the time. The datasets have now been greatly improved following detailed analyses and the development of new, more robust methodologies. The new, revised data have revealed different, more conservative historical patterns and trends.
- In spite of the recent increase in emissions, gross removals have historically and consistently exceeded emissions by about six-fold. Since 1990, Gabon's forests have sequestered an estimated 4 billion tCO_2eq and in comparison, emitted less than 800 million tCO_2eq.
- The BAU scenario in Figure 32 illustrates that without the forestry and conservation reforms made in the 2000's, net removals would be 53.7 million tCO_2eq/year lower than they are today (48%) and steadily decreasing each year. However, even under the BAU scenario, Gabon would still be set to have net gains by 2030.
- The tropical deforestation average scenario shows that had Gabon observed a deforestation rate equivalent to the average for tropical countries, net removals would have been on average 65.9 million tCO_2eq/year lower (59%), converging with net expected removals under the BAU scenario by 2023.

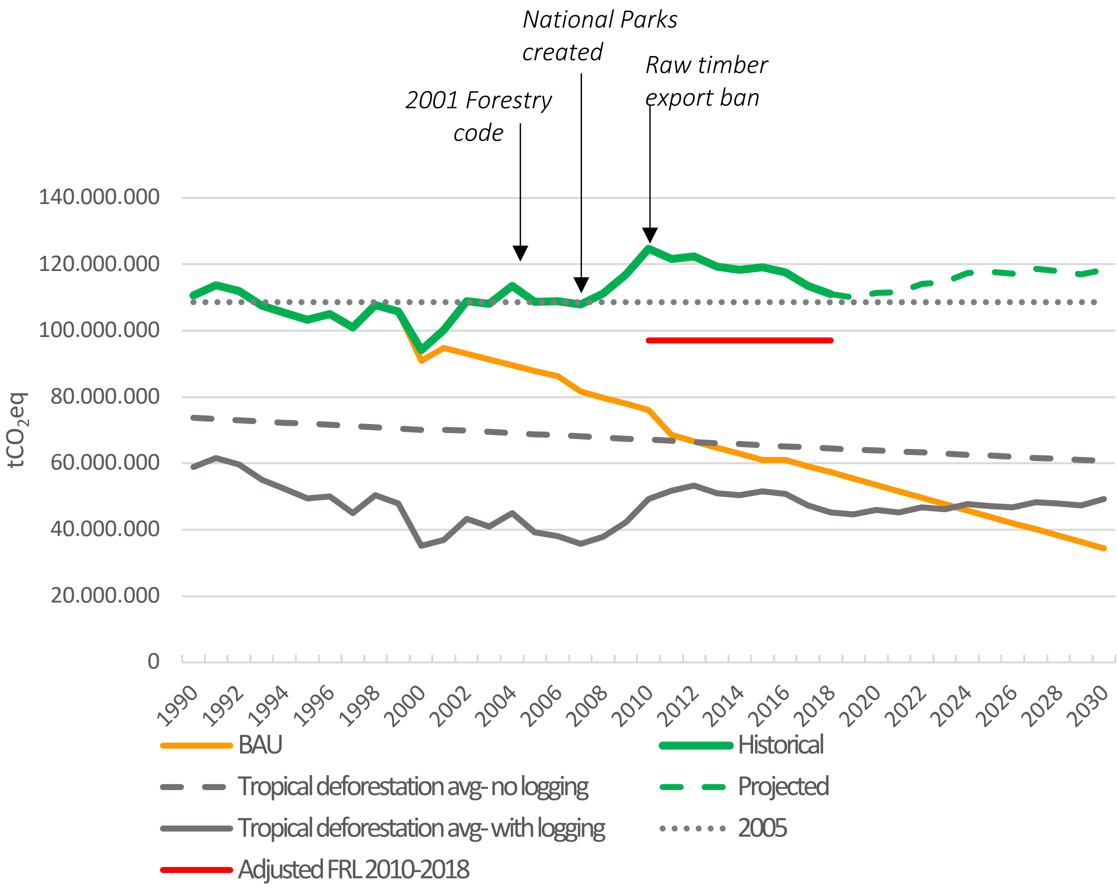

Figure 32 Total historical net removals (solid green line), projected net removals implementing the forest management policies the GoG has put in place (dashed green line), the 2005 benchmark (dotted grey line) against which Gabon pledged to reduce its emissions by 50% by 2025, the Business as Usual scenario (BAU) (solid orange line), the net global deforestation average for tropical forests including logging emissions (solid grey line), the net global deforestation average for tropical forests excluding logging emissions (dashed grey line), Gabon's proposed adjusted FRL for 2010-2018 (red line).

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18 Annexes

18.1 Annex 1. FSC certified companies in Gabon

CW = Controlled Wood

License Number	Certificate Code	Certificate Status	License Status	CW	Issue Date	Expiry Date	Organization Name
FSC-C044173	BV-COC-109734	Valid	✓		2020-01-28	2025-01-27	PRECIOUS WOODS - TGI
FSC-C002359	BV-FM/COC-840169	Valid	✓		2018-11-14	2023-11-13	PRECIOUS WOODS - CEB
FSC-C007904	BV-FM/COC-639590	Valid	✓		2019-06-02	2024-06-01	CBG
FSC-C011868	BV-COC-032146	Valid	✓		2019-06-02	2024-06-01	CPBG
FSC-C021473	BV-COC-840169	Valid	✓		2018-10-11	2023-10-10	PRECIOUS WOODS - CEB
FSC-C023023	BV-COC-639590	Valid	✓		2019-06-02	2024-06-01	COMPAGNIE DES BOIS DU GABON (CBG)
FSC-C023023	BV-COC-639590	Valid	✓		2019-06-02	2024-06-01	CBG
FSC-C023023	BV-COC-639590	Valid	✓		2019-06-02	2024-06-01	Compagnie de Services et de Logistique Pétrolière (CSLP)
FSC-C068077	BV-COC-134217	Valid	✓	✓	2020-01-08	2025-01-07	THEBAULT TRANSBOIS
FSC-C084349	CU-COC-836851	Valid	✓	✓	2015-04-24	2021-04-23	Corà Wood Gabon S.A.
FSC-C084418	CU-COC-861819	Valid	✓		2020-03-22	2025-03-21	SOMIVAB
FSC-C109909	FCBA-COC-000312	Valid	✓		2012-02-13	2022-02-12	CEMA GABON

FSC-C116230	NC-FM/COC-006621	Valid	✓		2018-11-08	2023-11-07	Rougier Gabon
FSC-C118282	NC-COC-006617	Valid	✓	✓	2018-11-08	2023-11-07	Rougier Gabon
FSC-C118282	NC-COC-006617	Valid	✓	✓	2018-11-08	2023-11-07	Négoce de grumes de bois national
FSC-C118282	NC-COC-006617	Valid	✓	✓	2018-11-08	2023-11-07	Scierie de Mévang Identificateur : MEV
FSC-C118282	NC-COC-006617	Valid	✓	✓	2018-11-08	2023-11-07	Scierie de Mbouma Oyali Identificateur : MBO
FSC-C118282	NC-COC-006617	Valid	✓	✓	2018-11-08	2023-11-07	Usine de fabrication de contreplaqués d'Owendo Identificateur : OWE
FSC-C124065	BV-COC-124065	Valid	✓		2020-01-28	2025-01-27	PLACAGES DEROULES DU GABON
FSC-C141104	CU-CW/FM-853952	Valid	✓		2018-06-11	2023-06-10	Corà Wood Gabon S.A.
FSC-C144419	NC-FM/COC-035450	Valid	✓		2018-11-08	2023-11-07	Rougier Gabon
FSC-C144772	BV-COC-144772	Valid	✓		2018-11-30	2023-11-29	MAC VENEER
FSC-C148875	CU-COC-865304	Valid	✓		2019-06-04	2024-06-03	Gabonese Best Natural Source- G.B.N.S. - SARL
FSC-C149179	CU-COC-865968	Valid	✓		2019-07-08	2024-07-07	Gabon Special Economic Zone
FSC-C150501	NC-FM/COC-03545A	Valid	✓		2019-08-02	2024-08-01	Rougier Gabon
FSC-C150523	NC-FM/COC-03545B	Valid	✓		2019-08-02	2024-08-01	Rougier Gabon

FSC-C154713	NC-COC-057039	Valid			2020-01-20	2025-01-19	Gabon Veneer SARL
FSC-C152771	BV-COC-152771	Valid			2019-11-27	2024-11-26	GREENPLY GABON SA
FSC-C158293	BV-COC-158293	Valid			2020-07-06	2025-07-05	SOCIETE ZHENG DA INTERNATIONAL BOIS DU GABON
FSC-C158641	CU-COC-872153	Valid			2020-07-27	2025-07-26	Africa View sa
FSC-C159272	CU-COC-874178	Valid			2020-08-18	2025-08-17	Star Ply Gabon
FSC-C159482	NC-COC-053967	Valid			2020-11-14	2025-11-13	Gabon Wood Industries
FSC-C159612	CU-COC-874317	Valid			2020-09-01	2025-08-31	Woods International SARL

18.2 Annex 2. Example of forest cover and land-use change matrices generated for the Activity Data of the FRL.

Evolution between 2005 and 2010 in domaine rural

Rural Area level (ha)

Considered as IN domaine rural for year 2010

	IPCC	2005 / IPCC sub-category		2010 / IPCC sub-category evolution	Forest: Dense forest (10, ha)	Forest: Seconday forest (11, ha)	Forest: Inonded forest (12, ha)	Forest: Mangrove (13, ha)	Cropland: Cropland (20, ha)	Other lands: Bare soil (21, ha)	Grassland: Savanah/grassland (22, ha)	Humid area: Water (23, ha)	Humid area: Swamp area (25, ha)	Settlements: Settlements excluding roads (24, ha)	Settlements: Roads (241, ha)	Evolution 2005-2010: total of the area of the type of evolution of the sub-category between 2005-2010 (ha)	Evolution 2005-2010: % of the area of the type of evolution of the sub-category between 2005-2010	2005: total of the area of the sub-category for 2005 (ha)	2005: total area of IPCC class for 2005 (ha)
Considered as IN domaine rural for year 2005	Forest	Dense forest	10	deforestation					2,028		782			0	214	3,023	0.001		
			10	degradation		12,439			6,744		235			149	1,026	20,592	0.009		
			10	stable	1,264,499											1,264,499	0.530	1,288,115	1,711,899
			11	deforestation					1,620		265			2,293		4,178	0.002		
			11	degradation					7,863		437			97		8,397	0.004		
		Seconday forest	11	stable		278,441										278,441	0.117	291,016	
		Inonded forest	12	stable			132,769									132,769	0.056	132,769	
	Cropland		20	regeneration		12,205										12,205	0.005		
		Cropland	20	stable					5,247							5,247	0.002	17,452	17,452
	Other lands	Bare soil	21	stable						6,462						6,462	0.003	6,462	6,462
	Grassland		22	regeneration		1,029										1,029	0.000	137,493	
		vanah/grassland	22	stable							136,464					136,464	0.057		137,493
	Humid area	Water	23	stable								139,470				139,470	0.059	139,470	
		Swamp area	25	stable									54,075			54,075	0.023	54,075	193,546
	Settlements	s excluding roads	24	stable										36,133		36,133	0.015	36,133	
			241	regeneration		351										351	0.000		
		Roads	241	stable											19,840	19,840	0.008	20,192	56,325
Considered NOT IN domaine rural for year 2005	Forest	Dense forest	10	deforestation					207							207	0.000		
			10	degradation		519			408						34	961	0.000		
			10	stable	232,835											232,835	0.098	234,003	
			11	deforestation					83							83	0.000		
			11	degradation					311							311	0.000		
		Seconday forest	11	stable		18,535										18,535	0.008	18,928	252,931
	Cropland		20	regeneration		1,033										1,033	0.000		
		Cropland	20	stable					720							720	0.000	1,753	1,753
	Humid area	Water	23	stable								1,403				1,403	0.001	1,403	1,403
	Settlements		24	regeneration		108										108	0.000		
		s excluding roads	24	stable										608		608	0.000	716	
			241	regeneration		1,523										1,523	0.001		
		Roads	241	stable											2,415	2,415	0.001	3,938	4,654
2010		the sub-category for 2010 (ha) in the domaine rural			1,497,334	326,184	132,769	-	25,230	6,462	138,183	140,874	54,075	39,280	23,528	2,383,918		2,383,918	2,383,918
		% of the sub-category for 2010 in the domaine rural			0.628	0.137	0.056	-	0.011	0.003	0.058	0.059	0.023	0.016	0.010				
		ce of IPCC class for 2010 (ha) in the domaine rural						1,956,286	25,230	6,462	138,183		194,949		62,809	2,383,918			

Color legend:
- stable 2005-2010
- regeneraton 2005-2010
- degradation 2005-2010
- deforestation 2005-2010

Synthesis of evolutions between 2000 and 2010	Domaine rural level	95% CI
Forests 2010 (ha)	1,956,286	159,868
Forests 2005 (ha)	1,964,830	159,330
Regeneration (ha)	16,250	9,537
Degradation (ha)	30,261	18,131
Deforestation (ha)	7,491	4,273

Source: (SIRS, 2020b)

18.3 Annex 3. Detailed rationale for excluding soil as a carbon pool for CO_2 emissions calculations

Gabon reports soil carbon stocks in its FRL document but excludes calculations of soil carbon emissions in the first FRL submission, aiming instead to include it as part of the improvement plan, following the collection of supplementary data. The reasons for this are outlined below.

There are several published sources of soil carbon stock data for Gabon (Chiti et al., 2017, 2016; Cuni-Sanchez et al., 2016; Gautam and Pietsch, 2012; Kauffman and Bhomia, 2017; Wade et al., 2019), but country-specific data on soil carbon stock changes due to land-use and management are lacking. Further, comparisons between these studies show inconsistent results. For example, different results at the same sites were reported in two separate studies, probably due to methodological differences (Chiti et al., 2017; Cuni-Sanchez et al., 2016), and significant differences between unlogged and Logged Forest were reported at a site-specific study (Chiti et al., 2016) but no difference was found at a national scale (Wade et al., 2019). Similarly, carbon stocks reported for old-growth forest at one site (Gautam and Pietsch, 2012) differ to those collected at a national scale (Wade et al., 2019). Overall, the NRI represents the most comprehensive study of soil carbon stocks in Gabon to date: from these data, but the published analysis found that land-use type is not a reliable predictor of soil carbon, but rather lithology, local climate, and soil type exerts more dominant controls (Wade et al., 2019).

IPCC guidelines state that for forest remaining Forest Land at Tier 1 level, it is assumed that mineral soil carbon stocks on land that has been forest for at least 20 years are in equilibrium and do not change (IPCC, 2006b). Under Forest Land Remaining Forest Land, Gabon considers selective timber harvesting as a key activity. Of the two soil carbon studies in Gabon that have compared logged and unlogged forest, the NRI study is the most representative, given its geographic scope. This study concludes that there is no compelling evidence for carbon stock changes related to selective timber harvesting in Gabon (Wade et al., 2019, and A. Wade, *pers. comm*.). Based on these data and in line with IPCC recommendations, soil carbon emissions from SMF activities under Forest Land remaining Forest Land can be reasonably ignored, however, more detailed measurements from forests with known disturbance history, such as the number of years since logging and logging intensity etc. would be useful.

For Forest Land converted to non-Forest Land-use categories, IPCC guidelines assume that carbon is emitted or removed over a 20-year transition period at which time the new carbon value is assumed to be obtained. Further, the inclusion of soil carbon at Tier 1 level is recommended if soil related emissions are considered to be a *key category* (i.e. one that has a significant influence on a country's total greenhouse gas inventory in terms of the absolute level, trend, or uncertainty in emissions and removals, and includes both source and sink categories), and where country-specific data on soil carbon stock changes due to land-use and management are lacking (IPCC, 2006b). For higher tiers, it is recognised that the collection of national data on soil carbon stock changes may be challenging, given the high spatial variability of soil carbon stocks and extensive sampling required to detect changes.

While more data is required to determine the exact contribution of soil carbon emissions to the country's total greenhouse gas inventory, there is reason to believe it may be relatively minor. Deforestation rates have been historically low in Gabon, with most agricultural conversion only occurring in the last 10 years, and overall forest losses contributing less than 10% of forest-sector emissions in other carbon pools measured. While mangrove soils contain significant quantities of carbon (Kauffman and Bhomia, 2017), further work is needed to quantify soil carbon changes following deforestation and degradation, and available remote sensing data indicate historical Mangrove Forest cover losses to be undetectable. Given this, the relatively recent (<20 years ago), limited scale (< 0.05% annual forest cover loss) of forest conversion to non-Forest Land-use categories in Gabon means that soil-related emissions from forest losses are unlikely to be a key category. However, as cropland matures, agricultural development plans roll out and soil carbon changes accumulate over the IPCC-recognised 20-year transition period, the future potential for soil carbon emissions to become a key category demands the need for more detailed studies on the impacts of management and land-use change on SOC stocks.

In preparation for this scenario, the lack of country-specific data on soil carbon stock changes and sequestration currently precludes a Tier 2 approach, with a Tier 1 approach necessarily applying.

A simple approach to estimating SOC emissions following land-use change would be to calculate it as the difference between SOC density in Forest Land and Forest Land converted to non-Forest Land-use categories, using an adaptation of IPCC equation 2.2.5, following the approach in (Royal Government of Bhutan, 2019):

$$SOCemission = (SOCForest - SOCnon\text{-}forest) / 20\ years$$

Equation 31

To date, the only available data for SOC in non-forested land in Gabon are from savannahs at one site in Lopé National Park (Chiti et al., 2017; Cuni-Sanchez et al., 2016). These are natural savannahs that have existed in flux with adjacent forests for thousands of years, and whose carbon dynamics are ecologically incomparable to recent land-use conversion (including the role of pyrogenic carbon that has not yet been quantified). Further, methodological differences have already been identified as a potential issue for interpreting results at this site, highlighting the importance of using comparable methodology to monitor carbon stock changes between land-use types at larger geographic scales.

A wider literature search reveals that data are available for SOC stock changes between forest and oil palm plantations in Ghana (Chiti et al., 2014), however, for the aforementioned reasons including methodological differences as well as unquantified differences in lithology, climate and soil types, there is no indication that these data could be used as a reliable default value.

Given all these parameters, it is argued here that:

- Soil carbon emissions in Gabon are unlikely to be a key category at the present time, but may become more important for deforestation in the future,
- A Tier 1 approach is not recommended as default or regional values are likely to be unreliable, country-specific data on carbon stock changes due to land-use and management are recommended as preferential,
- Within the limits set by time and logistics, a targeted programme of field data collection is recommended using standardised, comparable methodology, to measure carbon stock dynamics within forestland remaining Forest Land (in Logged Forests, degraded Mangrove Forests and forests degraded by shifting agriculture), and following different land-use changes (e.g. before and

after conversion to oil palm or other plantation types, and following Mangrove Forest loss). As a programme of above-ground re-measures for the NRI is already underway, this should be integrated within the NRI framework, including more detailed information on disturbance history (e.g. logging intensity, time since disturbance) at each plot.

18.4 Annex 4. Explanation for discrepancies in forest area cover

In the direct expansion model, two important parameters inform the results: these are the proportion of each land cover and land-use change within the PSUs (deforestation, degradation, stable or regeneration) and the area with which to multiply these proportions.

- At the **national scale**, proportions are derived from all PSUs, and are multiplied by the area of Gabon,
- At the **National Land Tenure scale**, the proportions change since only the areas of the PSUs involved in a layer are considered to derive these proportions, which are then multiplied by the area of the layer concerned.

As the proportions and areas involved in the different types of matrices differ, discrepancies between the national level and the sum of the Land Tenure levels inevitably occur. The uncertainties for each category are related to the number of PSUs considered and the area concerned, and the differences observed are due to the accumulation of these small uncertainties. All observed differences in forest cover between the National Land Tenure and national level analyses are small and fall within the 95% CI of the national level estimates (Table 30). These differences will be addressed as part of the improvement plan.

Table 30 Differences in forest cover values between the sub-national level and Land Tenure analyses.

Year	Forest cover (ha)			
	Sum of National Land Tenure Scale	National level	Difference	95% CI
1990	23,717,107	23,663,312	53,795	532,580
2000	23,757,101	23,619,984	137,117	529,886
2005	23,746,349	23,607,573	138,776	529,896
2010	23,724,074	23,600,088	123,987	530,179
2015	23,669,389	23,546,258	123,131	531,327
2018	23,718,785	23,523,037	195,748	531,380

18.5 Annex 5. Activity Data for Biomass losses due to permanent land-use change (Forest Land converted to non-Forest Land-use categories), reported under REDD+ Activities Deforestation and Conservation.

Table 31 Activity Data for biomass losses due to permanent land-use change.

National Land Tenure	REDD+ Activity	IPCC LUC	Forest Type	Average Yearly change (ha)									
				1990-2000		2000-2005		2005-2010		2010-2015		2015-2019	
				Area		Area	U	Area	U	Area	U	Area	U
Rural Area	Deforestation	Forest to Cropland	Old growth, old secondary, logged	0	-	350	173.8%	447	87.9%	414	107.3%	1,925	79.1%
			Secondary	0	-	331	97.1%	341	103.3%	741	88.1%	3,209	76.1%
		Forest to Grassland	Old growth, old secondary, logged	0	-	19	196.0%	156	196.0%	19	196.0%	0	0.0%
			Secondary	0	-	22	196.0%	53	196.0%	0	0.0%	162	158.1%
		Forest to Wetland	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	106	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Settlement (including roads)	Old growth, old secondary, logged	0	-	614	68.2%	43	195.6%	96	187.1%	382	181.1%
			Secondary	0	-	824	179.2%	459	139.7%	43	128.8%	82	152.1%
		Forest to Other Land	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	310	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	194	196.0%	0	0.0%
		Forest to Non-Forest	Unidentified	3,325	108.8%	0	-	0	-	0	-	0	-
		Total Rural Area		**3,325**	**109%**	**2,161**	**77%**	**1,498**	**57%**	**1,924**	**92%**	**5,760**	**29%**
Other Land Tenure	Deforestation	Forest to Cropland	Old growth, old secondary, logged	0	-	0	0.0%	39	196.0%	4,479	143.5%	3,006	127.0%
			Secondary	0	-	109	114.0%	95	196.0%	1,721	147.5%	1,622	114.3%
		Forest to Grassland	Old growth, old secondary, logged	0	-	248	145.2%	15	196.0%	76	141.7%	52	196.0%
			Secondary	0	-	114	196.0%	0	0.0%	0	0.0%	54	196.0%
		Forest to Wetland	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	1,644	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%

		Forest to Settlement (including roads)	Old growth, old secondary, logged	0	-	609	95.8%	990	112.6%	162	127.0%	2,080	117.1%
			Secondary	0	-	0	0.0%	0	0.0%	73	164.1%	272	106.0%
		Forest to Other Land	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Non-Forest	Unidentified	1,417	82.6%	0	-	0	-	0	-	0	-
		Total Other Land Tenure		**1,417**	**83%**	**1,080**	**77%**	**1,138**	**99%**	**8,154**	**94%**	**7,086**	**16%**
		Total Rural Area + Other Land Tenure		**4,742**		**3,240**		**2,637**		**10,078**		**12,846**	
Protected Areas	Conservation	Forest to Cropland	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Grassland	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	60	196.0%	12	196.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	24	196.0%
		Forest to Wetland	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	5	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Settlement (including roads)	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	49	196.0%	0	0.0%
		Forest to Other Land	Old growth, old secondary, logged	0	-	0	0.0%	0	0.0%	44	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Non-Forest	Unidentified	86	142.4%	0	-	0	-	0	-	0	-
		Total Protected Areas		**86**	**142%**	**0**	**0%**	**0**	**0%**	**158**	**110%**	**36**	**145%**

18.6 Annex 6. Activity Data for Biomass Losses due to temporary land-use change (Forest Land converted to non-Forest Land-use categories), reported under REDD+ Activities Deforestation and Conservation.

Table 32 Activity Data for biomass losses due to temporary land-use change.

National Land Tenure	REDD+ Activity	IPCC LUC	Interpretation	Average Yearly Change (ha)									
				1990-2000		2000-2005		2005-2010		2010-2015		2015-2018	
				Area	U	Area	U	Area	U	Area	U	Area	U
Rural Area	Degradation												
		Forest Land to Cropland	Old growth, old secondary, older logged	0	-	1,498	83.0%	1,430	65.3%	266	93.7%	216	97.0%
			Secondary	0	-	1,162	103.5%	1,635	70.2%	2,206	93.7%	714	84.8%
		Forest Land to Grassland	Old growth, old secondary, older logged	0	-	0	0.0%	47	196.0%	105	196.0%	0	0.0%
			Secondary	0	-	0	0.0%	87	196.0%	0	0.0%	121	196.0%
		Forest Land to Wetland	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest Land to Settlement (including roads)	Old growth, old secondary, older logged	0	-	0	0.0%	242	155.5%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	19	196.0%	24	137.7%	0	0.0%
		Forest Land to Other Land	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Non-Forest	Unidentified	1,557	232.3%	0	-	0	-	0	-	0	-
		Total Rural Area		**1,557**	**232.3%**	**2,660**	**65.0%**	**3,461**	**44.5%**	**2,600**	**80.4%**	**1,052**	**65.0%**
Protected Areas	Conservation												
		Forest Land to Cropland	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	42	196.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	15	196.0%
		Forest Land to Grassland	Old growth, old secondary, older logged	0	-	0	0.0%	14	196.0%	9	196.0%	0	0.0%

			Secondary	0	-	0	0.0%	8	196.0%	0	0.0%	0	0.0%
		Forest Land to Wetland	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest Land to Settlement (including roads)	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	49	196.0%
		Forest Land to Other Land	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest to Non-Forest	Unidentified	17	142.7%	0	-	0	-	0	-	0	-
		Total Protected Area		**17**	**142.7%**	**0**	**0.0%**	**22**	**144.0%**	**9**	**196.0%**	**106**	**122.1%**
Other Land Tenure	Degradation												
		Forest Land to Cropland	Old growth, old secondary, older logged	0	-	1,164	196.0%	479	118.4%	675	168.0%	1,152	175.3%
			Secondary	0	-	670	136.8%	379	94.4%	1,334	99.9%	297	96.8%
		Forest Land to Grassland	Old growth, old secondary, older logged	0	-	65	196.0%	0	0.0%	8	196.0%	28	196.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	71	196.0%
		Forest Land to Wetland	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Forest Land to Settlement (including roads)	Old growth, old secondary, older logged	0	-	795	124.5%	22	196.0%	642	170.1%	113	196.0%
			Secondary	0	-	0	0.0%	0	0.0%	97	179.0%	0	0.0%
		Forest Land to Other Land	Old growth, old secondary, older logged	0	-	0	0.0%	0	0.0%	0	0.0%	0	0.0%
			Secondary	0	-	0	0.0%	0	0.0%	0	0.0%	82	196.0%
		Forest to Non-Forest	Unidentified	725	63.7%	0	-	0	-	0	-	0	-
		Total Other Land Tenure		**725**	**63.7%**	**2,695**	**98.5%**	**880**	**76.3%**	**2,756**	**75.1%**	**1,744**	**118.4%**

18.7 Annex 7. Activity Data for Biomass Losses due degradation (Forest Land Remaining Forest Land), reported under REDD+ Activities Deforestation and Conservation.

Table 33 Activity Data for biomass losses in Forest Land remaining Forest Land.

National Land Tenure	REDD+ Activity Reported under	IPCC LUC	Forest type degraded (RS)	Interpretation	Average Yearly Change (ha)									
					1990-2000		2000-2005		2005-2010		2010-2015		2015-2018	
					Area	**U**	**Area**	**U**	**Area**	**U**	**rea**	**U**	**Area**	**U**
Rural Area	Degradation	Forest Land to Forest Land	Dense + flooded	Old growth, old secondary, older logged	0	0.0%	945	119.0%	2,592	115.0%	0	0.0%	47	146.7%
		Total Rural Area			**0**	**0.0%**	**945**	**119.0%**	**2,592**	**115.0%**	**0**	**0.0%**	**47**	**146.7%**
Protected Areas	Conservation	Forest Land to Forest Land	Dense + flooded	Old growth, old secondary, older logged	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
		Total Protected Area			**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Other Land Tenure	Degradation	Forest Land to Forest Land	Dense + flooded	Old growth, old secondary, older logged	0	0.0%	308	158.2%	16	196.0%	276	196.0%	321	100.1%
		Total Other Land Tenure			**0**	**0.0%**	**308**	**158.2%**	**16**	**196.0%**	**276**	**196.0%**	**321**	**100.1%**

18.8 Annex 8. Activity Data for Removals

Table 34 Activity Data for removals, by REDD+ Activity. Each table shows the Activity Data in hectares (1990-2018) followed by uncertainties (%) (1990-2018).

REDD+ Activity	Degradation													
National Land Tenure	Other Land Tenure							Rural Area						
IPCC LUC	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land
Forest State	Stable	Stable	Degraded	Stable	Stable	Stable	Stable	Stable	Stable	Degraded	Stable	Stable	Stable	Stable
Forest Type Year	Old growth, old secondary, older logged	Secondary	Secondary	Mangrove	Unidentified	Young Secondary	Colonising	Old growth, old secondary, older logged	Secondary	Secondary	Mangrove	Unidentified	Young secondary	Colonising
1990	0	0	0	0	14,489,730	0	0	0	0	0	0	1,881,019	0	0
1991	0	0	0	0	13,714,532	0	0	0	0	0	0	1,888,568	0	0
1992	0	0	0	0	12,939,334	1,676	0	0	0	0	0	1,896,117	1,621	0
1993	0	0	0	0	12,164,136	3,352	0	0	0	0	0	1,903,667	3,242	0
1994	0	0	0	0	11,388,938	5,028	0	0	0	0	0	1,911,216	4,862	0
1995	0	0	0	0	10,613,740	6,704	0	0	0	0	0	1,918,765	6,483	0
1996	0	0	0	0	9,838,542	8,380	0	0	0	0	0	1,926,314	8,104	0
1997	0	0	0	0	9,063,344	10,056	0	0	0	0	0	1,933,863	9,725	0
1998	0	0	0	0	8,288,146	11,732	0	0	0	0	0	1,941,412	11,345	0
1999	0	0	0	0	7,512,948	13,408	0	0	0	0	0	1,948,961	12,966	0
2000	0	0	0	0	6,737,751	15,084	0	0	0	0	0	1,956,510	14,587	0
2001	7,258,717	280,626	308	142,349	0	0	0	1,511,968	296,608	945	0	0	0	0

2002	6,855,172	265,170	615	142,349	0	1,578	267	1,529,849	301,552	1,891	0	0	2,862	305
2003	6,451,626	249,714	923	142,349	0	3,156	534	1,547,730	306,496	2,836	0	0	5,724	610
2004	6,048,081	234,257	1,231	142,349	0	4,735	801	1,565,611	311,439	3,782	0	0	8,586	915
2005	5,644,535	218,801	1,538	142,349	0	6,313	1,069	1,583,493	316,383	4,727	0	0	11,448	1,220
2006	7,904,927	298,910	16	127,559	0	0	0	1,462,727	292,208	2,592	0	0	0	0
2007	7,192,955	280,465	32	111,901	0	2,796	124	1,504,571	293,400	5,183	0	0	3,044	206
2008	6,480,982	262,020	49	96,244	0	5,593	248	1,546,415	294,592	7,775	0	0	6,088	412
2009	5,769,010	243,575	65	80,586	0	8,389	371	1,588,259	295,784	10,367	0	0	9,132	617
2010	5,057,037	225,130	81	64,928	0	11,185	495	1,630,103	296,976	12,958	0	0	12,177	823
2011	6,435,654	305,791	276	78,631	0	0	0	1,234,768	293,584	0	0	0	0	0
2012	5,873,146	288,847	551	78,631	0	1,596	636	1,255,005	294,195	0	0	0	3,230	205
2013	5,310,637	271,903	827	78,631	0	3,191	1,271	1,275,242	294,805	0	0	0	6,459	409
2014	4,748,128	254,959	1,102	78,631	0	4,787	1,907	1,295,480	295,415	0	0	0	9,689	614
2015	4,185,619	238,014	1,378	78,631	0	6,383	2,542	1,315,717	296,026	0	0	0	12,919	819
2016	4,099,504	268,832	321	73,582	0	0	0	1,078,616	287,140	47	0	0	0	0
2017	3,707,557	249,750	643	73,582	0	6,162	72	1,076,046	282,851	93	0	0	5,132	491
2018	3,315,611	230,668	964	73,582	0	12,325	144	1,073,476	278,562	140	0	0	10,264	983
1990	0.0%	0.0%	0.0%	0.0%	NOT AVAILABLE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	NOT AVAILABLE	0.0%	0.0%
1991	0.0%	0.0%	0.0%	0.0%	3.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.5%	0.0%	0.0%
1992	0.0%	0.0%	0.0%	0.0%	3.3%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	8.4%	45.3%	0.0%
1993	0.0%	0.0%	0.0%	0.0%	3.5%	19.5%	0.0%	0.0%	0.0%	0.0%	0.0%	8.4%	32.0%	0.0%
1994	0.0%	0.0%	0.0%	0.0%	3.7%	15.9%	0.0%	0.0%	0.0%	0.0%	0.0%	8.4%	26.2%	0.0%
1995	0.0%	0.0%	0.0%	0.0%	4.0%	13.8%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	22.6%	0.0%
1996	0.0%	0.0%	0.0%	0.0%	4.3%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	20.3%	0.0%
1997	0.0%	0.0%	0.0%	0.0%	4.7%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	18.5%	0.0%
1998	0.0%	0.0%	0.0%	0.0%	5.1%	10.4%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	17.1%	0.0%
1999	0.0%	0.0%	0.0%	0.0%	5.6%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	8.2%	16.0%	0.0%
2000	0.0%	0.0%	0.0%	0.0%	6.3%	9.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.2%	15.1%	0.0%
2001	5.8%	51.2%	791.1%	83.6%	0.0%	0.0%	0.0%	12.8%	46.8%	595.1%	0.0%	0.0%	0.0%	0.0%
2002	6.1%	54.1%	395.5%	83.6%	0.0%	65.4%	117.4%	12.6%	46.0%	297.5%	0.0%	0.0%	54.6%	0.0%
2003	6.5%	57.5%	263.7%	83.6%	0.0%	46.2%	83.0%	12.5%	45.3%	198.4%	0.0%	0.0%	38.6%	145.2%
2004	6.9%	61.3%	197.8%	83.6%	0.0%	37.7%	67.8%	12.4%	44.6%	148.8%	0.0%	0.0%	31.5%	102.7%
2005	7.4%	65.6%	158.2%	83.6%	0.0%	32.7%	58.7%	12.2%	43.9%	119.0%	0.0%	0.0%	27.3%	83.9%

2006	4.9%	46.9%	980.0%	59.5%	0.0%	0.0%	0.0%	13.4%	46.4%	575.0%	0.0%	0.0%	0.0%	72.6%
2007	5.4%	50.0%	490.0%	67.9%	0.0%	93.7%	116.8%	13.0%	46.2%	287.5%	0.0%	0.0%	63.8%	0.0%
2008	6.0%	53.5%	326.7%	78.9%	0.0%	66.3%	82.6%	12.6%	46.0%	191.7%	0.0%	0.0%	45.1%	0.0%
2009	6.7%	57.6%	245.0%	94.2%	0.0%	54.1%	67.5%	12.3%	45.8%	143.8%	0.0%	0.0%	36.8%	132.7%
2010	7.7%	62.3%	196.0%	117.0%	0.0%	46.9%	58.4%	12.0%	45.6%	115.0%	0.0%	0.0%	31.9%	93.9%
2011	5.9%	47.6%	980.0%	102.8%	0.0%	0.0%	0.0%	14.4%	42.0%	0.0%	0.0%	0.0%	0.0%	76.6%
2012	6.5%	50.3%	490.0%	102.8%	0.0%	61.6%	102.6%	14.2%	41.9%	0.0%	0.0%	0.0%	51.3%	66.4%
2013	7.2%	53.5%	326.7%	102.8%	0.0%	43.6%	72.5%	13.9%	41.8%	0.0%	0.0%	0.0%	51.3%	0.0%
2014	8.1%	57.0%	245.0%	102.8%	0.0%	35.6%	59.2%	13.7%	41.8%	0.0%	0.0%	0.0%	51.3%	0.0%
2015	9.1%	61.1%	196.0%	102.8%	0.0%	30.8%	51.3%	13.5%	41.7%	0.0%	0.0%	0.0%	51.3%	131.9%
2016	8.3%	49.7%	300.3%	102.7%	0.0%	0.0%	0.0%	16.7%	43.6%	440.1%	0.0%	0.0%	0.0%	93.3%
2017	9.2%	53.5%	150.1%	102.7%	0.0%	72.1%	137.3%	16.8%	44.2%	220.1%	0.0%	0.0%	115.9%	76.2%
2018	10.2%	57.9%	100.1%	102.7%	0.0%	51.0%	97.1%	16.8%	44.9%	146.7%	0.0%	0.0%	115.9%	66.0%

REDD+ Activity	Enhancement											
National Land Tenure	Other Land Tenure						Rural Area					
IPCC LUC	Cropland becomes Forest Land	Grassland becomes Forest Land	Wetland becomes Forest Land	Settlement becomes Forest Land	Other Land becomes Forest Land	Non-forest becomes Forest Land	Cropland becomes Forest Land	Grassland becomes Forest Land	Wetland becomes Forest Land	Settlement becomes Forest Land	Other Land becomes Forest Land	Non-forest becomes Forest Land
Forest State	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating
Forest Type Year	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary	Young Secondary	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary	Young Secondary
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	1,676	0	0	0	0	0	1,621

1992	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1993	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1994	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1995	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1996	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1997	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1998	0	0	0	0	0	1,676	0	0	0	0	0	1,621
1999	0	0	0	0	0	1,676	0	0	0	0	0	1,621
2000	0	0	0	0	0	1,676	0	0	0	0	0	1,621
2001	832	267	0	746	0	0	2,798	305	0	64	0	0
2002	832	267	0	746	0	0	2,798	305	0	64	0	0
2003	832	267	0	746	0	0	2,798	305	0	64	0	0
2004	832	267	0	746	0	0	2,798	305	0	64	0	0
2005	832	267	0	746	0	0	2,798	305	0	64	0	0
2006	2,005	124	0	791	0	0	2,648	206	0	397	0	0
2007	2,005	124	0	791	0	0	2,648	206	0	397	0	0
2008	2,005	124	0	791	0	0	2,648	206	0	397	0	0
2009	2,005	124	0	791	0	0	2,648	206	0	397	0	0
2010	2,005	124	0	791	0	0	2,648	206	0	397	0	0
2011	1,225	636	0	370	0	0	2,826	205	0	404	0	0
2012	1,225	636	0	370	0	0	2,826	205	0	404	0	0
2013	1,225	636	0	370	0	0	2,826	205	0	404	0	0
2014	1,225	636	0	370	0	0	2,826	205	0	404	0	0
2015	1,225	636	0	370	0	0	2,826	205	0	404	0	0
2016	5,132	72	0	1,030	0	0	4,375	491	0	710	47	0
2017	5,132	72	0	1,030	0	0	4,375	491	0	710	47	0
2018	5,132	72	0	1,030	0	0	4,375	491	0	710	47	0
1990	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1991	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1992	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1993	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1994	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%

1995	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1996	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1997	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1998	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
1999	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
2000	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	45.3%
2001	84.1%	117.4%	0.0%	101.6%	0.0%	0.0%	55.7%	145.2%	0.0%	196.0%	0.0%	0.0%
2002	84.1%	117.4%	0.0%	101.6%	0.0%	0.0%	55.7%	145.2%	0.0%	196.0%	0.0%	0.0%
2003	84.1%	117.4%	0.0%	101.6%	0.0%	0.0%	55.7%	145.2%	0.0%	196.0%	0.0%	0.0%
2004	84.1%	117.4%	0.0%	101.6%	0.0%	0.0%	55.7%	145.2%	0.0%	196.0%	0.0%	0.0%
2005	84.1%	117.4%	0.0%	101.6%	0.0%	0.0%	55.7%	145.2%	0.0%	196.0%	0.0%	0.0%
2006	125.1%	116.8%	0.0%	96.0%	0.0%	0.0%	69.1%	132.7%	0.0%	164.4%	0.0%	0.0%
2007	125.1%	116.8%	0.0%	96.0%	0.0%	0.0%	69.1%	132.7%	0.0%	164.4%	0.0%	0.0%
2008	125.1%	116.8%	0.0%	96.0%	0.0%	0.0%	69.1%	132.7%	0.0%	164.4%	0.0%	0.0%
2009	125.1%	116.8%	0.0%	96.0%	0.0%	0.0%	69.1%	132.7%	0.0%	164.4%	0.0%	0.0%
2010	125.1%	116.8%	0.0%	96.0%	0.0%	0.0%	69.1%	132.7%	0.0%	164.4%	0.0%	0.0%
2011	68.5%	102.6%	0.0%	138.7%	0.0%	0.0%	48.5%	131.9%	0.0%	102.7%	0.0%	0.0%
2012	68.5%	102.6%	0.0%	138.7%	0.0%	0.0%	48.5%	131.9%	0.0%	102.7%	0.0%	0.0%
2013	68.5%	102.6%	0.0%	138.7%	0.0%	0.0%	48.5%	131.9%	0.0%	102.7%	0.0%	0.0%
2014	68.5%	102.6%	0.0%	138.7%	0.0%	0.0%	48.5%	131.9%	0.0%	102.7%	0.0%	0.0%
2015	68.5%	102.6%	0.0%	138.7%	0.0%	0.0%	48.5%	131.9%	0.0%	102.7%	0.0%	0.0%
2016	79.9%	137.3%	0.0%	166.4%	0.0%	0.0%	86.5%	130.7%	0.0%	124.0%	196.0%	0.0%
2017	79.9%	137.3%	0.0%	166.4%	0.0%	0.0%	86.5%	130.7%	0.0%	124.0%	196.0%	0.0%
2018	79.9%	137.3%	0.0%	166.4%	0.0%	0.0%	86.5%	130.7%	0.0%	124.0%	196.0%	0.0%

REDD+ Activity	Conservation														
National Land Tenure	Protected Areas														
IPCC LUC	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining forest land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Cropland becomes Forest Land	Grassland becomes Forest Land	Wetland becomes Forest Land	Settlement becomes Forest Land	Other Land becomes Forest Land	Non-forest becomes Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land
Forest State	Stable	Stable	Degraded	Stable	Stable	Stable	Stable	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Stable	Stable
Forest Type / Year	Old Growth, old Secondary, Older Logged	Secondary	Secondary	Mangrove	Unidentified	Young Secondary	Colonising	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary	Young Secondary	Logged (1-10)	Logged (11-25)
1990	0	0	0	0	784,801	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	876,634	0	0	0	0	0	0	0	444	0	0
1992	0	0	0	0	968,466	444	0	0	0	0	0	0	444	0	0
1993	0	0	0	0	1,060,299	889	0	0	0	0	0	0	444	0	0
1994	0	0	0	0	1,152,131	1,333	0	0	0	0	0	0	444	0	0
1995	0	0	0	0	1,243,964	1,778	0	0	0	0	0	0	444	0	0
1996	0	0	0	0	1,335,797	2,222	0	0	0	0	0	0	444	0	0
1997	0	0	0	0	1,427,629	2,667	0	0	0	0	0	0	444	0	0
1998	0	0	0	0	1,519,462	3,111	0	0	0	0	0	0	444	0	0
1999	0	0	0	0	1,611,294	3,555	0	0	0	0	0	0	444	0	0
2000	0	0	0	0	1,703,127	4,000	0	0	0	0	0	0	444	0	0
2001	1,653,760	3,542	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	1,671,869	3,542	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	1,689,978	3,542	0	0	0	0	0	0	0	0	0	0	0	0	0

2004	1,542,679	0	0	0	0	0	0	0	0	0	0	0	0	68,579	100,371
2005	1,561,930	0	0	0	0	0	0	0	0	0	0	0	0	66,136	101,672
2006	1,584,226	0	0	15,658	0	0	0	63	103	0	28	0	0	67,254	116,031
2007	1,535,299	0	0	31,316	0	91	103	63	103	0	28	0	0	217,904	360,267
2008	1,884,111	0	0	46,974	0	181	207	63	103	0	28	0	0	214,570	360,749
2009	2,254,000	0	0	62,632	0	272	310	63	103	0	28	0	0	195,960	355,431
2010	2,623,888	0	0	78,290	0	363	414	63	103	0	28	0	0	175,260	352,201
2011	2,663,550	0	0	78,113	0	0	0	0	363	0	29	0	0	144,595	358,937
2012	2,709,363	0	0	78,113	0	29	363	0	363	0	29	0	0	117,083	362,520
2013	2,755,176	0	0	78,113	0	58	727	0	363	0	29	0	0	95,979	359,695
2014	2,800,988	0	0	78,113	0	87	1,090	0	363	0	29	0	0	73,800	357,944
2015	2,846,801	0	0	78,113	0	116	1,453	0	363	0	29	0	0	53,908	353,908
2016	2,872,856	0	0	78,110	0	0	0	597	0	0	78	0	0	37,758	345,702
2017	2,891,770	0	0	78,110	0	675	0	597	0	0	78	0	0	21,077	343,328
2018	2,912,359	0	0	78,110	0	1,350	0	597	0	0	78	0	0	0	343,673
1990	0.0%	0.0%	0.0%	0.0%	NOT AVAILABLE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1991	0.0%	0.0%	0.0%	0.0%	10.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1992	0.0%	0.0%	0.0%	0.0%	9.5%	72.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1993	0.0%	0.0%	0.0%	0.0%	8.6%	51.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1994	0.0%	0.0%	0.0%	0.0%	8.0%	42.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1995	0.0%	0.0%	0.0%	0.0%	7.4%	36.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1996	0.0%	0.0%	0.0%	0.0%	6.9%	32.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1997	0.0%	0.0%	0.0%	0.0%	6.4%	29.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1998	0.0%	0.0%	0.0%	0.0%	6.0%	27.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
1999	0.0%	0.0%	0.0%	0.0%	5.7%	25.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%

2000	0.0%	0.0%	0.0%	0.0%	5.4%	24.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.9%	0.0%	0.0%
2001	7.3%	196.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2002	7.2%	196.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2003	7.2%	196.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2004	7.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.2%	8.8%
2005	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.2%	8.8%
2006	13.9%	0.0%	0.0%	594.2%	0.0%	0.0%	0.0%	196.0%	142.8%	0.0%	196.0%	0.0%	0.0%	12.0%	8.9%
2007	14.6%	0.0%	0.0%	297.1%	0.0%	148.6%	142.8%	196.0%	142.8%	0.0%	196.0%	0.0%	0.0%	12.2%	8.9%
2008	11.9%	0.0%	0.0%	198.1%	0.0%	105.1%	100.9%	196.0%	142.8%	0.0%	196.0%	0.0%	0.0%	12.2%	9.0%
2009	9.9%	0.0%	0.0%	148.5%	0.0%	85.8%	82.4%	196.0%	142.8%	0.0%	196.0%	0.0%	0.0%	12.2%	9.0%
2010	8.5%	0.0%	0.0%	118.8%	0.0%	74.3%	71.4%	196.0%	142.8%	0.0%	196.0%	0.0%	0.0%	12.0%	9.0%
2011	8.4%	0.0%	0.0%	118.9%	0.0%	0.0%	0.0%	0.0%	148.5%	0.0%	196.0%	0.0%	0.0%	11.9%	9.2%
2012	8.2%	0.0%	0.0%	118.9%	0.0%	196.0%	148.5%	0.0%	148.5%	0.0%	196.0%	0.0%	0.0%	11.8%	9.2%
2013	8.1%	0.0%	0.0%	118.9%	0.0%	138.6%	105.0%	0.0%	148.5%	0.0%	196.0%	0.0%	0.0%	11.8%	9.2%
2014	7.9%	0.0%	0.0%	118.9%	0.0%	113.2%	85.7%	0.0%	148.5%	0.0%	196.0%	0.0%	0.0%	11.9%	9.2%
2015	7.8%	0.0%	0.0%	118.9%	0.0%	98.0%	74.3%	0.0%	148.5%	0.0%	196.0%	0.0%	0.0%	12.1%	9.1%
2016	7.7%	0.0%	0.0%	118.9%	0.0%	0.0%	0.0%	196.0%	0.0%	0.0%	139.5%	0.0%	0.0%	12.3%	9.1%
2017	7.7%	0.0%	0.0%	118.9%	0.0%	174.0%	0.0%	196.0%	0.0%	0.0%	139.5%	0.0%	0.0%	12.3%	9.0%
2018	7.6%	0.0%	0.0%	118.9%	0.0%	123.1%	0.0%	196.0%	0.0%	0.0%	139.5%	0.0%	0.0%	0.0%	8.9%

REDD+ Activity	SMF														
National Land Tenure	Logging Concessions														
IPCC LUC	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Forest Land remaining Forest Land	Cropland becomes Forest Land	Grassland becomes Forest Land	Wetland becomes Forest Land	Settlement becomes Forest Land	Other Land becomes Forest Land	Non-forest becomes Forest Land	Forest Land remaining forest land	Forest Land remaining forest land
Forest State	Stable	Stable	Degraded	Stable	Stable	Stable	Stable	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Regenerating	Stable	Stable
Forest Type Year	Old Growth, old Secondary, Older Logged	Secondary	Secondary	Mangrove	Unidentified	Young Secondary	Colonising	Young Secondary	Colonising	Colonising	Young Secondary	Young Secondary	Young Secondary	Logged (1-10)	Logged (11-25)
1990	0	0	0	0	2,503,463	0	0	0	0	0	0	0	0	1,703,103	2,354,992
1991	0	0	0	0	3,102,298	0	0	0	0	0	0	0	1,481	1,677,841	2,444,786
1992	0	0	0	0	3,744,174	1,481	0	0	0	0	0	0	1,481	1,622,721	2,521,397
1993	0	0	0	0	4,379,950	2,961	0	0	0	0	0	0	1,481	1,586,884	2,584,827
1994	0	0	0	0	4,981,678	4,442	0	0	0	0	0	0	1,481	1,598,277	2,635,074
1995	0	0	0	0	5,566,996	5,922	0	0	0	0	0	0	1,481	1,639,262	2,672,138
1996	0	0	0	0	6,136,595	7,403	0	0	0	0	0	0	1,481	1,709,148	2,696,021
1997	0	0	0	0	6,726,974	8,883	0	0	0	0	0	0	1,481	1,771,437	2,706,721
1998	0	0	0	0	7,278,635	10,364	0	0	0	0	0	0	1,481	1,885,626	2,704,238

1999	0	0	0	0	7,901,775	11,844	0	0	0	0	0	0	1,481	1,941,519	2,688,574
2000	0	0	0	0	8,511,495	13,325	0	0	0	0	0	0	1,481	2,024,013	2,659,727
2001	7,722,520	0	0	13,486	0	0	0	3,797	342	0	2,666	0	0	2,237,849	2,620,455
2002	7,926,401	0	0	13,486	0	6,462	342	3,797	342	0	2,666	0	0	2,465,945	2,551,326
2003	8,198,079	0	0	13,486	0	12,924	684	3,797	342	0	2,666	0	0	2,606,962	2,501,479
2004	8,616,405	0	0	13,486	0	19,387	1,026	3,797	342	0	2,666	0	0	2,654,471	2,398,492
2005	8,907,537	0	0	13,486	0	25,849	1,368	3,797	342	0	2,666	0	0	2,700,513	2,424,166
2006	6,591,575	0	0	13,552	0	0	0	911	131	0	4,653	0	0	2,774,894	2,465,683
2007	7,169,890	0	0	13,552	0	5,565	131	911	131	0	4,653	0	0	2,717,842	2,269,726
2008	7,326,364	0	0	13,552	0	11,129	262	911	131	0	4,653	0	0	2,786,975	2,369,424
2009	7,485,359	0	0	13,552	0	16,694	392	911	131	0	4,653	0	0	2,906,084	2,416,625
2010	7,691,852	0	0	13,552	0	22,259	523	911	131	0	4,653	0	0	2,953,183	2,488,339
2011	6,621,407	0	0	0	0	0	0	1,372	166	0	1,871	0	0	2,802,092	2,684,187
2012	7,121,152	0	0	0	0	3,243	166	1,372	166	0	1,871	0	0	2,635,507	2,867,590
2013	7,637,792	0	0	0	0	6,485	332	1,372	166	0	1,871	0	0	2,513,416	2,989,605
2014	8,129,633	0	0	0	0	9,728	498	1,372	166	0	1,871	0	0	2,394,898	3,132,847
2015	8,617,473	0	0	0	0	12,970	664	1,372	166	0	1,871	0	0	2,320,992	3,235,477
2016	9,000,508	0	0	0	0	0	0	2,899	24	0	4,400	0	0	2,170,982	3,400,320
2017	9,344,269	0	0	0	0	7,299	24	2,899	24	0	4,400	0	0	2,017,983	3,599,690
2018	9,668,375	0	0	0	0	14,598	48	2,899	24	0	4,400	0	0	1,882,538	3,801,161
1990	0.0%	0.0%	0.0%	0.0%	NOT AVAILABLE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.8%	9.0%

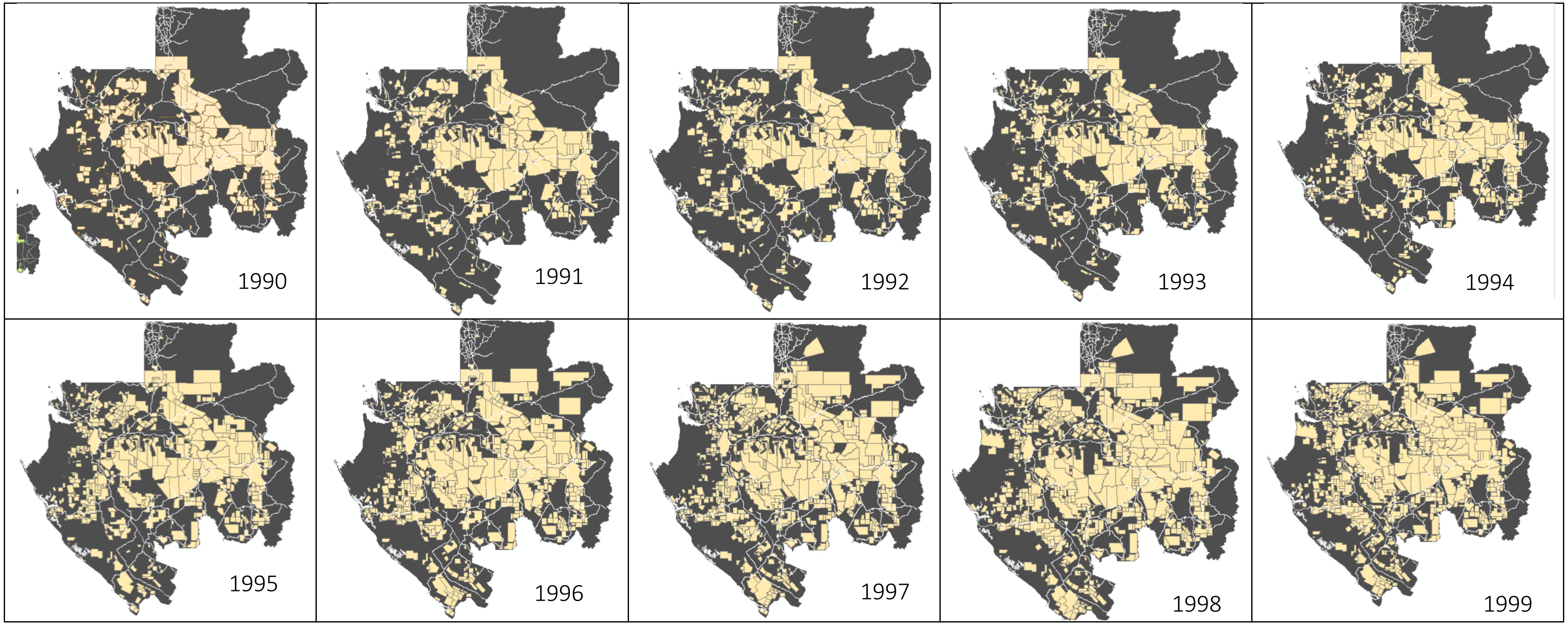
1991	0.0%	0.0%	0.0%	0.0%	10.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	11.9%	8.9%
1992	0.0%	0.0%	0.0%	0.0%	8.8%	60.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	11.9%	8.9%
1993	0.0%	0.0%	0.0%	0.0%	7.5%	43.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	11.7%	8.8%
1994	0.0%	0.0%	0.0%	0.0%	6.7%	35.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	11.8%	8.8%
1995	0.0%	0.0%	0.0%	0.0%	6.1%	30.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.2%	8.8%
1996	0.0%	0.0%	0.0%	0.0%	5.7%	27.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.5%	8.8%
1997	0.0%	0.0%	0.0%	0.0%	5.3%	24.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.7%	8.8%
1998	0.0%	0.0%	0.0%	0.0%	5.0%	23.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.6%	8.8%
1999	0.0%	0.0%	0.0%	0.0%	4.7%	21.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.9%	8.8%
2000	0.0%	0.0%	0.0%	0.0%	4.4%	20.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.9%	12.3%	8.8%
2001	5.2%	0.0%	0.0%	196.0%	0.0%	0.0%	0.0%	156.3%	168.4%	0.0%	57.1%	0.0%	0.0%	12.5%	8.8%
2002	5.4%	0.0%	0.0%	196.0%	0.0%	0.0%	168.4%	156.3%	168.4%	0.0%	57.1%	0.0%	0.0%	13.1%	8.8%
2003	5.3%	0.0%	0.0%	196.0%	0.0%	0.0%	119.1%	156.3%	168.4%	0.0%	57.1%	0.0%	0.0%	12.7%	8.8%
2004	4.9%	0.0%	0.0%	196.0%	0.0%	0.0%	97.2%	156.3%	168.4%	0.0%	57.1%	0.0%	0.0%	12.2%	8.8%
2005	4.8%	0.0%	0.0%	196.0%	0.0%	0.0%	84.2%	156.3%	168.4%	0.0%	57.1%	0.0%	0.0%	12.2%	8.8%
2006	6.8%	0.0%	0.0%	196.0%	0.0%	0.0%	0.0%	89.6%	156.0%	0.0%	47.0%	0.0%	0.0%	12.0%	8.9%
2007	6.1%	0.0%	0.0%	196.0%	0.0%	0.0%	156.0%	89.6%	156.0%	0.0%	47.0%	0.0%	0.0%	12.2%	8.9%
2008	6.2%	0.0%	0.0%	196.0%	0.0%	0.0%	110.3%	89.6%	156.0%	0.0%	47.0%	0.0%	0.0%	12.2%	9.0%
2009	6.2%	0.0%	0.0%	196.0%	0.0%	0.0%	90.1%	89.6%	156.0%	0.0%	47.0%	0.0%	0.0%	12.2%	9.0%
2010	6.1%	0.0%	0.0%	196.0%	0.0%	0.0%	78.0%	89.6%	156.0%	0.0%	47.0%	0.0%	0.0%	12.0%	9.0%
2011	6.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	91.1%	112.9%	0.0%	56.8%	0.0%	0.0%	11.9%	9.2%
2012	6.2%	0.0%	0.0%	0.0%	0.0%	0.0%	112.9%	91.1%	112.9%	0.0%	56.8%	0.0%	0.0%	11.8%	9.2%
2013	5.7%	0.0%	0.0%	0.0%	0.0%	0.0%	79.8%	91.1%	112.9%	0.0%	56.8%	0.0%	0.0%	11.8%	9.2%
2014	5.4%	0.0%	0.0%	0.0%	0.0%	0.0%	65.2%	91.1%	112.9%	0.0%	56.8%	0.0%	0.0%	11.9%	9.2%
2015	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	56.4%	91.1%	112.9%	0.0%	56.8%	0.0%	0.0%	12.1%	9.1%
2016	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.4%	196.0%	0.0%	61.0%	0.0%	0.0%	12.3%	9.1%
2017	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	196.0%	70.4%	196.0%	0.0%	61.0%	0.0%	0.0%	12.3%	9.0%
2018	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	138.6%	70.4%	196.0%	0.0%	61.0%	0.0%	0.0%	12.2%	8.9%

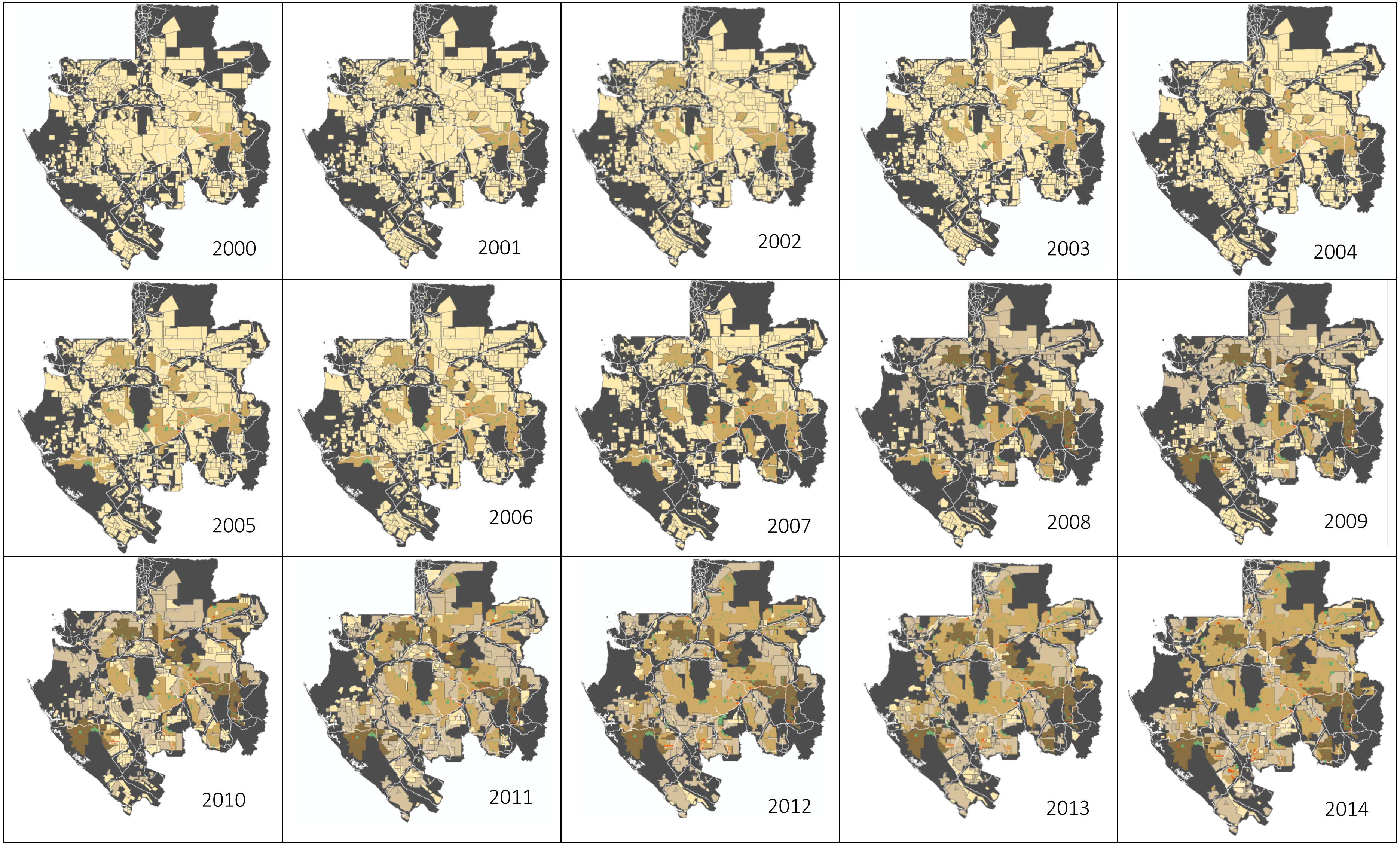
18.9 Annex 9. Logging Emissions Factors by site

Table 35 Logging Emissions Factors for 12 concessions measured in Gabon, expressed in tC /m^3.

Site code	Harvest Intensity (m^3/ha)	Extracted Log Emissions (ELE)			Logging Damage Factor (LDF)			Logging Infrastructure Factor (LIF)			Total Emissions Factor (TEF)			Source
		AGB	BGB	Total	AGB	BGB	Total	AGB	BGB	Total	AGB	BGB	Total	
GAB1	6.30	0.10	0.02	0.12	0.43	0.10	0.53	1.50	0.35	1.85	2.03	0.48	2.50	Ellis et al.,2019
GAB2	5.11	0.15	0.03	0.18	1.21	0.28	1.50	2.02	0.47	2.49	3.38	0.79	4.17	Ellis et al.,2019
GAB3	9.56	0.09	0.02	0.11	0.20	0.05	0.24	1.18	0.28	1.46	1.47	0.35	1.82	Ellis et al.,2019
GAB4	10.83	0.12	0.03	0.15	0.30	0.07	0.37	0.55	0.13	0.68	0.97	0.23	1.20	Ellis et al.,2019
GAB5	20.46	0.11	0.02	0.13	0.24	0.06	0.29	0.56	0.13	0.70	0.91	0.21	1.12	Ellis et al.,2019
GAB6	3.27	0.12	0.03	0.15	0.41	0.10	0.51	3.15	0.74	3.88	3.67	0.86	4.54	Ellis et al.,2019
GAB8	16.47	0.10	0.02	0.13	0.94	0.22	1.17	0.42	0.10	0.52	1.47	0.35	1.82	Ellis et al.,2019
GAB7	18.04	0.14	0.03	0.18	0.41	0.10	0.51	0.53	0.13	0.66	1.09	0.26	1.34	Ellis et al.,2019
GAB9	4.82	0.14	0.03	0.17	1.64	0.39	2.03	2.00	0.47	2.47	3.78	0.89	4.67	Ellis et al.,2019
GAB10	5.66	-	-	-	-	-	-	-	-	-	1.93	0.45	2.38	Medjibe et al., 2013
GAB11	11.38	-	-	-	-	-	-	-	-	-	2.23	0.52	2.76	Medjibe et al., 2013
GAB12	8.11	-	-	-	-	-	-	-	-	-	2.04	0.48	2.52	Medjibe et al., 2011
Mean	**10.00**	**0.12**	**0.03**	**0.15**	**0.64**	**0.15**	**0.79**	**1.32**	**0.31**	**1.64**	**2.08**	**0.49**	**2.57**	
95%CI	**3.20**	**0.01**	**0.00**	**0.02**	**0.33**	**0.08**	**0.41**	**0.61**	**0.14**	**0.75**	**0.58**	**0.14**	**0.71**	
U	**31.9%**	**11.0%**	**11.0%**	**11.0%**	**51.4%**	**51.4%**	**51.4%**	**45.9%**	**45.9%**	**45.9%**	**27.8%**	**27.8%**	**27.8%**	

18.10 Annex 10. Time series maps of logging concessions




2000
2001
2002
2003
2004
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2007
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2009
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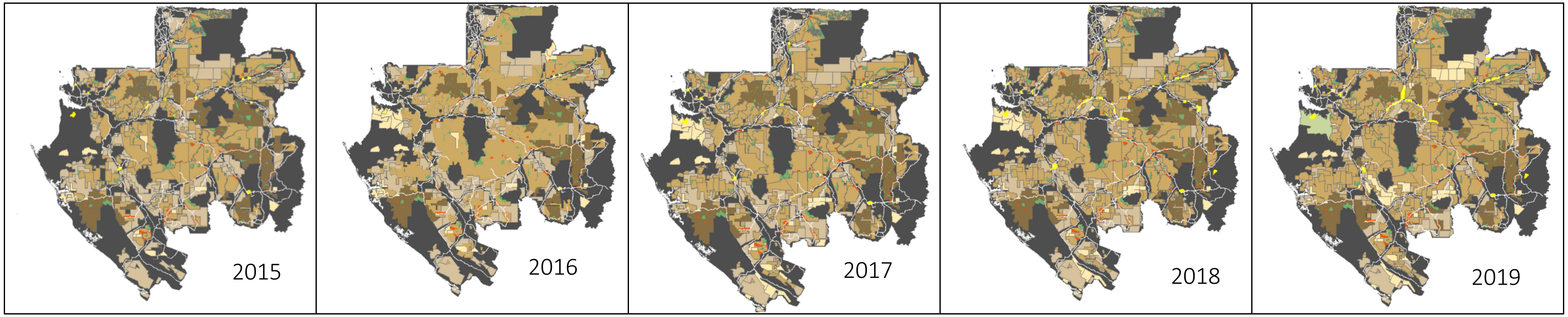
2011
2012
2013
2014


2015
2016
2017
2018
2019

18.11 Annex 11. Calculation of carbon stocks for upwards adjustment

Table 36 Forested area by forest type (ha) for 2013-2018, and carbon stock values applied to calculate total carbon stocks for the upwards adjustment.

Forested area (ha)							
Eligibility Year	Old growth, old secondary, older logged	Secondary	Logged (1-25)	Mangrove	Young Secondary	Colonising	Total
2013	16,978,847	567,535	5,958,695	156,744	24,291	4,109	23,690,221
2014	16,974,230	551,476	5,959,489	156,744	32,388	5,478	23,679,805
2015	16,965,610	535,418	5,964,284	156,744	40,485	6,848	23,669,389
2016	17,051,484	556,340	5,954,762	151,692	19,268	587	23,734,133
2017	17,019,642	533,337	5,982,078	151,692	38,536	1,175	23,726,459
2018	16,969,821	510,334	6,027,372	151,692	57,804	1,762	23,718,785
Total Vegetation carbon Stock (t/ha)	175.0	118.0	213.4	148.8	118.0	58.3	
Carbon stock from Forest type (see Table 19)	Forest average	Secondary	Logged	Mangrove	Secondary	Colonising	

Table 37 Total and mean Carbon stocks for GCF eligibility years 2013-2018, to inform the upwards adjustment.

Total Carbon stocks (t/ha)							
Eligibility Year	Old Growth and Old Secondary Forest	Secondary	Logged Forest	Mangrove	Young Secondary Forest	Colonising Forest	Total
2013	2,972,077,815	66,976,188	1,271,745,690	23,320,551	2,866,658	239,707	4,337,226,610
2014	2,971,269,493	65,081,098	1,271,915,065	23,320,551	3,822,211	319,609	4,335,728,028
2015	2,969,760,651	63,186,007	1,272,938,558	23,320,551	4,777,764	399,512	4,334,383,043
2016	2,984,792,513	65,655,033	1,270,906,277	22,568,847	2,273,876	34,269	4,346,230,816
2017	2,979,218,692	62,940,399	1,276,736,204	22,568,847	4,547,753	68,538	4,346,080,433
2018	2,970,497,746	60,225,766	1,286,403,300	22,568,847	6,821,629	102,807	4,346,620,095
				Mean Carbon stock value (tC/ha)			**4,341,044,837**

18.12 Annex 12. Explanation for deriving uncertainty from interpolated data

Activity Data (AD) interpolated between assessment years *a* and *b* can be expressed as follows:

$$AD_{a+1} = AD_a + \frac{\Delta}{10}$$

where

$$\Delta = (AD_b - AD_a)$$

It therefore it follows that:

$$\mathrm{var}(AD_{a+1}) = var\left(AD_a + \frac{\Delta}{10}\right)$$

The variance of $\left(a + \frac{\Delta}{10}\right)$ is derived as:

$$\mathrm{U}\left(AD_a + \frac{\Delta}{n}\right) = \mathrm{U}(AD_a + \Delta) = f\big(var(AD_a + \Delta)\big)$$

$$var(AD_a + \Delta) = var(AD_a) + var(\Delta) + \mathbf{2}\boldsymbol{cov}(AD_a, \Delta)$$

The variance of Δ is therefore:

$$var(\Delta) = var(AD_b - AD_a) = var(AD_a) + var(AD_b) - \mathbf{2}\boldsymbol{cov}(AD_a, AD_b)$$

Simplified, this gives:

$$var(AD_a + \Delta) = 2var(AD_a) + var(AD_b) - \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) + \mathbf{2}\boldsymbol{cov}(AD_a, \Delta)$$

Further, it is known that: $AD_b = AD_a + \Delta$

Since $var(AD_b)$ is known, it follows that:

$$var(AD_b) = var(AD_a + \Delta)$$

Substitution and simplification:

$$var(AD_b) = 2var(AD_a) + var(AD_b) - \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) + \mathbf{2}\boldsymbol{cov}(AD_a, \Delta)$$

$$\mathbf{2}\boldsymbol{cov}(AD_a, \Delta) = \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) - 2var(AD_a)$$

Therefore:

$$var(AD_a + \Delta) = 2var(AD_a) + var(AD_b) - \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) + \mathbf{2}\boldsymbol{cov}(AD_a, \Delta)$$

$$var(AD_a + \Delta) = \mathbf{2}\boldsymbol{var}(AD_a) + var(AD_b) - \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) + \mathbf{2}\boldsymbol{cov}(AD_a, AD_b) - \mathbf{2}\boldsymbol{var}(AD_a)$$

$$\boldsymbol{var}(\boldsymbol{AD_a} + \Delta) = \boldsymbol{var}(\boldsymbol{AD_b})$$