2020

BELIZE FOREST REFERENCE LEVEL (FRL) / FOREST REFERENCE EMISION LEVEL (FREL), 2001 - 2015

Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development and Immigration

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LIST OF ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, Forestry, and Other Land Use
BFD	Belize Forest Department
BUR	Biennial Update Report
CfRN	Coalition for Rainforest Nations
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties
FAO	Food and Agriculture Organization (of the United Nations)
FOLU	Forest and Other Land Use
Gg	Gigagrams
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GPG	Good Practice(s) Guidance
GWP	Global Warming Potential
Ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change, and Forestry
m^3	Cubic meter
MAFFESDI	Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development, and Immigration
MLP	Managed Lands Proxy
MPG	Modalities, Procedures, and Guidelines
MRV	Measuring, Reporting, and Verification
N_2O	Nitrous oxide
NCCO	National Climate Change Office
NIR	National Inventory Report
NFMS	National Forest Monitoring System
REDD+	Reducing Emissions from Deforestation and Forest Degradation
TNC	Third National Communication
UNFCCC	United Nations Framework Convention on Climate Change

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1. INTRODUCTION

With the adoption of the Paris Agreement by the twenty-first Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) the new international climate change regime for the post-2020 period is set.

Article 5(2) locks REDD+ guidance developed since COP13 into the new climate regime and provides already provides guidance on how transparency is ensured in the implementation of REDD+ activities. It is important to recall that REDD+ COP guidance emphasizes the importance of accurate and robust national GHG inventories and puts in place a verification process unique compared to all other sectors responsible for GHG emissions.

Amongst others, the Paris Agreement introduced the Enhanced Transparency Framework (ETF) for action and support referred to in Article 13 and simplified as indicated below:

- Enhanced transparency framework for action and support established
- Build on and enhance the transparency arrangements under the Convention
- Purpose transparency of action: provide a clear understanding of climate change action, including clarity and tracking of progress towards achieving Parties' INDCs
- Purpose transparency of support: provide clarity on the support provided and received and full overview of aggregate financial support provided
- Each Party shall provide info: National Inventory Report + Information necessary to track progress in implementing and achieving its NDC (Article 13.7)
- Technical expert review
- CMA1 building on experience from the transparency arrangements under the Convention, adopt common modalities, procedures, and guidelines.

COP24 and CMA1 met simultaneously in Katowice in December 2018 to agree on the operational rules of the Paris Agreement. The Paris Agreement Work Programme or PA rulebook is the guidance to operationalize the new climate regime and was adopted by COP24 and CMA1 in Katowice in 2018. It is composed of the following elements:

- Further guidance on NDCs (decision 1/CP.21);
- Features of nationally determined contributions;
- Information to facilitate clarity, transparency, and understanding of nationally determined contributions;
- Accounting for Parties' nationally determined contributions;
- Further guidance in relation to the adaptation communication (art. 7.10/11);
- Modalities, procedures, and guidelines for the transparency framework for action and support (art. 13);
- Global stock-take (art. 14);
- Committee to facilitate implementation and promote compliance (art. 15.2); and,
- Article 6 PA under the SBSTA.

As indicated above, UNFCCC guidance on REDD+ is already defined in the period 2007 – 2015 and currently locked in the new climate regime thanks to Article 5 of the Paris Agreement. Thus, REDD+ was not included directly in the negotiations on the Paris Agreement rulebook as an agenda item under the subsidiary bodies. Nevertheless, several rules referred to it either directly or indirectly.

Specifically, on transparency, COP24 and CMA1 agreed on the modalities, procedures, and guidelines (MPGs) for the transparency framework for action and support established under Article 13 of the Paris Agreement. In particular,

- Decision 1/CP.24, section VI Matters related to the MPGs for transparency, paragraphs 38 – 46:
    - The final biennial update reports shall be those that are submitted to the secretariat no later than 31 December 2024 (decision -/CP.24, paragraph 38);
    - The MPGs will supersede the MRV system under the Convention established by decision 1/CP.16, paragraphs 40–47 and 60–64, and decision 2/CP.17, paragraphs 12–62 (decision -/CP.24, paragraph 39);
    - Biennial transparency reports (BTRs), technical expert review and facilitative, multilateral consideration of progress to replace biennial reports, biennial update reports, international assessment and review, and international consultation and analysis under the Convention (decision -/CP.24, paragraph 41);
    - National Communication + BTR may be submitted as a single report (decision -/CP.24, paragraph 43).

One of the major compromises achieved by the international community in the climate talks is the applicability of the new regime to all Parties. The clear distinction between Annex I and non-Annex I Parties as indicated in the Convention is lost with the Paris Agreement. As agreed in Durban by COP17 the new regime should be applicable to all Parties. Along with this basis what Parties were able to negotiate while drafting the Paris Agreement is the degree of flexibility to be granted to developing country parties, in particular, SIDS and LDCs. The result of this negotiation is clear and expressed in several parts of the Paris Agreement and its accompanying and implementing decisions.

In particular, flexibility is inscribed in the PA in the following sections:
Decision 1/CP.21, paragraph 90: Also decides that all Parties, except for the least developed country Parties and small island developing States, shall submit the information referred to in Article 13, paragraphs 7, 8, 9 and 10, as appropriate, no less frequently than on a biennial basis, and that the least developed country Parties and small island developing States may submit this information at their discretion. LDCs and SIDs may comply with the requirements under Article 13 at their discretion. This means full flexibility.

Article 4.6 of the Paris Agreement: the least developed countries and small island developing States may prepare and communicate strategies, plans and actions for low greenhouse gas emissions development reflecting their special circumstances.

Article 11.1 of the Paris Agreement: Capacity-building under this Agreement should enhance the capacity and ability of developing country Parties, in particular, countries with the least capacity, such as the least developed countries, and those that are particularly vulnerable to the adverse effects of climate change, such as small island developing States, to take effective climate change action, including, inter alia, to implement adaptation and mitigation actions, and should facilitate technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information.

Belize, as a member of the group of the Small Island Developing States (SIDS), is granted full flexibility in the fulfillment of the Paris Agreement and consequently also in the fulfillment of all its rules including transparency.

The enhanced transparency framework for action and support with built-in flexibility considers Parties' different capacities and builds upon collective experience (Article 13, paragraph 1 of the Paris Agreement). As such, 'the transparency framework shall provide flexibility in the implementation of the [transparency framework] to those developing country Parties that need it in the light of their capacities. The modalities, procedures, and guidelines referred to in paragraph 13 of this Article shall reflect such flexibility' (Article 13, paragraph 2 of the Paris Agreement). In particular:

- The enhanced transparency framework for action and support, with built-in flexibility which considers Parties' different capacities and builds upon collective experience, is hereby established (para 1)
- The transparency framework shall provide flexibility in the implementation of the provisions of this Article to those developing country Parties that need it in the light of their capacities (para 2)
- The modalities, procedures, and guidelines referred to in paragraph 13 of this Article shall reflect such flexibility (para 2)
- The transparency framework shall build on and enhance the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries and small island developing States, and be implemented in a facilitative, non-intrusive, non-punitive manner, respectful of national sovereignty, and avoid placing an undue burden on Parties (para 3)

Flexibility to LDCs and SIDS is confirmed by the Katowice decision on transparency (decision 18/CMA.1) as indicated below:

- Decision 18/CMA.1, Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement and Annex, Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (MPG Annex):
    - 'Parties shall submit their first biennial transparency report and national inventory report, if submitted as a stand-alone report, at the latest by 31 December 2024' (Decision 18/CMA.1, paragraph 3);
    - Least developed country Parties and small island developing States may submit the following information at their discretion (Decision 18/CMA.1, paragraph 4 and Annex, paragraph 11):

        - National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases prepared using good practice methodologies accepted by the IPCC (as a stand-alone report or as a component of a biennial transparency report – MPG Annex, paragraph 12)
        - Information necessary to track progress made in implementing and achieving its NDC
        - information related to climate change impacts and adaptation
        - information on financial, technology transfer and capacity-building support needed and received
    - Guiding principles:
        - Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries (LDCs) and small island developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties (Decision 18/CMA.1, Annex, paragraph 3a)
        - Providing flexibility to those developing country Parties that need it in the light of their capacities (Decision 18/CMA.1, Annex, paragraph 3c)

Section C of the MPGs on transparency is dedicated to flexibility. In particular:

- These MPGs specify the flexibility that is available to those developing country Parties that need it in the light of their capacities pursuant to Article 13, paragraph 2, reflecting flexibility, including in the scope, frequency, and level of detail of reporting, and in the scope of the review, as referred to decision 1/CP.21, paragraph 89 (para 5)
- The application of flexibility provided for in the provisions of these MPGs for those developing country Parties that need it in the light of their capacities is to be self-determined (para 6)
- The developing country Party shall clearly indicate the provision to which flexibility is applied, concisely clarify capacity constraints, noting that some constraints may be relevant to several provisions, and provide self-determined estimated time frames for improvements in relation to those capacity constraints (para 6)
- When a developing country Party applies flexibility provided for in these MPGs, the technical expert review teams shall not review the Party's determination to apply such flexibility or whether the Party possesses the capacity to implement that specific provision without flexibility (para 6).

Considering all these Decisions and Considerations of the process agreed under the Paris Agreement. Belize has the honor to present to you the Forest Reference Emission Level (FREL) of the country at the national level to be evaluated during the period of 2020.

The FREL is in line with the timeline of actions that Belize presented in its IINDC 2015back in 2015 and more so especially with The National Climate Change Policy, Strategy and Action Plan (NCCPSAP), 2015- 2020, therefore the timeline of the FREL will be from the period of 2001 to 2015 and will have a validity of the FREL will be for a period of 5 years (2016-2020).

The country has made its best effort to present all its information in a transparent, accurate, complete, comparable and consistent manner following the basic principles for preparing greenhouse gas inventories of the 2006 Intergovernmental Panel on Climate Change (IPCC).

2. KEY ELEMENTS

2.1. Modalities for FREL/FRL according to 12/CP.17

- ***Paragraph 7***. *The FREL presented by Belize is expressed in* ***tons of CO_2 equivalent per year***, *to serve as a benchmark for assessing the country's performance in implementing the REDD+ activities.*

- ***Paragraph 8.*** *As explained below (section 1.3.), Belize developed a* ***single database for the National GHG Inventory and the FREL***. *This grants full consistency. All calculations are explicit to maximize transparency. This database also allows to easily check which emissions and removals from the National GHG Inventory are selected for the FREL.*

- ***Paragraph 9***. *The national circumstances considered in this FREL submission are explained in section 1.4. The exclusion of unmanaged lands was conducted to reflect the anthropogenic effect in Belize's emissions profile.*

- ***Paragraph 10***. *In this submission, Belize presents an improvement plan, which considers the gradual improvement of methods, as well as the future inclusion of additional carbon pools.*

- ***Paragraph 11***. *Belize's FREL is presented at the national level.*

- ***Annex, chapeau***. *the information provided by Belize is guided by the 2006 IPCC guidance and guidelines, specifically the* ***2006 IPCC guidelines for National GHG Inventories***.

- ***Annex, paragraphs (a), (b)***. *A comprehensive database is attached to this report. Also, extensive descriptions of the methods and data used are provided below, as well as in technical annexes to facilitate understanding by the readers and the UNFCCC reviewers.*

- ***Annex, paragraph (c)***. *Those carbon pools included and the reasons for those excluded are provided in Section 1.5. In terms of activities covered, emissions and removals are considered for Forest land and conversions to and from Forest land, which cover any type of REDD+ activity. In essence, this is equivalent to including all activities in the FREL as a benchmark for performance.*

- ***Annex paragraph (d)***. *The forest definition used for the FREL is the same as for the National GHG Inventory.*

2.2. REDD+ activities

As indicated in the Decision 1/CP.16, paragraph 71, Belize has decided to develop a **national**[1] forest reference emission level (FREL) in accordance with national circumstances and as a *benchmark* to assess the country's performance in implementing the activities referred to in decision 1/CP.16, paragraph 70: **reducing emissions from deforestation**, **reducing emissions from forest degradation**, **conservation of forest carbon stocks**, **sustainable management of forests** and **enhancement of forest carbon stocks**.

2.3. Consistency with the National GHG Inventory

This FREL was developed following the guidance provided in Decision 12/CP.17, decision 4/CP.15, paragraph 7, and seeks to maintain consistency with the anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks with the **national greenhouse gas (GHG) inventory contained in the country's first Biennial Update Report**, which is currently being developed following the UNFCCC reporting guidelines for Biennial Update Reports for Parties not included in Annex I to the Convention (decision 2/CP.17).

The FREL values and the underlying historical emissions and removals are derived from the national GHG inventory database (attached to this report as a Microsoft Excel file), to maintain full consistency and transparency in national reporting to UNFCCC. The national GHG inventory and this FREL were estimated following the **2006 IPCC guidelines**. Both the National GHG Inventory totals and the REDD+ emissions and removals are based on the same data, methods, and assumptions and come from the same estimation procedure as explicitly shown in the attached database.

2.4. Definition of Managed and Unmanaged Lands Exclusion of natural disturbances

Belize's National GHG Inventory includes a distinction between managed and unmanaged lands, following the 2006 IPCC guidelines and the managed lands proxy (MLP). Therefore, the GHGI excludes the effect of recurrent hurricanes and pests, which have historically dominated emissions and removals in the country (**Figure 1**). Total managed and unmanaged lands are shown in **Table 1**.

Unmanaged Land is Forest land with no evidence of human activity. **Managed Lands** cover the entire territory in Belize that does not fall under the definition of Unmanaged Lands. Following IPCC's best

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[1] The scale of this FREL is National. The total land area is 22,960 square kilometers (km2) (8,867 square miles [mi^2]), of which 95% is located on the mainland, and 5% is distributed over more than 1,060 cays or islands. The country is divided into six districts, nine municipalities, and more than 240 villages. Thus, a sampling grid of 22.700 plots located 1km distance apart was used to allow a national coverage analysis of the mainland. All lands assessed were considered as managed lands. Cays and Islands were not included.

practice, **the area of unmanaged lands is monitored by Belize**. Emissions and removals are estimated for both types of land, as this is important information for the Government of Belize. **The current FREL includes only emissions and removals in Managed Lands**. Unmanaged lands converted to managed lands will be tracked in the future and those emissions and removals will be considered.

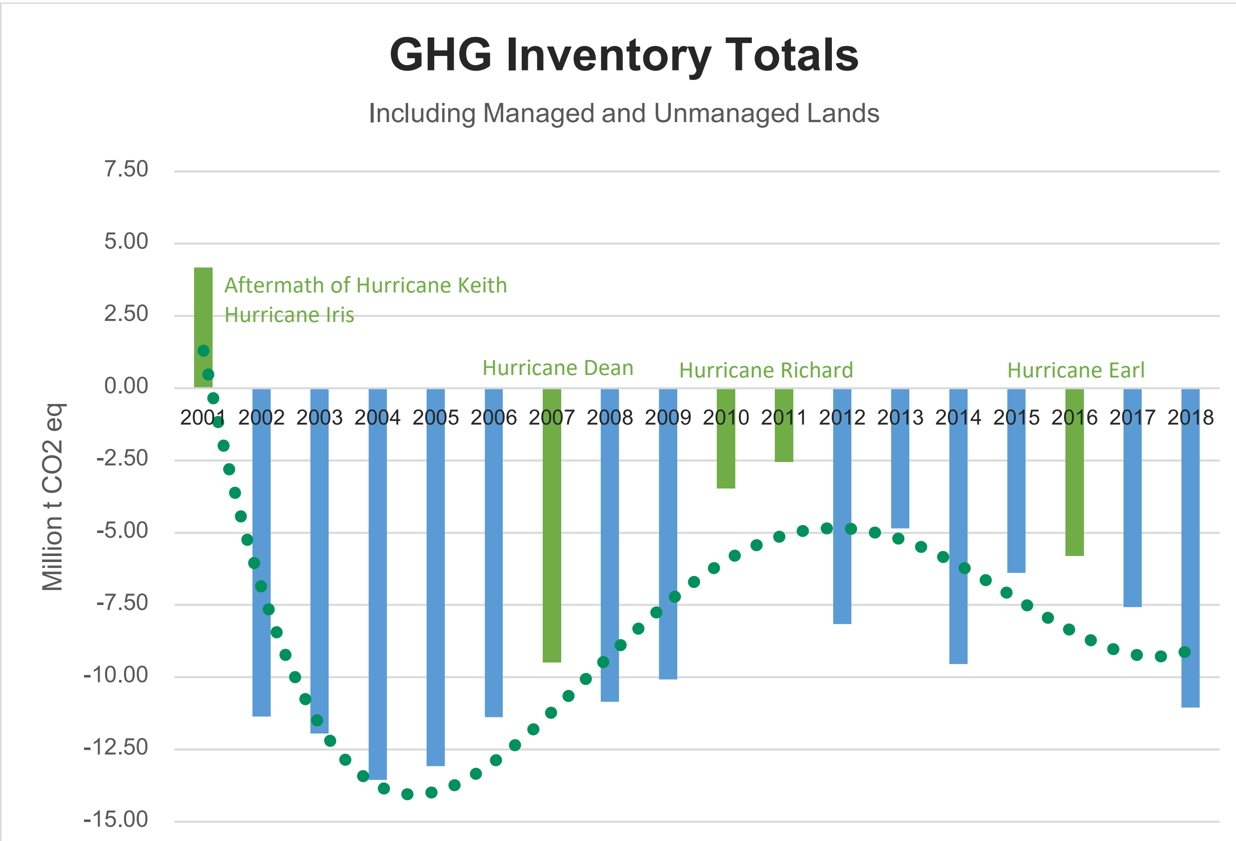

Figure 1. Total emissions and removals in Belize (including Managed and Unmanaged Lands). The cyclic behavior is largely due to recurring hurricanes. Important hurricane events are highlighted in the graph. Usually, in the year of a large-scale hurricane, emissions increase, followed by a period of recovery (increased removals).

Table 1. Area of managed and unmanaged lands in Belize in the period 2001-2018.

Category	Managed Lands	Unmanaged Lands
Forest land (Undisturbed)	26,640.45	1,038,072.78
Forest land (Disturbed)	181,160.36	117,921.69
Cropland	207,896.04	0.00
Grassland	445,146.84	4,222.26
Wetland	151,699.77	0.00
Settlements	36,391.86	0.00
Other land	603.18	0.00
Sub-total	1,050,538.50	1,160,216.73
National total	**2,210,755.23**	
% of Managed Lands	**47.52%**	

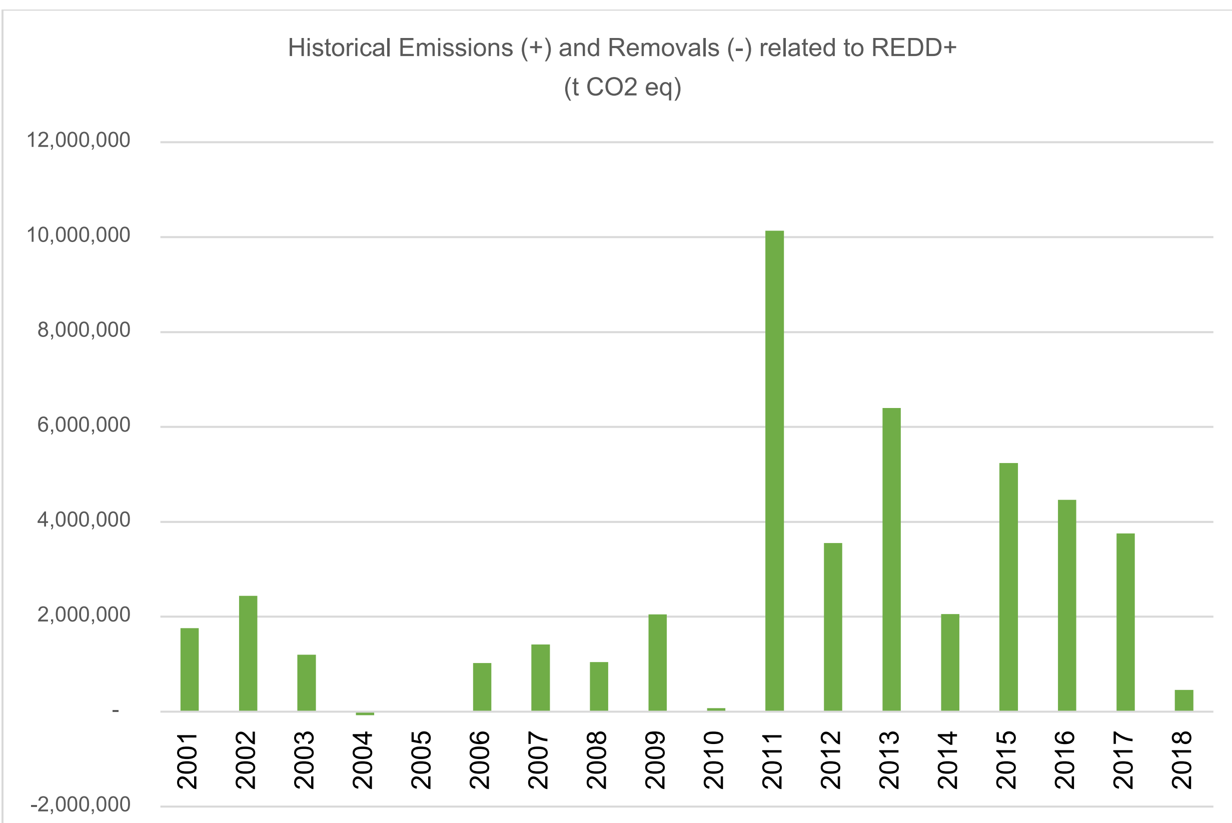

Figure 2. Emissions and removals considered for REDD+, including managed lands only and those sources and sinks relevant to Forest lands, conversion of Forest lands and conversion to Forest lands.

2.5. Carbon pools

The national GHG inventory and the FREL includes the carbon pools: **above-ground biomass** and **below-ground biomass** and excludes dead organic matter and soil carbon. The latter were excluded due to a lack of data. In the case of these exclusions, Belize recognizes that IPCC provides default values for deadwood, litter, and soil organic carbon. However, arduous work has been conducted to present to the COP a time-series including accurate biomass emissions and removals, including national information on carbon stocks, but also carbon stock changes (i.e. forest growth). Belize's position is that such detailed work on biomass ought to be matched by the same level of accuracy for the other pools. Hence, Belize would like to recall paragraph 10, of decision 12/CP.17 enabling the gradual improvement of their data and methods, including additional pools as appropriate.

2.6. Greenhouse gases

The national GHG inventory and the FREL include **methane (CH4)** and **nitrous oxide (N2O)** emissions from biomass burning in Forest land and Forest land conversion, included where data is available. Emissions in carbon dioxide equivalents (CO2e) are reported using the **100-year global warming potentials** (GWPs) contained in **IPCC's Fifth Assessment Report (AR 5)**.

2.7. Reference Period

The **reference period for this FREL is 2001-2015** and includes **yearly estimates of emissions and removals**, as included in the national GHG inventory. This period covers 15 years which is the maximum allowed by the Green Climate Fund for REDD+ results-based payments.

2.8. Definition of the FREL

The FREL values were determined using the model (y = 244053x + 702027) which is the linear model with the best statistical fit for the historical data on emissions and removals. The proposed FREL values are:

Table 2. FREL Values (net emissions) in tCO2e, 2016-2020.

Year	FREL Values (net emissions) in t CO2e
2016	4,606,875
2017	4,850,928
2018	5,094,981
2019	5,339,034
2020	5,583,087

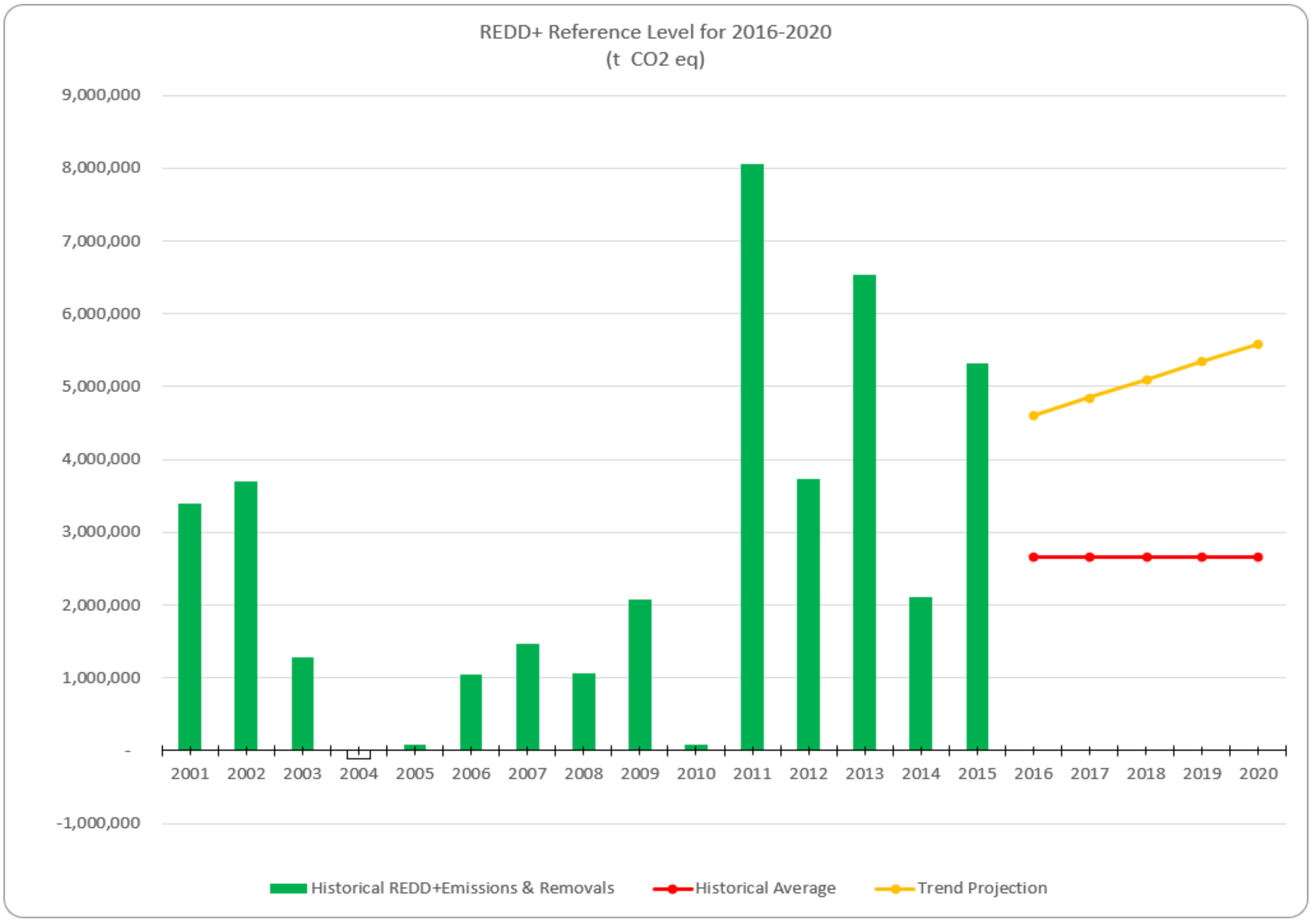

Figure 3. Reference Level in tons of CO2 equivalent per year (yellow line) and historical average as a crediting line for the Green Climate Fund (in red).

2.9. Crediting Line for the Green Climate Fund

For purposes of the Green Climate Fund, Belize developed a crediting line that represents the **historical average of net emissions and removals**, also based on the historical emissions and removals.

Table 3. Crediting Line (net removals) in tCO2e, 2016-2020Name here.

Year	Crediting Line (net removals) in t CO2e
2016	2,570,217
2017	2,570,217
2018	2,570,217
2019	2,570,217
2020	2,570,217

3. National Circumstances

Vast and unique tropical forests exist in Belize which is a habitat to unique biodiversity of global significance[2]. Most of the country and the entire coastal area consist of low-lying plains. Belize is known for its abundant natural resources and a vast array of ecotypes especially with respect to water and biodiversity. Belize hosts more than 150 species of mammals, 540 species of birds, 151 species of amphibians and reptiles, nearly 600 species of freshwater and marine fish, and 3,408 species of vascular plants[3]. In fact, Belize has the highest forest cover in both Central America and the Caribbean, including the largest intact blocks of forests in Central America, namely the Selva Maya and the Maya Mountain Massif [4].

Forest conservation has, historically, been a major priority for Belize. This is evidenced by the country's extensive protected areas system[5]. The Protected Areas of Belize have evolved over the last few decades from being considered primarily as a resource bank, typically for forestry, to become a complex network of large and small "enclaves" having a diversity of purposes and under a variety of management regimes, some more effective than others, reflecting changing conservation attitudes, as has the scope and direction of the various agencies responsible for their administration[6].

The country has 44% (1.22 Million hectares) of its land and sea resources protected under a variety of management structures: 769,093 ha of terrestrial reserves, 159,030 ha of marine reserves, and a further 128,535 ha protected through 'officially recognized' private conservation initiatives[7]. Belize has 102 protected areas (PAs) representing 22.6% of its national territory (land and marine). These include 19 Forest Reserves, 17 National Parks, 3 Nature Reserves, 7 Wildlife Sanctuaries, 5 Natural Monuments, 9 Archeological Reserves, 8 Private Reserves, 8 Marines Reserves, 13 Spawning Sites, 6 Public Reserves, and 7 Bird sanctuaries. The terrestrial PAs cover 34.9% of the total land surface, while the marine reserves cover 10.6% of the country's marine area[8].

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2 https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

3 https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

4 FCPF R-PP Belize https://www.forestcarbonpartnership.org/redd-countries-1

5 FCPF R-PP Belize https://www.forestcarbonpartnership.org/redd-countries-1

6 https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

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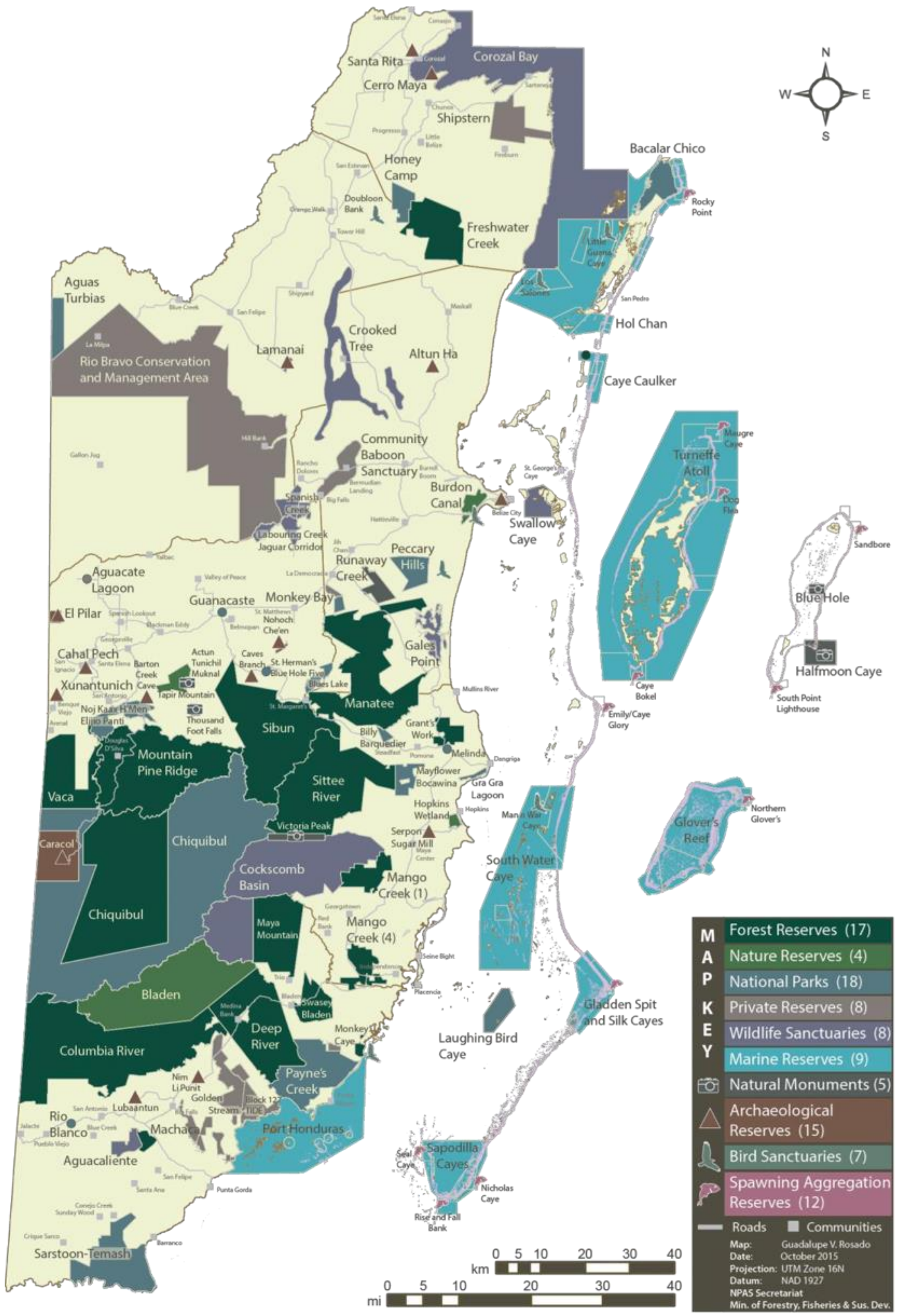

Figure 4. National Protected Areas System (National Protected Areas System Plan Revised, 2015)

Protected Areas in Belize include archaeological reserves and "accepted" private reserves. As part of Belize's protected areas system, there are Birds Sanctuaries that are some of the oldest protected areas. Archaeological Reserves include several Maya Sites managed by the National Institute of Culture and History (NICH)[9].

Extractive Reserves form a grouping of Forest Reserves and Marine Reserves. These management categories were created for the management of extractive resources. This is the largest section of Protected Areas Categories (50% of total protected area extension):

- Forest Reserves = 9.3% of Total National Territory;
- Marine Reserves = 3.7% of Total National Territory; and,
- Combined coverage = 13.0% of Total National Territory.
-

The other conservation management categories are a grouping that represents management categories with conservation objectives. These include Nature Reserves, Wildlife Sanctuaries, no no-take areas (marine reserves), National Parks, and Natural Monuments. This grouping includes a total of 53 areas falling in 6 different classes including conservation/wilderness/no-take zones of marine reserves. The total national coverage of this category of protected areas is 9.3% of the total national territory[10].

With respect to Private Protected Areas, there are 8 private protected areas that meet the classification of either having a standing agreement with the Government, and those that have a de facto recognition and have management structure in place (Shipstern Nature Reserve, Community Baboon Sanctuary, Runaway Creek, Aguacate Lagoon, Monkey Bay Wildlife Sanctuary and Golden Stream Corridor Preserve). The total area that these 8 protected areas represent is 31,663 hectares or 3.2% of Belize's National Territory[11].

These forests also provide sustenance for much of the population. Recently, forests have been under increasing pressures from land conversion and degradation activities. Belize's biodiversity is exposed to various direct anthropogenic and natural threats both within and outside of the Protected Areas (PAs). Over the last five decades, the forest cover in Belize had steadily decreased due in general, to the expansion of unsustainable economic activities, such as large-scale and slash and burn agriculture, aquaculture, illegal logging, unsustainable logging, encroachment, forest/bush fires and other uncontrolled conversion of forest to intense anthropogenic land and extensive damages from climate climate-related hurricanes, and storms and pests. These include the unregulated development of urban and coastal areas and the rising

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9 https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

10 https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

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pollution from cruise ship tourism leading to the degradation of mangroves and coral reefs and deforestation and unsustainable extraction of non-timber forest products in hotspot areas [12,13].

Deforestation has been more severe along rivers. Increases in illegal transboundary incursions by immigrants into Belize forests and Protected Areas for farming, hunting, and harvesting non-timber forest products presents possibilities for increasing deforestation, affecting many of the 3,408 species of vascular plants occurring in Belize and the animal populations that depend on them for food and shelter[14]. Loss of forests in deforestation hotspots, particularly in key watersheds, leads to loss of ecosystem services: protection of water quality in adjacent watersheds, and reduction of nutrient flows that are damaging to the reefs[15].

Rapid and uncontrolled coastal development has resulted in increased habitat loss in Belize's coastal zone. It is estimated that about 75-80% of all coastal land in Belize has been purchased for the development of tourism and residential areas, posing a serious threat to mangroves, coastal wetlands, and other coastal ecosystems. It estimated that in 1990 about 98% of Belize's original mangroves (approximately 80,016 ha) remained; however, two years later an additional 519 ha had been lost due to increased urban expansion and tourism development, a 0.7% reduction in the national total. Since mangroves play a crucial role in coastal tropical biodiversity by acting as a nursery for many species that live in and around coral reefs and providing multiple niches for great numbers of fish, crustaceans, and other species, their disappearance due to coastal development poses a serious threat to both mangrove and reef diversity in Belize[16].

Coastal ecosystems are also threatened by the expansion of aquaculture, primarily through shrimp and tilapia farming. Aquaculture in Belize has been expanding in volume and value more rapidly than most other agro-production activities. It was estimated that aquaculture experienced a 160% annual increase in production volume from 2000 to 2010, particularly farmed shrimp[17].

Many of the country's poor population are forced to rely on subsistence agriculture where they slash and burn the forests and often squat on and farm public lands and in protected areas. There is increased pressure on natural resources through the harvesting of forest products and the demand for bushmeat and

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[12] https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

[13] https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

[14] https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

[15] https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

[16] https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

[17] https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

protein from marine resources, which may lead to the over-harvesting of many species like gibnut and turtles[18].

On the other hand, and after analysis of drivers of deforestation and forest degradation in Belize[19] from 2000 -2017, the predominant conversion is from Forest to Cropland. It seems that the main factor driving deforestation in Belize is the existing land tenure legislation, which requires that leased lands that are forested must be "developed" by the owners or their leases would be revoked. This provides an enormous incentive for landowners to clear the land in an effort to meet the requirements of "development". However, it has been observed that many of these lands lie idle after they have been cleared since the landowners lack the capital to engage in alternative land uses. Hence, simple amendments to the existing land tenure law could have a significant impact on biodiversity conservation, the deforestation and forest degradation rate and the subsequent fragmentation of Key Biodiversity Areas and forests [20] as well as in the implementation of REDD+ Strategy.

Since the pre-independence period, timber was one of Belize's major export products. Forests are a valuable asset and generate a range of important ecosystem services such as biodiversity habitats, non-timber forest products for local and indigenous communities, fuel for rural communities, and largely untapped potential for the use of medicinal plants in the pharmaceutical industry. Forests provide soil stabilization, which prevents excessive sedimentation of estuaries and coral reefs and reduce the runoff of nutrients from agricultural areas to the sensitive reef and mangrove ecosystems. In terms of the loss of ecosystem services such as water quality protection by riparian forests, location is important[21].

Historically the development of Belize's economy was based on logging. The country of Belize was established based on logwood cutting. Throughout history, we have seen the extraction of *Haematoxylum campechianum* (Logwood), *Swietenia macrophylla* (mahogany), *Cedrela odorata* (cedar) and currently the extraction of *Dalbergia stevensonii* (rosewood) which is leading to forest degradation because all sizes are being extracted with and without permits countrywide [22].

In addition, Belize lies within the hurricane belt and the constant threat of hurricanes, which is expected to increase in both frequency and intensity due to climate change, remains a real threat to Belize's forests, reefs, and PAs. In recent years, forests in Belize have been significantly affected by hurricanes (e.g., Chantal, Keith, and Iris) causing considerable forest damage in the north and south of the country due to extended

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[18] https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

[19] First Draft of REDD+ Strategy April 2019. Section 4: Drivers of Deforestation and Forest Degradation

[20] https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

[21] https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

[22] Identification of Deforestation and Forest Degradation drivers in Belize: Program for the Reduction of Emissions from Deforestation and Forest Degradation in Central America and the Dominican Republic (2011)

flooding and persistently strong winds. In addition to the physical damage (e.g., toppled trees, windbreak, and defoliation), hurricanes leave native forests exposed to potential pest infestations that can wipe out entire forests. The outbreak of the bark beetle (*Dendroctonus spp*.) in 2000 and 2001 that affected over 26,000 ha of mature pine stands (*Pinus caribaea* and *P. tecunumanii*) in Belize's Mountain Pine Ridge Forest Reserve with nearly 100% mortality, is believed to be partially related to post-hurricane effects. Damage to forests also affects animal populations by reducing their food supply and changes in habitat availability that in turn may affect species composition[23].

In 2010, hurricane damage led to extensive forest areas being destroyed leaving much debris which that accumulated and dried up to form fuel. Consequently, during the 2011 dry season, Belize experienced some of the most extensive forest fires all over the country (Central Belize). These fires and other forest degradation are leading to loss of biodiversity and emissions of GHGs into the atmosphere and contributing to further climate change[24].

An increase in both hurricane frequency and intensity due to climate change is also responsible for the weakening or the destruction of the reef system, compromising its ability to buffer the tidal impacts from storms; this may cause severe negative impacts on coastal ecosystems (e.g., mangroves and coastal lagoons) and species due to increased water salinity, extended flooding, and coastal erosion[25].

Although Belize has managed to preserve its environmental capital to a greater extent than its neighbors, it still faces some serious environmental problems that adversely affect the poor, and growth prospects. The short-term impacts of natural disasters and the long-term effects of climate change are expected to undermine the resilience of natural ecosystems and human vulnerability, increasing the urgency of tackling these challenges[26].

3.1. Procedures and arrangements for the preparation of the FRL/FREL [27]

To respond to the set of international reporting requirements inscribed in the UNFCCC and in the Paris Agreement, Belize is fully committed to establishing a coherent, overarching governance structure to coordinate climate change management initiatives at the national level. The institutional framework critical for the implementation of climate change commitments and opportunities, including REDD+ is provided by Figure 5 below.

23

24 https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

25 https://www.thegef.org/sites/default/files/project_documents/PIMS%25204907_GEF5%2520BD%2520EA%2520Belize_20-Jun-2012_0.pdf

26 https://www.thegef.org/sites/default/files/project_documents/9-19-11%2520Belize%2520PIF_0.pdf

27 Paragraph 13, annex to 17/CP.8.

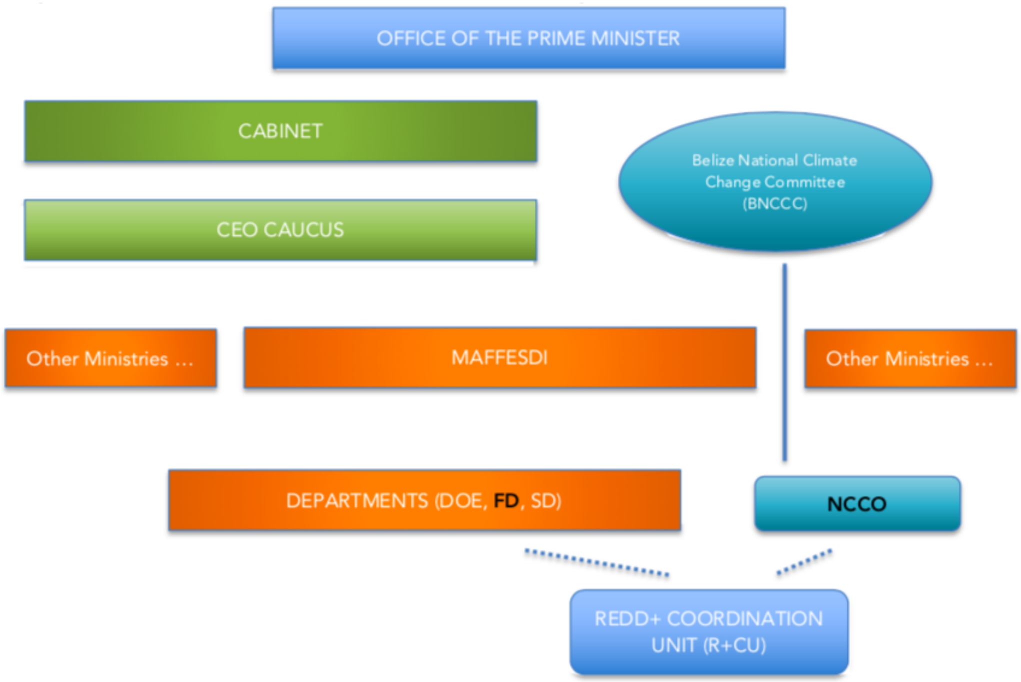

Figure 5. Institutional Arrangements for REDD+ in Belize.

At the ministerial level, the competence to deal with climate change issues is within the Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration (MAFFESDI). Actually, the authority of MAFFESDI is currently split into two ministers responsible for Agriculture, Immigration and all the rest respectively.

MAFFESDI is responsible for the governance and management of natural resources towards the sustainable development of Belize. This includes, among others, the collaborative efforts to implement, monitor and evaluate the strategic sustainable long and medium-term development of the country. In addition, MAFFESDI is responsible for guiding the development of Belize in line with all major multilateral environmental agreements including the United Nations Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD).

The National Climate Change Office (NCCO) was established in 2012 within the Ministry responsible for Environment and Sustainable Development as a national entity responsible for climate change initiatives at the national level. To this end, the Office is strategically positioned to coordinate the implementation of climate change adaptation and mitigation actions and to coordinate climate change programs, projects, and initiatives.

The Belize Forest Department (BFD) is a public entity under the authority of MAFFESDI. Its main task is to foster Belize's economic and human development by effectively enforcing relevant policies and regulations for the sustainable management of its natural resources through strategic alliances and efficient coordination with relevant stakeholders. The BFD has the mandate to manage Belize's forest resources and develop the Belize National Forest Policy.

The Department of Agriculture's aim is to provide an environment that is conducive to increase production and productivity, promoting investment, and encouraging private sector involvement in agribusiness enterprises in a manner that ensures competitiveness, quality production, trade, and sustainability[28].

The REDD+ Coordination Unit (R+CU) has been established within the premises of MAFFESDI and under the NCCO. The main tasks of the R+CU are to manage and coordinate the REDD+ readiness phase and ensure all REDD+ requirements under the UNFCCC are respected so that REDD+ implementation can start promptly.

3.2. Process for the preparation of the FREL

A brief description of procedures and arrangements are undertaken to collect and archive data for the preparation of the FRL/FREL is included, as well as efforts to make this a continuous process for the Measurement, Reporting, and Verification (MRV) system, including information on the role of the institutions involved.

The process started with the review of previous emission estimation methods and estimates, identification and formation of the teams, allocation of tasks, technical training, data collection, data analysis, QA/QC procedures, and finalized with a compilation of the FREL. The process was completed by an external independent review and structuration of an improvement plan.

Table 4. Schedule of inventory tasks

Stages	Responsible
Identification and formation of the teams	National Climate Change Office (NCCO) & Forest Department (FD)
Allocation of tasks	National Climate Change Office (NCCO) & Forest Department (FD)
Technical training	CfRN, GHG Institute, FAO.
Data collection	Forest Department, NCCO, R+CU
QC/QA procedures	QC: NCCO, Forest Department, R+CU / QA: CfRN
Data analysis	NCCO, Forest Department, R+CU, CfRN
Compilation of the GHG AFOLU inventory	NCCO, Forest Department, R+CU, CfRN
QC/QA procedures	QC: NCCO, Forest Department, R+CU / QA: CfRN
Independent review	CfRN Independent Panel of review
Improvement plan	NCCO, Forest Department

[28] https://www.agriculture.gov.bz/.

Means of data acquisition and management

The Belize Forest Department identified all the national experts and/or institutions where the data would be sourced. All data are documented and stored as per archiving and documentation procedures, with the main custodian being the Forest Department in its database for archiving and retrieval.

The archives database contains; (a) all inputs datasets and datasheets; (b) country-specific excel calculation tool, including Forest related-GHG emission and removals estimates from 2000-2017, (c) manuals and protocols, (f) literature reviewed, (g) completed QA/QC templates and protocols, and (h) all reports and documentation.

3.3. Description of national legislation

Belize is fully committed to the international regime established on the promotion of sustainable development and the fight against climate change. In those areas, Belize has made significant progress in transitioning from the Millennium Development Goals in 2015 and has ratified the Paris Agreement on climate change in 2016. As such, Belize has taken ownership of the SDGs and developed several policy frameworks towards sustainable development and climate change over the last decade. These include, among others: (1) Horizon 2010-2030, (2) National Energy Policy Framework, (3) Sustainable Energy Action Plan 2014-2033, (4) National Climate Resilience Investment Plan 2013, (5) Growth and Sustainable Development Strategy 2016-2019, (6) the National Climate Change Policy, Strategy and Action Plan 2015-2020.

In addition, as a Party to the Paris Agreement, Belize submitted its Nationally Determined Contribution (NDC) to the UNFCCC in 2015. It is also important to emphasize that Belize is currently also undertaking a full review of existing policies such as forest and land-use policies with the aim to enhance their effectiveness and to better align them with the national climate change commitments.

In addition, the Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration (MAFFESDI) did a detailed policy review called 'Legal and Institutional Framework for REDD+ implementation in Belize". All strategic documents mentioned below provide policy guidance on the forest and land used sector, amongst others.

Strategic policy frameworks

- National Development Framework for Belize (2010-2030), "Horizon 2030", 2016

Revised Low Carbon Development Roadmap for Belize, April 2016

- Growth and sustainable development strategy (GSDS), 2016-2019,
- National Change Policy, Strategy and Action Plan (NCCPSAP), MAFFESDI, 2014

Framework environmental protection law

- National Environmental Policy and Strategy (2014-2024), 2014
- National Environmental Action Plan (2015– 2020), 2014
- The Environmental Protection (Amendment) Act, 2009

Forest

- National Forest Policy, 2015
- The Forest (Amendment) Act, 2017
- Forests (protection of mangroves) Regulations, 2018
- Forest (Protection of Trees) Regulations, 2010
- Private Forest (Conservation) Act, 2000
- Forest Fire Protection Act, 2000
- Sustainable Forest Management Licenses (SFML)

Agriculture

- The National Food and Agriculture Policy (2002- 2020), 2003
- The National Agriculture and Food Policy of Belize (NAFP) (2015-2030), 2015
- Agriculture Development Management and Operational Strategy (ADMOS), 2005
- National Adaptation Strategy to address Climate Change in the Agriculture Sector in Belize, 2014
- Agricultural Fires Act, 2000

Land tenure

- National Land Use Policy and Integrated Planning Framework for Land Resource Development (Draft), Ministry of Natural Resources, November 2011
- National Lands Act, 2003
- The Land Utilization (Amendment) Act, 2017
- Land Tax Act, 2003
- Land Acquisition Act, 2000

Spatial Planning

- National Protected Areas Policy and System Plan, 2015
- National Protected Areas System Act, 2015
- Protected Areas Conservation Trust (PACT) (Amendment) Act, 2017
- Integrated Coastal Zone Management Plan, 2016
- Coastal Zone Management Act, 2003

Biodiversity

- National Biodiversity Strategy and Action Plan (NBSAP) (2016- 2020), 2018
- Biodiversity Initiative – Biodiversity Policy and Institutional Review, October 2018 (DRAFT)

Taxation

- Environmental Tax (Amended) Act, 2017
- The Fiscal Incentive Program, 2016

- The Fiscal Incentives Act, 2011
- Finance and Audit (Reform) Act, 2011
- The Mines and Minerals Act
-

Description and the reference/links to forest, forest users, and REDD+ can be found in the above-mentioned report.

4. Methodologies employed

4.1. Land Representation

Belize followed 2006 IPCC guidelines structure for the AFOLU sector, including the six mainland uses proposed: Forestland, Cropland, Grassland, Wetland, Settlement and Other Land (Level 1). Additional subdivisions were defined following national circumstances, including climate, soil and disturbance history in line with IPCC guidance (Levels 2 and 3).

Table 5. Land classification in Belize following the 6 land uses defined in the 2006 IPCC guidelines.

LEVEL 1	LEVEL 2	LEVEL 3
	Broad-leaf Mature Forest	Riparian Forest
		Swamp Forest
		Other Forest
	Broad-leaf Secondary Forest	Riparian Forest
		Swamp Forest
		Other Forest
	Pine Forest	
	Mangroves	Tall mangroves
		Dwarf mangroves
		Littoral forest
	Plantations	Teak
		Other Plantations (TEBABUYA SP.)
	Swidden Farming	
CROPLANDS	Annual crops	Rice, Beans, Corn, Sugar Cane
	Perennial crops	Banana, Coffee, Citrus
	Follow lands	
GRASSLANDS	Pastures/Shrublands /Savannas/Ferns/Thickets	Riparian shrubland vegetation, Shrubland (thicket), Ferns, Savannah with scattered pine trees, Savannah with scattered shrubs, Bare-savannah, Agriculture-pasture
	Regenerating Shrubs & Bushes	

	Regenerating Shrubs & Bushes (Mountain Pine Ridge)	
WETLANDS		Wetland, Coastal lagoon, Inland water bodies, Aquaculture
SETTLEMENTS		Residential areas, rooftops, market, sport facilities areas and parking lots.
OTHER LANDS		Roads, highways, quarries, eroded areas, beach sand, dried up soil in savannah areas, bare rock, and exposed riverbeds

Level 1: FOREST LANDS (F)

For Belize, forest is a plot of land with an area of 0.5 hectares or more, with trees 5 meters or higher, and a canopy cover of 30% or higher. This definition also includes forest plantation. In addition, it includes an ecosystem that due to biotic conditions (terrain, soil type, rainfall, et cetera), the trees cannot grow higher than 5 meters.
.[29]

Level 2: Mature Broadleaf Forest (MBL)

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

[29] Deforestation is when Forest land is converted to another land use (cropland, grassland, settlement, wetland, and other land). Conversion can be caused by humans or natural causes, but if the subsequent land use is anthropogenic (*i.e.* cropland, managed grassland, settlement, wetlands or other land), then the conversion is considered to be a deforestation. Conversely, forest land conversion to regenerating grassland (a natural recurring process in Belize due to hurricanes) is not considered to be deforestation, but a temporarily unstocking of lands, following the 2006 IPCC guidelines.

Level 3: Mature Riparian Forest

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests are generally located on alluvial plains along watercourses or in gullies in mountainous areas. The defining characteristic is that a mature riparian forest is found **within 66 feet from a water source**.

Level 3: Mature Swamp Forest

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a closed canopy cover of 30% or higher. These forests are characterized by being **inundated seasonally or permanently**.

Other Mature Broadleaf Forest (MBLO)

Other Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations. If the specific class was not Riparian or Swamp MBL, then MBLO was used.

Level 2: Secondary Broadleaf Forest (SBL)

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** (with more than <u>70% mortality</u>) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to a nearby mature forest on similar sites.

Level 3: Secondary Riparian Forest

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** (with more than <u>70% mortality</u>) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forests on similar sites.

The defining characteristic is that secondary riparian forest is found **within 66 feet from a water source**.

Level 3: Secondary Swamp Forest

Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forests on similar sites.

The defining characteristic of the secondary swamp forests is that these are **inundated seasonally or permanently**.

Other Secondary Broadleaf Forest (SBLO)

Other Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

The defining characteristic of the secondary swamp forests is that these are **inundated seasonally or permanently**.

Level 2: Pine Forest (PINE)

Mature Pine Forest

A plot of land that is 0.5 hectares or more, with pine-dominated evergreen mature trees with a height of 5 meters or higher. Pine forests have some intermittent mixing of broadleaf tree species (oak, craboo). The defining characteristic is an **open canopy** that is dominated by pine trees with some intermittent small gaps of low broadleaf tree species, grass, or shrubs.

Secondary Pine Forest

A plot of land that is 0.5 hectares or more, with pine-dominated evergreen mature trees with a height of 5 meters or higher. Pine forests have some intermittent mixing of broadleaf tree species (oak, craboo). The defining characteristic is an **open low canopy** that is dominated by pine saplings with some intermittent small gaps of low shrubby vegetation, grass or small broadleaf trees.

These are pine forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period.

Level 2: Mangrove (MAN)

Level 3: Littoral Mangrove Forest

Comprised of a monoculture of mangrove trees 5 meters or taller. It also includes mixed-species forests over 5 meters tall in brackish to saline conditions. Littoral mangroves are mostly found along the coastline and on cayes.

Level 3: Dwarf Mangrove Forest

Composed of mangrove species lower than 5 m tall. It also includes mixed-species forests lower than 5 meters tall in brackish to saline conditions. Dwarf mangroves are mostly found along the coastline and on cayes.

Level 2: Forest Plantation (PLANTF)

Planted monoculture stands of broadleaf tree species. The main defining characteristic here is a stand of trees planted in rows with a **somewhat open canopy.** Common species planted include teak, mahogany, cedar, melina, and acacia.

Level 2: Regenerating Forest (REGFOR)

A forest that was highly disturbed
by either hurricane, fire, or pests, and is left to regrow. The distinguishing characteristic is a significant loss in canopy cover without having a land-use change.

Level 1: Cropland (C)

Agricultural activity is 0.5 hectares of land that has a 20% cover with crops in the sample plot/point. Land that was once used for swidden agriculture and has been abandoned and is 'regenerating toward a secondary forest' is also considered cropland under specific class fallow land.

Level 3: Swidden Farming [30]

A system of cultivation where land is cleared (and oftentimes burned) to produce staple food-crop for a short period of time (1 to 3 years), followed by a long fallow period. Only annual crops are planted in swidden farming. Swidden farming is also referred to as milpa farming or slash-and-burn farming.

Level 3: Intensive Agriculture

A production system characterized by having high output per unit of lands as a result of an increase in the use of technological inputs (e.g improved seed, irrigation, fertilizer application, pesticides, mechanization, and capital). Intensive agriculture can be small scale or large scale. It can also be annual crops (eg. Corn, beans, etc.) or perennial crops (citrus, coconut, etc.)

Level 2: Fallow Land (FALL)

Regeneration immediately after the abandonment of agricultural activity. Fallow land that was monocrop takes eighteen (18) years to transition to the secondary broad lead forest. During the initial eight (8) years of growth, fallow land has bushes. Consequently, for the next ten (10) years, fallow land is dominated by broadleaf pioneer tree species such as bay cedar, trumpet tree, pole wood, et cetera. At this stage, the defining characteristic of fallow land is an open canopy, with intermittent large trees, low vegetation, and high vine coverage. The canopy is generally lower than 5 meters. Fallow land is referred to as *wamil*.

Level 1: Grassland (G)

Grassland is 0.5 hectare of land that has a 20% cover of savannah, grass, shrubs, ferns, and tickets in the sample plot/point.[31] Cattle pasture is considered grassland.

Level 2: Lowland Savannah, Shrubland, Shrubland, Pasture

Level 3: Lowland Savannah

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[30] Definitions of Cropland were provided by the Coordinator for the Research & Innovation Program at the Department of Agriculture. Annual crops are crops that complete their life cycle from seed germination to seed production in one year (e.g. beans, corn, lettuce, sweet pepper, et cetera). Perennial crops are a crops that live year round, producing several crops or harvests during its life time (e.g. fruit trees).

[31] Definition for Grassland relied on the 'Classification system for the forest and land cover map of Belize 2012/014 based on RapidEye imagery' of 2016, published by the Forest Department.

Savannah is dominated by graminoids (grasses and sedges) with scattered tree species. The dominant species is pine.

- Savannah with scattered trees: Dominated by graminoids (grasses and sedges) scattered with various tree species such as Oak, Palmetto Palms, Pines, and Calabash.

- Savannah with Scattered Shrubs: Dominated by graminoids (grasses and sedges) scattered with various shrub species.

- Open Savannah: Large expanse of areas covered by graminoids (grasses and sedges) only.

Level 3: Shrubland

Includes areas of small trees, herbaceous species, and bushes with sparse and clumped trees. These thick and woody vegetation are less than 5 meters in height because of natural soil conditions, for example, savannah soil, low land areas, poor soils, and waterlogged soils.

Level 3: Pasture

This includes areas covered with grass and small plants or scattered trees. This includes livestock grazing areas and backyards/lawns, especially backyards in farming communities (e.g. Mennonite communities). The defining characteristic of pasture is that are established by humans.
Large patches covered by tiger ferns (bracken) and other fern species. These are generally found in areas of higher elevation. In the Columbia Forest Reserve, ferns and thickets appeared after hurricane disturbance in forests.

Level 2: Regenerating Shrubs & Bushes (REGBUSH)/(REGBUSHP)

- Areas disturbed by natural causes (hurricane and fires) or human disturbance (abandoned pasture) that are left to regrow into a natural transition. Grassland areas that remain as regenerating bushes that remain as regenerating bushes and shrubs because of continuous disturbance (natural and human) that does not allow them to transition to another category. However, regenerating bushes, e.g. abandoned pastures, can eventually transition to another category such as secondary forest.

- Regenerating bushes and shrubs in the **Mountain Pine Ridge Forest Reserve**: pine forests destroyed by a combination of pests and fire disturbances that was unable to recover to an upland pine forest with the Mountain Pine Ridge Forest Reserve (see section 'Analysis of LULUC from 2001 to 2018' for explanation).

Level 1: Wetland (W)

Level 3: Wetland (WET)

Wetland is an area that is 0.5 hectares or more that has a 20% permanent or seasonal floods, dominated by herbaceous/graminoid vegetation. Wetlands can have trees such as calabash (*Cresentia cujete*) or no trees.

Level 3: Inland Water Bodies (IWB)

An area that is 0.5 hectare or more that has 20% of rivers, streams, inland lagoons, lakes, cenotes, and reservoirs that may have aquatic vegetation.

Level 1: Settlement (S)

A settlement is an area that is 0.5 hectares or more that has 20% of urban construction that falls within the following subcategories.

Level 3: City (SET)

Plots that fall within either Belize City or Belmopan City.

Level 3: Town (SET)

Plots that fall within Corozal, Dangriga, Orange Walk, Punta Gorda, San Ignacio, San Pedro, Benque Viejo or Santa Elena town.

Level 3: Village (SET)

A settlement that is smaller than a town, having homes and related urban infrastructure.

Level 3: Road (SET)

Paved or unpaved permanently transited roadways.

Level 3: Mining (SET)

Areas generally quarried for construction material (white mall for road construction).

Level 3: Aquaculture (SET)

Areas that are generally shrimp farms/ponds.

Level 3: Other Settlement (SET)

Urban constructions that do not fall within any of the above (e.g. telephone antennas, etc.).

Level 1: Other land (O)

Other land is an area that is 0.5 hectares or more that has 80% of soils that fall in the following subcategories:

Level 3: Bare Soil (BARS)

An area that has no vegetation, are not rocks and is not a beach.

Level 3: Bare Soil Rocks (BARS)

An area that is bare and is rocks.

Level 3: Bare Soil Beach (BARS)

An area that falls on beaches having no vegetation.

4.2. Data Collection

Forest Inventories

Broad-leaf Mature Forest: The information comes from the study "An investigation of tropical forest response to hurricane disturbance with evidence from long-term plots and earth observation in Central America" by Dr. Percival Cho (Ministry of Agriculture, Fisheries, Forestry and the Environment of Belize and Lancaster University) published in September 2013[32]. The methodology used for the Permanent Sample plots are from Sustaining the Yield: improved timber harvesting practices in Belize by Neil Bird and published in 1998[33] and also from the paper: Diversity, dynamics and carbon budget of tropical forests subject to hurricane and anthropogenic disturbance: Field Research Methods by Dr. Percival Cho finalized in 2013[34] .

During the period 1992 to 1998, 32 one-hectare permanent forest plots were established in mature, hurricane-disturbed and/or selectively-logged broadleaf forests of Belize and censused multiple times using the same standardized pan-tropical methodology used in other networks (Bird, 1998); (Brewer and Webb,

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[32] Percival Cho (2013). An investigation of tropical forest response to hurricane disturbance with evidence from long-term plots and earth observation in Central America.

[33] Neil Bird (1998). Sustaining the Yield: improved timber harvesting practices in Belize 1992-1998.

[34] Percival Cho (2013). Diversity, dynamics and carbon budget of tropical forests subject to hurricane and anthropogenic disturbance: Field Research Methods.

2002).[35] Measurements were quality-controlled and well documented (e.g. Bird, 1998), which provides a robust basis for evaluating growth rates (Clark and Clark, 2000)[36].

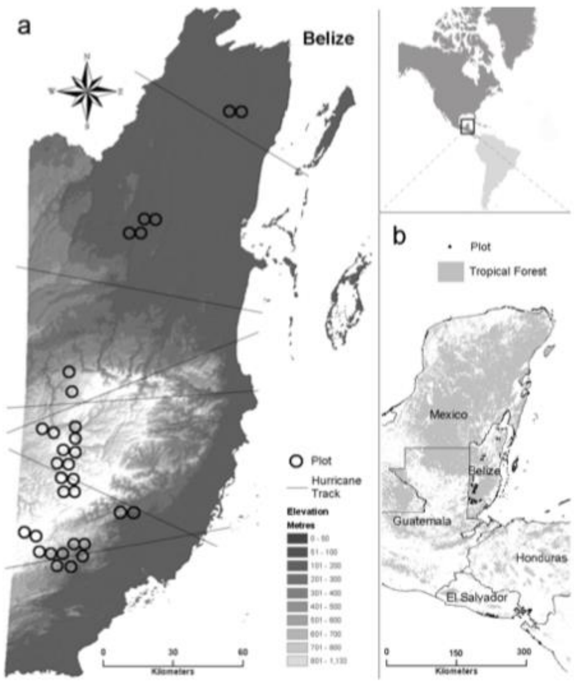

Figure 6. Location of FORMNET-B plots.

Plots were divided into 25 quadrats or subplots each 20 x 20 m within which all stems ≥100 mm in diameter at 1300 mm above the ground (diameter at breast height or DBH) were identified, measured, tagged and mapped. The point of diameter measurement (POM) was painted and crown form and position in the canopy were assessed for each tree along with any relevant features including the presence of climbers, pests, rot, stem deformity or damage. Measurements of dead standing trees along with proximate causes were also taken. Stems 10 to 99 mm in diameter were measured in the central quadrat. Plot location methodology followed Beetson et al. (1992)[37] and was described in Bird (1998). In total, plots were placed within ten forest types ranging in altitude from 20 to 770 m.a.s.l and within areas receiving mean annual rainfall ranging from 1500 to 3000 mm.yr^{-1}, covering Lowland Moist Broadleaf (LM), Lowland Wet Broadleaf (LW) and Sub-montane Wet Broadleaf (SW), representing a wide range of growing conditions in Belize.

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[35] Steven Brewer and Molly Webb (2002). A seasonal evergreen forest in Belize: unusually high tree species richness for northern Central America. Botanical Journal of the Linnean Society.

[36] David Clark and Deborah Clark (2000). Landscape-scale variation in forest structure and biomass in a tropical rain forest. Forest Ecology and Management.

[37] Trevor Beetson, Marks Nester and Jerry Vanclay (1992). Enhancing a Permanent Sample Plot System in Natural Forests. The Statistician.

Most plots are in different stages of recovery following natural or anthropogenic disturbance or degradation. Past disturbances were gleaned from forestry records dating back to the 1920s (Bird, 1998) and from satellite images. Landsat images from the 1970s showed that several plots were established in forests recovering from past fires following hurricane disturbance in 1961 and 16 plots were affected by hurricanes within the past 15 years.

- *Broad-leaf Mature Forest - Logging:* Selective logging began in the CRFR around 1920 and continued at intervals in the 1940s, 70s, and 90s (Bird, 1998). In 1996 the forest was zoned into compartments and placed under sustained-yield timber production with harvesting limited to one 500-hectare compartment per annum. To support the implementation of sustained-yield harvesting, ten 1-hectare permanent sample plots were established in the reserve between 1993 and 1997 (Bird, 1998). Twelve (12) of the plots were included in a controlled experiment to study the long-term impacts of selective logging (Bird, 1998). The plots were placed in six replicates of adjacent logged and unlogged pairs, and each plot was surrounded by a buffer of eight hectares of similar treatment. Logged plots and buffers were subjected to a uniformed felling intensity of six stems.ha^{-1} and wood volume removals were meticulously recorded (Bird, 1998). Other plots in the network were logged under conventional selective logging methods as part of a study of logging damage. Unfortunately, after 1998 the plots were abandoned due to financial and institutional constraints. At the time of establishment, the forest within the plots resembled undisturbed old-growth and exhibited characteristics of all-aged, old-growth tropical forest, with a high stocking of trees greater than 60 cm in diameter (Bird, 1998).

- *Broad-leaf Mature Forest - Hurricane:* On 8 October 2001 Hurricane Iris struck the CRFR and affected eight (8) of the ten (10) permanent plots. Maximum sustained winds were estimated at around 225 km hr^{-1}. Hurricane tracks in the North Atlantic Hurricane Database (Landsea et al., 2004)[38] indicate the last major hurricane (category 3 or higher on the Saffir-Simpson scale) to have affected the location of the plots occurred at least one hundred years prior to Hurricane Iris (Bird, 1998). Seven (7) of the disturbed plots were used to study the effect of hurricane damage on tree mortality and recruitment (one plot could not be relocated during this study as the demarcation records were unavailable at the time). As controls, an equivalent number of undisturbed plots established in nearby areas around the same time were used. One control plot was located within the CRFR and six were in the nearby Chiquibul Forest Reserve. The seven (7) control plots were situated in mature tropical forests that have not been disturbed by hurricanes since 1961 (Bird, 1998). Censuses took place before and after the hurricane. BZ-2, BZ-3 and BZ-4 were censused in March 1993 and four years later in February 1997. BZ-27, BZ-28, BZ-29, and BZ-30 were censused in 1997 only. All the plots were censused again approximately ten years after Hurricane Iris: BZ-2

[38] Christopher W. Landsea, Steve Feuer, Andrew Hagen, David A. Glenn, Nicholas T. Anderson, Jamese Sims, Ramon Perez, and Michael Chenoweth (2004). The Atlantic hurricane database reanalysis project documentation for 1851-1910 alterations and additions to the HURDAT database. Hurricanes and Typhoons Past, Present and Future.

in June 2010, BZ-3 and BZ-4 in May 2011, and BZ-27, BZ-28, BZ-29 and BZ-30 between March and May 2011.

As part of Cho *et al* (2013) studies of forest recovery after hurricane degradation, data from all 85 censuses in the 1990s was compiled, sourced directly from the authors. During the period 2010 to 2013 seventeen (17) of the plots were restored and new censuses of live trees and dead logs were carried out. Botanical vouchers were collected from previously unknown abundant and rare species and taxonomical records were standardized against 'The Plant List' (www.theplantlist.org) (Kalwij, 2012)[39]. The data were digitized and validated following methods outlined in Peacock et al. (2007)[40] and Fox et al. (2010)[41].

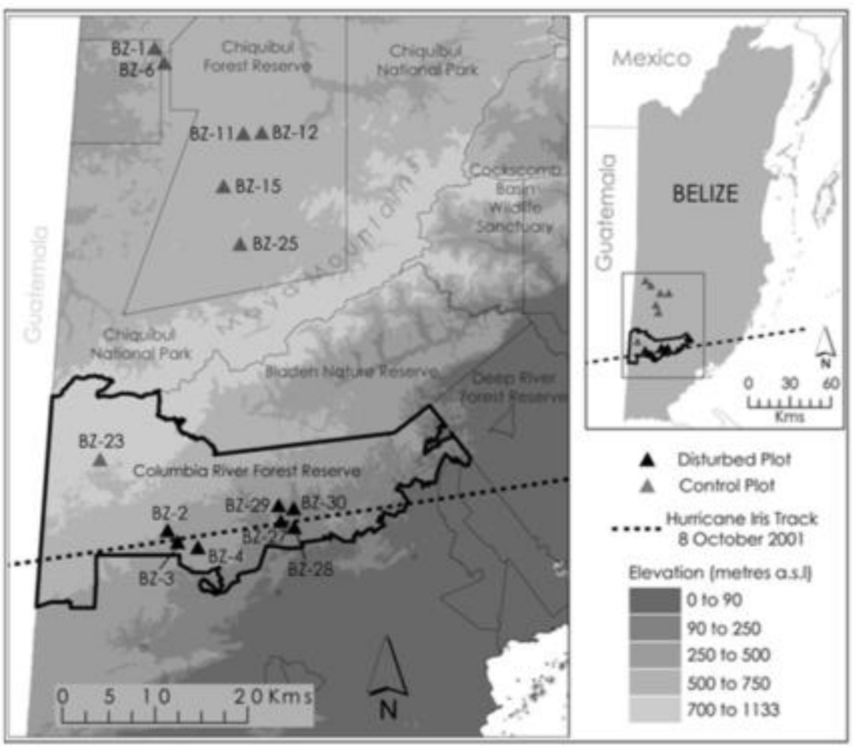

Figure 7. Map of the study area showing the location of the study plots.

Plot numbers follow the officially designated numbering system for FORMNET-B plots, where 'BZ' stands for Belize and is followed by the number representing the sequence in which the plots were established. Symbols of adjacent plots are offset by approximately 1.5 kilometers to prevent overlap.

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[39] Jesse Kalwij (2012). Review of 'The Plant List, a working list of all plant species'. Journal of Vegetation Science.

[40] Julie Peacock, Tim Baker, Simon Lewis, Gabriela Lopez-Gonzalez and Oliver Phillips (2007). The RAINFOR database: Monitoring forest biomass and dynamics. Journal of Vegetation Science.

[41] Julian Fox, Cossey Yosi, Patrick Niamago, Forova Oavika, Joe Pokana, Kunsey Lavong and Rodney J. Keenan (2010). Assessment of Aboveground Carbon in Primary and Selectively Harvested Tropical Forest in Papua New Guinea. Biotropica.

A relational database was constructed in MS Access to house and link individuals to their respective repeat measurements. The aim of the database is to store and make available long- term forest monitoring data from the forest ecosystems of Belize and to facilitate linkages to other databases of permanent forest plot measurements such as 'Forestplots.net' (Lopez- Gonzalez et al., 2011)[42]. FORMNET-B (GIVD ID# NA-BZ-001), as the database is known, contains 33 722 stems (32 066 individuals) of which 79 % are palms, lianas and woody trees ≥ 100 mm DBH, 17 % are saplings 10 to 99 mm DBH), 2 % are seedlings < 10 mm DBH and 2 % are immature palms (with an indefinite stem). Repeat-census data incorporate 62 436 total individual records of tree measurements. On average, plots in FORMNET-B have been monitored for ten years (±7.35 st dev) with an average of 2.7 censuses (±1.07 st dev) per plot. This database was published, and more details can be found in the paper "*The FORMNET-B database: monitoring the biomass and dynamics of disturbed and degraded tropical forests*"[43].

Mangroves: The methodology for the estimation of Mangrove biomass originates from the protocol: "Mesoamerican Barrier Reef Systems Project (MBRS) Manual of Methods for the MBRS Synoptic Monitoring Program/Selected Methods for Monitoring Physical and Biological Parameters for use in The Mesoamerican Region"[44]. The Environmental Research Institute (ERI) of the University of Belize has a long-term monitoring presence in five study sites on Turneffe Atoll. Turneffe Atoll is located 32 kilometers east of Belize City. It is a part of the Mesoamerican Barrier Reef System and is within a marine reserve co-managed by the Turneffe Atoll Sustainability Association with the Belize Fisheries Department. The five sites are Calabash, North East Turneffe, Zone V, West Turneffe and North West Turneffe. Calabash, North East Turneffe and Zone V are sites that are located on the eastern coast whereas West Turneffe and North West Turneffe are on the western coast.

Each study site has three mangrove plots which measure 10 meters by 10 meters in area. ERI annually collects monitoring data from these study sites (methodology from CARICOMP Methods Manual)[45]. General methods for measurement of mangrove ecosystem structure and function are as described by Lugo and

[42] Gabriela Lopez-Gonzalez, Simon Lewis, Mark Burkitt and Oliver Phillips (2011). ForestPlots.net: A web application and research tool to manage and analyse tropical forest plot data. Journal of Vegetation Science.

[43] Cho, P., Blackburn, G. A., Bird, N. M., Brewer, S. W., and Barlow, JPercival Cho, George Blackburn, Neil Bird, Steven Brewer and Jos Barlow (2013).: The FORMNET-B database: monitoring the biomass and dynamics of disturbed and degraded tropical forests. Journal of Vegetation Science., doi: 10.1111/jvs.12103, 2013.

[44] Patricia Almada-Villela (2003). Manual of Methods for the MBRS Synoptic Monitoring Program.

[45] CARICOMP (2001). Caribbean Coastal and Marine Productivity (CARICOMP). A Comparative Research and Monitoring Network of Marine Laboratories, Parks and Reserves. CARICOMP Methods Manual Levels 1 and 2. CARICOMP Data Management Center and Florida Institute of Oceanography.

Snedaker (1975)[46], Pool et al. (1977)[47], and Snedaker and Snedaker (1984)[48]. The standardized procedure for mangrove communities requested specific parameters to be recorded. Forest characterization, recognizing stress, the establishment of plots, trunk diameter at breast height (dbh), height range for trees within the plot, the salinity of sub-surface (interstitial) water, biomass within the plot, standing crop, community description (within the plot), tidal range, abundance and percentage cover. In terms of seedlings and saplings, subplots are established, and seedlings are tagged, identified, mapped, root seedlings (<2.5 cm dbh) are measured, growth (new leaf biomass) is also measured.

Pine Forest: The data obtained for Pine Forest in Belize is based on data collected by the Forest Department from two plots located in the Mountain Pine Ridge Forest Reserve (BZ-46 and BZ-54). Two censuses, 2017 and 2018, from Plot BZ-46 were used for calculation purposes for the growth rate as this is the only plot with more than one census. The above-ground biomass was calculated from one plot (BZ-54), unlike the disturbed Plot BZ-46, BZ-54 is a mature undisturbed Upland Pine Forest. The methodology to establish and census permanent sample plots in Pine Forests follows closely the same methodology for broad-leaf forests except for certain variations as documented.

4.3. Land Use and Land Use Change Data

According to the 2006 IPCC guidelines, Belize implemented Approach 3, as it is characterized by spatially-explicit observations of land-use categories and land-use conversions, tracking patterns at specific point locations.

To achieve this, Belize decided to use the image visualization tool called Collect Earth / Open Foris developed since 2013 as a tool for the collection of Land Use and Land Use Change data using mid- and high-resolution imagery. Collect Earth (as well as all the tools developed within Open Foris) can be downloaded for free from the OpenForis.org page (http://www.openforis.org/). This software is developed in Java, uses Google Earth as its main data collection interface and integrates several web services that provide very high-resolution satellite images, as well as temporal analysis using free images from NASA and ESA since 1984 which facilitates the process of visual interpretation.

This tool combines the ease of use of such a simple and well-known software such as Google Earth, which is used for the data collection interface, with the power to handle Open Foris Collect surveys; as well as, the file and analysis capacity of Google Earth Engine and the very high-resolution images of Bing Maps.

[46] Ariel Lugo, Samuel Snedaker (1975). Properties of a mangrove forest in southern Florida. Proceedings of the International Symposium on the Biology and Management of Mangroves.

[47] Douglas Pool, Samuel Snedaker and Ariel Lugo (1977). Structure of mangrove forests in Florida, Puerto Rico, Mexico and Costa Rica. Biotropica.

[48] Samuel Snedaker and Jane Snedaker (1984). The Mangrove Ecosystem: Research Methods. UNESCO Monographs on Oceanographic Methodology.

Collect Earth uses a sample design predetermined by the survey administrator, as well as a form design (generated through Open Foris Collect) that will be shown when clicking on a plot that is displayed in Google Earth (figure 8).

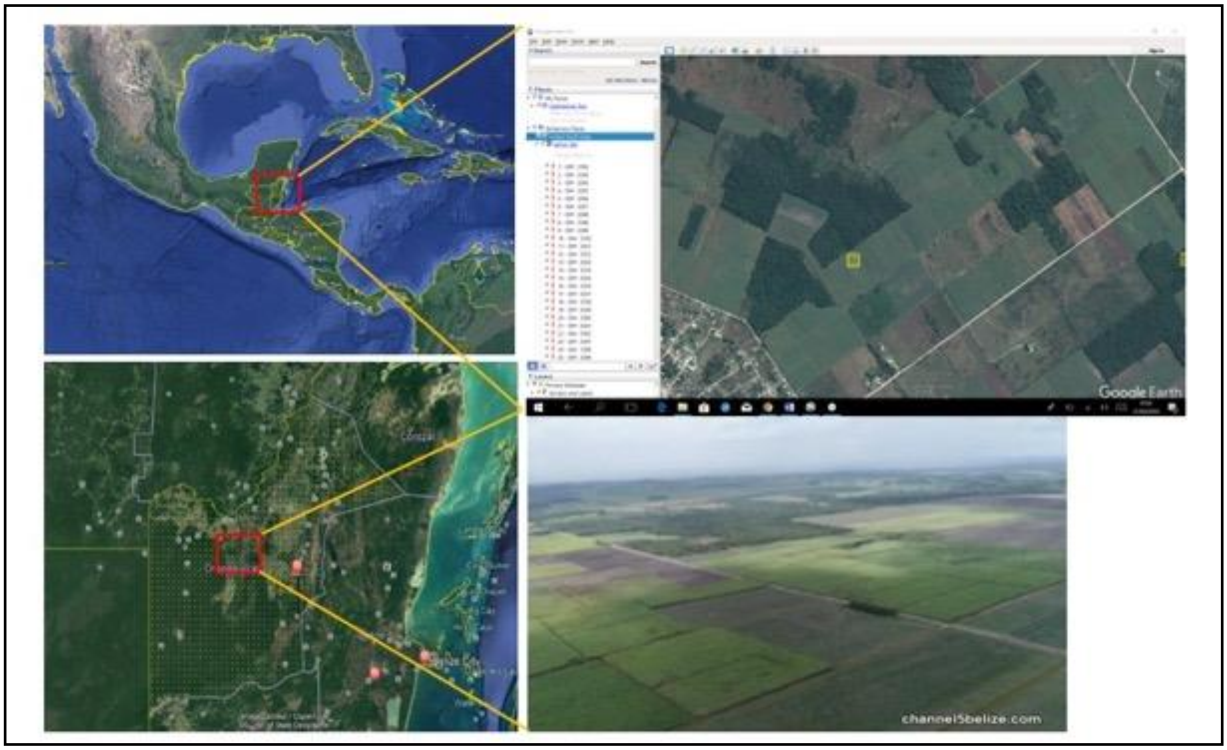

Figure 8. Example of collect earth visual interface on google earth.

Collect Earth is integrated with Bing Maps and Google Earth Engine, which means that when the form is displayed (clicking on the plot) a process is initiated that opens several windows showing that same plot in Bing Maps, which will sometimes have better very high-resolution images that Google Earth, as well as in Google Earth Engine Code Editor and Google Earth Engine Explorer. Through Google Earth Engine, access to all the historical archive of NASA (Landsat 5, 7 and 8 and MODIS) from 1984 to the present was made possible, as well as the ESA (Sentinel-2), which offers very high-quality image resolution (10 meters per pixel as opposed to 30 meters per pixel from Landsat) from 2014 every 16 days. Google Earth Engine not only enables imagery capabilities, but also analytical tools producing, for example, vegetation graphs or image composites to eliminate cloud cover (Figure 9).

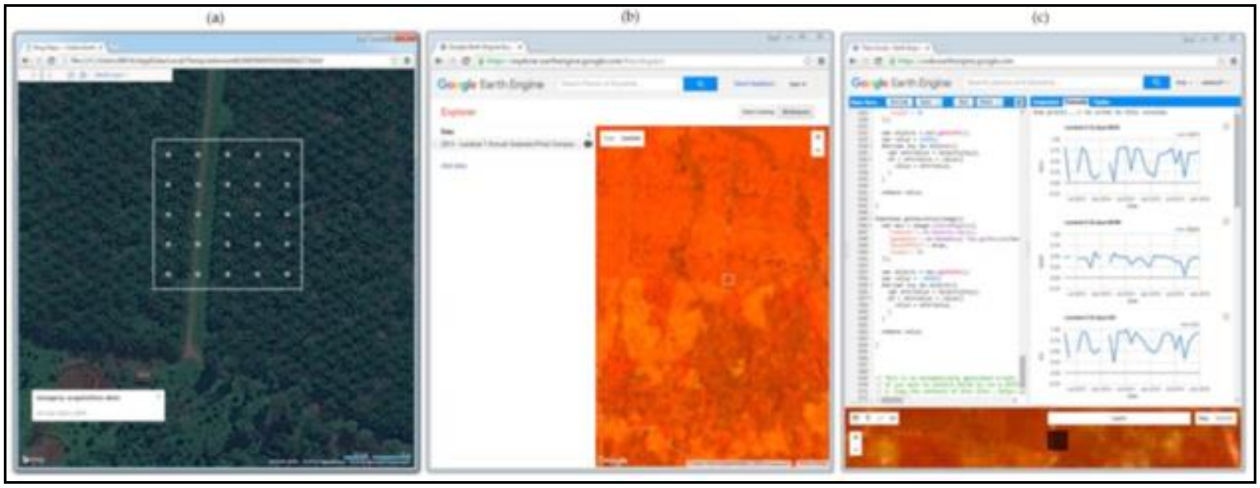

Figure 9. Example of collect earth integrated with Bing Maps & Google Earth Engine.

Collect plot size & distance

To define a grid for plots for Belize, it was necessary to establish the total land area of Belize. This was calculated with Arc Map using the country district shapefiles obtained from the Lands Information Center of Belize. The result of the geometric calculation was an area of 22,110 square kilometers. After a systematic selection done in Google Earth Engine, using the grid design parameters, a total of 21,991 plots were created (see CE Protocol). For Belize, a plot size of 0.5 hectares with 1 kilometer between plots was defined for the 2018 Mapathon. Half-a-hectare (0.5ha) plot was defined along the country definition of a forest for Belize (see section 'IPCC definition for the AFOLU sector'). Figure 1 illustrates how a plot was visualized in each of the platforms integrated with Collect Earth/Open Foris.

Figure 10. Showing 0.5 hectares plot size.

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Figure 11. Showing 1km distance between plots.

The distinctions of canopy cover through visual interpretation is intrinsically related to the understanding a national forest definition. Starting from the premise that plots of 0.5 ha undergo visual and through a visualization system (Google Earth) focusing on the changes in land use. This is part of a hierarchy level presented below, based on the interpretation of the plots for its category definition observed on satellite images.

Table 6. Hierarchy Level

Categories	% Minimum
Forest	➢ 30
Cropland	➢ 20
Grassland	➢ 20
Wetland	➢ 20
Settlement	➢ 20
Other Land	➢ 80

The starting point of this hierarchy is given by the definition of forest acquired by the country visualization of images within CE described below.

According to the classification of the matrix, if a plot seen under CE has 30% of its coverage under any of the forest classifications and its relationship to canopies classes, its land use is classified as "Forest". Similarly, a visual analysis of the parcel environment is made according to expert judgment and if what predominates is Other Land Uses that reflect or represent more than 70% of the image, it is assigned that specific Land Use that predominates.

Classification of land use in Collect Earth

For example, in the image of March 19, 2001, the Land Use is a mature forest but by September 8, 2001, it has been deforested, converting it to a new Land Use Change. On the image, it predominates under bare land; however, on June 18, 2003, it has some cultivation. When seen again on February 6, 2011, it is clearly appreciated that they are agricultural land. In this sense, it is classified as croplands (Figure 12).

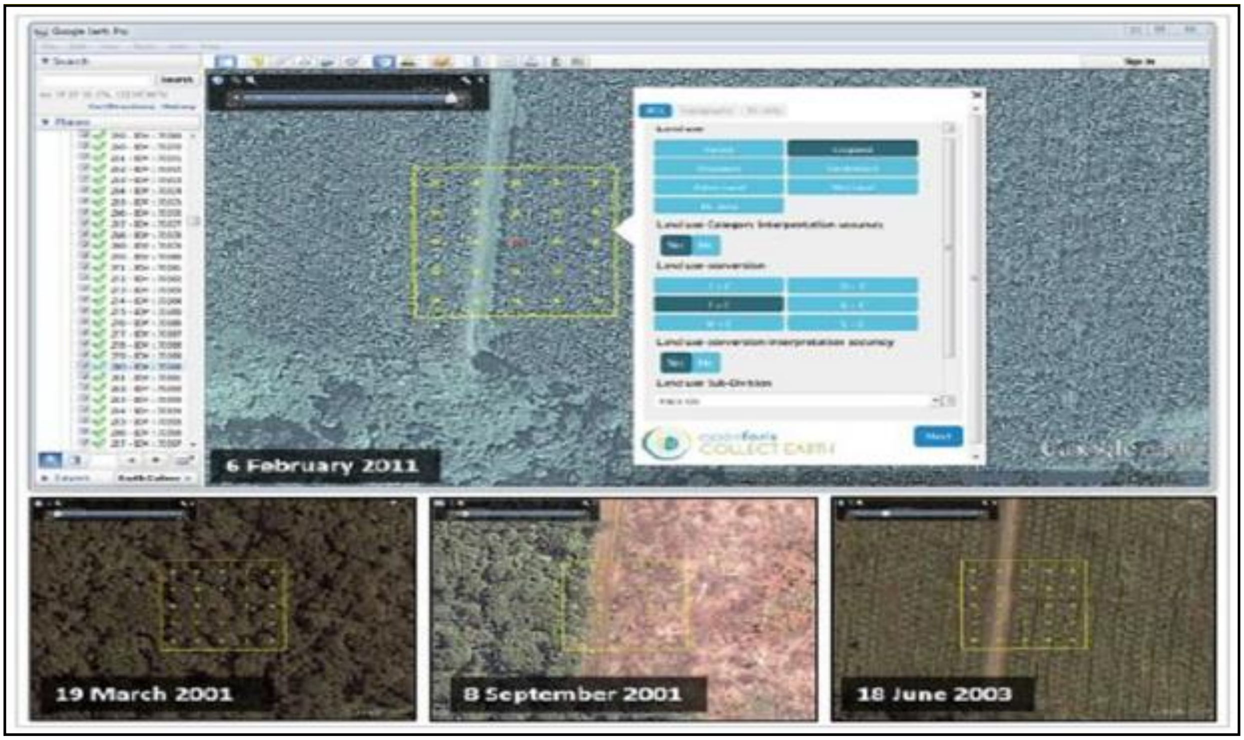

Figure 12. Example of how the CE image is analyzed to determine its classification of land use

This combination of several tools, as well as the power for the temporal analysis of Google Earth Engine, which among other things allows the visualization of graphs of vegetation indexes on the plots (figure 13). This facilitates the temporal analysis of land use change and determines definitions accordingly to the type of final Land Use that will be assigned to that plot.

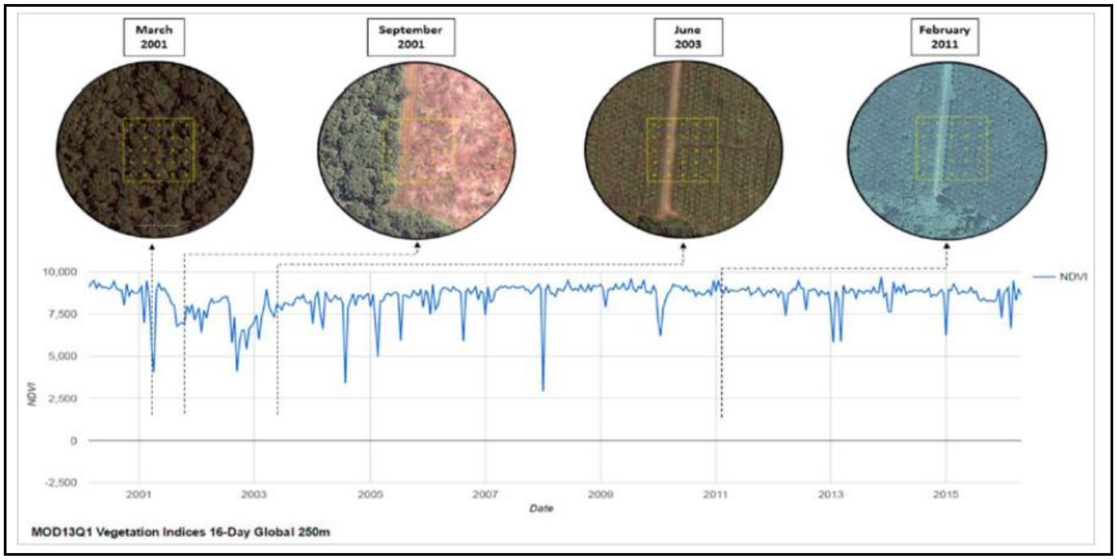

Figure 13. Example of temporal analysis tools to visualize land use change.

With this method it was possible to obtain annual data for time series of 2000-2017, and spatially explicit, since the position of each of the plots is known and therefore, auxiliary data -maps- can be used to stratify the information by districts, climatic zones, conservation areas, forest concessions, etc. For each plot, we know the land use for each year, the subdivision, the conversion class and year of conversion, topography, human impact type (disturbance levels 1, 2 and 3), elevation, slope, aspect, climate, soil class, district, community; protection organization, level and year, and ecosystem. This information allowed a very detailed annual analysis of the dynamics of land use.

More details about the methodological processes of the Collect Earth Assessment can be found in the document called " Belize Collect Earth/Open Foris Land Use and Land Use Change Assessment Protocol."[49]

4.4. Category-level data analysis methodologies

Biomass estimation

Broadleaf Mature Forest: For the study "Rapid carbon sequestration following hurricane disturbance in mature tropical forest: new insights and methods from Central America" by Cho et al. (2013), 304 trees of 48 species ranging in diameter from 10 to 223 cm were harvested in forests across Belize. An allometric model was designed to estimate stem AGB separately from crown AGB, thereby allowing for more sensitivity to stem and crown damage. It is a volume to biomass model, which is useful for both timber and

[49] Edgar Correa et. al (2019). Belize Collect Earth/Open Foris Land Use and Land Use Change Assessment Protocol.

biomass purposes, where the volume of the stem is converted to biomass by multiplying by wood density (Brown, 1997[50]; Chave et al., 2005[51]).

The approach was to first develop a stem volume equation to estimate the volume of the entire stem from the ground to the first major branch. Second, convert stem volume to biomass by multiplying by oven-dried wood density. Oven-dried wood density values were obtained from a local database of oven-dried wood densities for 42 tree species in Belize (Belize Forest Department, 1942[52]). For species not represented in this local database, mean values were obtained from the Global Wood Density Database (Chave *et al*., 2009a[53]; Chave *et al*., 2009b[54]) first by averaging at the species level within Central America, and second at the genus level. For genera not represented and for unidentified trees, the plot mean wood density based on a stem was calculated for the census in which the tree first appeared (Baker *et al*., 2004[55]). For these trees, the plot mean wood density was kept constant across censuses to avoid spurious changes in a tree's biomass. Third, develop an expansion factor to estimate crown biomass from stem biomass, for different crown forms according to the Dawkins crown classification system (Dawkins, 1958[56]).

The 304 sample trees were divided into two datasets. The first included 289 large trees from 33 to 223 cm DBH collected in Belize as part of a study of log volume carried out during the 1990s (Bird, 1998). The second included 15 small trees from 10 to 30 cm DBH which were destructively harvested in 2013 to estimate stem volume of smaller trees and to determine crown biomass ratios for different Dawkins crown form classes. The trees were collected within a logging concession along proposed skid trails. Approximately four trees were selected in each Dawkins crown form class from one to four to provide suitable averages. No trees were found which had crown form scores of five.

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[50] Brown, S.: Estimating biomass and biomass change of tropical forests: a Primer. FAO Forestry Paper 134, Food and Agricultural Organization of the United Nations, Rome, Italy, 55 pp., 1997.

[51] Chave, J., Andalo, C., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Folster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.P., Nelson, B.W., Ogawa, H., Puig, H., Riera, B. and Yamakura, T.: Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia, 145, 87-99,2005.

[52] Belize Forest Department: 42 secondary hardwoods of British Honduras. Bulletin No. 13, Belize Forest Department, Belize, 56 pp., 1942.

[53] Chave, J., Coomes, D., Jansen, S., Lewis, S.L., Swenson, N.G. and Zanne, A. E.: Towards a worldwide wood economics spectrum. Ecol. Lett., 12, 351–366, 2009a.

[54] Chave, J., Coomes, D. A., Jansen, S., Lewis, S. L., Swenson, N. G. and Zanne, A.E.: Data from: Towards a worldwide wood economics spectrum. Dryad Digital Repository, doi:10.5061/dryad.234, 2009b

[55] Baker, T. R., Phillips, O. L., Malhi, Y., Almeida, S., Arroyo, L., Di Fiore, A., Erwin, T., Higuchi, N., Killeen, T. J., Laurance, S. G., Laurance, W. F., Lewis, S. L., Monteagudo, A., Neill, D. A., Vargas, P. N., Pitman, N. C. A., Silva, J. N. M. and Martinez, R. V.: Increasing biomass in Amazonian forest plots. *Phil. Trans.: Biol. Sci*., 359, 353-365, 2004a

[56] Dawkins, H. C.: The management of natural tropical high forest with special reference to Uganda. *Institute Paper No. 34*. Oxford: Imperial Forestry Institute, University of Oxford, UK, 1958

Two stem volume equations were developed: one that included a term for stem height and another that did not.

$$AGB_T = \frac{\rho \times \exp\left(-9.480 + 0.975 \ln DBH^2 H_S\right)}{1 - \left(0.723 CFI - 0.091\right)}$$

where *AGBT* is total tree aboveground biomass in Mg, *ρ* is oven-dried wood density in g cm^{-3}, *DBH* is diameter at breast height in cm, *HS* is stem height in meters, and *CFI* is Dawkins crown form index (crown form / 5). The second equation without stem height was:

$$AGB_T = \frac{\rho \times \exp(-8.367 + 2.261 \ln DBH)}{1 - (0.723 CFI - 0.091)}$$

Uncertainty of the estimates was quantified due to model and measurement error following the methods outlined in Chave *et al.* (2004)[57].

The AGB of all live trees were summed at the stand level in each census and converted to live aboveground carbon (AGC) assuming 47% carbon (C) content [47.35 ± 2.51] (Martin & Thomas, 2011)[58].
To estimate net hurricane-related C flux, the approach used was to estimate total C removed by Hurricane Iris and subtract this from total C sequestered following the hurricane.

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[57] Chave, J., Condit, R., Aguilar, S., Hernandez, A., Lao, S. and Perez, R.: Error propagation and scaling for tropical forest biomass estimates. *Phil. Trans. R. Soc. Lond. B*, 03TB055D.1, doi: 10.1098/rstb.2003.1425, 2004.

[58] Martin, A. R. and Thomas, S. C.: A reassessment of carbon content in tropical trees. *Plos One,* 6, e23533, doi: 10.1371/journal.pone.0023533, 2011.

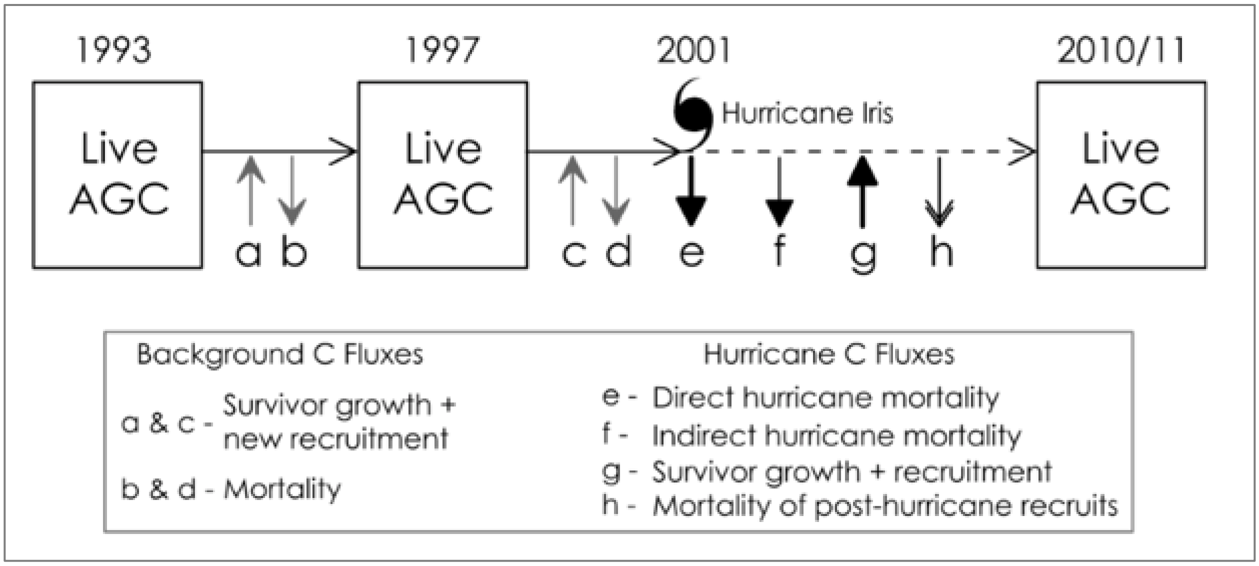

Figure 14. Sketch of forest dynamics over the study period from 1993 to 2010/2011.

Live aboveground carbon stocks (AGC) are represented by rectangles. Horizontal arrows represent changes in AGC between two censuses; dashed arrows represent change due to hurricane disturbance; solid arrows represent background change. Vertical grey arrows are background carbon fluxes that contribute to changes in stand AGC. Vertical black arrows are carbon fluxes caused directly or indirectly by the hurricane, that also contribute to changes in stand AGC.

Mangrove: Data from the plots and sub-plots by the Environmental Research Institute (ERI) of the University of Belize were used to estimate biomass. Biomass of the mangrove forest trees greater than 2.5 cm dbh was estimated by using trunk diameter and tree density (number of trees per unit area). Individual tree biomass was calculated using the dbh to weight conversion factor of (1) Golley et al. (1962):

Biomass (g) = dbh (cm) x 3,390

and (2) Cintron and Shaeffer Novelli (1984):

Biomass (g) = b[(dbh)2 (height)]m

where b and m are constants of 125.9571 and 0.8557, respectively. The total biomass of trees was calculated for the plots by summing individual tree measurements. Data are expressed as wet weight for the living biomass (kg/m2).

Pine:

Pine in Biomass was estimated using the equation:

(Log vol (m^3) = 2.4 Loge (dbh cm)-8.69)x 0.0625 (wd)

Where:
Vol: Volume (m3)
dbh: Diameter at Breast Height (cm)
wd: Wood Density (kg/m3)

This equation to calculate the biomass was applied only to Pine trees within the permanent sample plot and excluded broad-leaf species which are a minimal percentage of the total permanent sample plot.

4.5. Category-level methodologies for GHG emissions and absorptions estimations

Following paragraphs 10[59] and 21[60], annex to 17/CP.8, information on the specific category-level methodologies employed, including a description of the data and assumptions used to estimate GHG emissions and absorptions are provided in this section.

The Belize GHG inventory was conducted from a series of steps and using a range of data from diverse sources. The estimation of the emissions and removals used a combination of (a) country-specific methods and data, (b) IPCC methodologies, and (c) emission factors (EFs). The methods were consistent with the 2006 IPCC guidelines for national greenhouse gas inventories and are to the extent possible, in line with international practice. IPCC methodology tiers 1, 2 and 3 were applied.

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[59] Paragraph 10, annex to 17/CP.8, states that the IPCC Guidelines offer a default methodology which includes default emission factors and in some cases default activity data. As these default factors, data and assumptions may not always be appropriate for specific national circumstances, non-Annex I Parties are encouraged to use their country-specific and regional emission factors and activity data for key sources or, where these do not exist, to propose plans to develop them in a scientifically sound and consistent manner, provided that they are more accurate than the default data and documented transparently.

[60] According to paragraph 21, annex to 17/CP.8, Non-Annex I Parties are encouraged to provide information on methodologies used in the estimation of anthropogenic emissions by sources and removals by sinks of GHG not controlled by the Montreal Protocol, including a brief explanation of the sources of emission factors and activity data. If non-Annex I Parties estimate anthropogenic emissions and removals from country- specific sources and/or sinks which are not part of the IPCC Guidelines, they should explicitly describe the source and/or sink categories, methodologies, emission factors and activity data used in their estimation of emissions, as appropriate.

For the estimation of GHG emissions and removals for the Forest and Land Use Change Sector, Belize has followed the methodologies proposed in the 2006 IPCC guidelines, Volume 4, Chapter 2 "Generic Methodologies Applicable to Multiple Land-use Categories", for change in biomass carbon stocks (above-ground biomass and below-ground biomass) and Non-CO2 emissions. It includes the analysis for Land remaining in a land-use category and Land converted to a new land-use category.

All definitions, methods, and assumptions are described as follows:

4.6. Overview of carbon stock change estimation

Annual carbon stock changes for the entire AFOLU sector estimated as the sum of changes in all land-use categories

Annual Carbon Stock Changes for the entire AFOLU Sector estimated as the sum of changes in all land-use categories (Equation 2.1, Ch2, V4)

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

Where:
ΔC = carbon stock change

Indices denote the following land-use categories:
AFOLU = Agriculture, Forestry and Other Land Use
FL = Forest Land

- **CL =** Cropland
- **GL =** Grassland
- **WL =** Wetlands
- **SL =** Settlements
- **OL =** Other Land

Table 7. IPCC LU Categories and Sub-Category

BELIZE	
LU	Sub-Category
FL	Broad-leaf Mature Forest
	Broad-leaf Secondary Forest
	Pine Forest
	Mangroves
	Plantations
CL	Annual crops
	Perennial crops
	Fallow Lands
GL	Pastures/ Shrubland/ Ferns / Thickets/ Savannas
	Regenerating Shrubs & Bushes/ Pine
WL	Wetlands
SL	Settlements
OL	Other lands

Annual carbon stock changes for a land-use category as a sum of changes in each stratum within the category (Equation 2.2, Ch2, V4)

$$\Delta CLU = \sum_{i} \Delta C\ LUi$$

Where:

ΔC_{LU} = carbon stock changes for a land-use (LU) category as defined in Equation 2.1.

***i* =** denotes a specific stratum or subdivision within the land-use category (by any combination of species, climatic zone, ecotype, management regime, etc., see Chapter 3), *i* = 1 ton.

Annual carbon stock changes for a stratum of a land-use category as a sum of changes in all pools (Equation 2.3, Ch2, V4)

$$\Delta C_{LUi} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{Li} + \Delta C_{HWP}$$

Where:

ΔCLU_i = carbon stock changes for a stratum of a land-use category Subscripts denote the following carbon pools:

AB = above-ground biomass
BB = below-ground biomass
DW= deadwood
LI = litter
SO= soils
HWP = harvested wood products

Table 8. Carbon pools data sources

BELIZE			
	Included	Source	Notes
ΔC_{AB}	Yes	Cho et al, 2013	
ΔC_{BB}	Yes	IPCC 2006	
ΔC_{DOM}	No		No data available
ΔC_{SOC}	No		No data available
ΔC_{HWP}	No		No data available
ΔC_{AB}	Yes	Cho et al, 2013	
ΔC_{BB}	Yes	IPCC 2006	
ΔC_{DOM}	No		No data available
ΔC_{SOC}	No		No data available
ΔC_{HWP}	No		No data available

Clarification Notes:

The country does not have yet a National Forest Inventory. The only country-specific source available is Cho et al (2013), which was an inventory based on selective distribution, locating sampling plots in areas usually affected by hurricanes. This might or might not be representative of the dynamics of the whole country; thus, there is a possibility of bias in the estimations. The country is in the process of setting new permanent sampling plots, following the same methodology including strata that were not included in this research (such as dry forests).

Carbon in Dead Wood, Soils and Harvested Wood Products was not included due to lack of national statistics.

Annual carbon stock change in a given pool as a function of gains and losses (gain-loss method) (Equation 2.4, Ch2, V4)

$$\Delta C = \Delta C_G + \Delta C_L$$

Where:

ΔC = annual carbon stock change in the pool, tonnes C yr^{-1}

ΔC_G = annual gain of carbon, tonnes C yr^{-1}

ΔC_L = annual loss of carbon, tonnes C yr^{-1}

Change in biomass carbon stocks (above-ground biomass and below-ground biomass) inland remaining in a land-use category

Annual change in carbon stocks in biomass in land remaining in a particular land-use category (gain-loss method) (Equation 2.7, Ch2, V4)

$$\Delta C_B = \Delta C_G + \Delta C_L$$

Where:

ΔC_B = annual change in carbon stocks in biomass for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_G = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_L = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tonnes C yr^{-1}

Annual increase in biomass carbon stocks due to biomass increment in land remaining in the same land-use category (Equation 2.9, Ch2, V4)

$$\Delta C_G = \sum_{i,j} (A_{i,j} \bullet G_{TOTAL\ i,j} \bullet CF_{i,j})$$

Where:

ΔC_G= annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use category by vegetation type and climatic zone, tonnes C yr^{-1}

A = area of land remaining in the same land-use category, ha

G_{TOTAL}= mean annual biomass growth, tonnes d. m. ha^{-1} yr^{-1}

i = ecological zone (i = 1 to n)

j = climate domain (j = 1 to m)

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

Table 9. Sources of IPCC Categories and Sub- Categories

A: area of land remaining in the same land-use category			
LU	Sub-Category	Source	Notes
FL	Broad-leaf Mature Forest	Collect Earth	Years 2000 – 2015
	Broad-leaf Secondary Forest	Collect Earth	Years 2000 – 2015
	Pine Forest	Collect Earth	Years 2000 – 2015
	Mangroves	Collect Earth	Years 2000 – 2015
	Plantations	Collect Earth	Years 2000 – 2015
CL	Annual crops	Collect Earth	Years 2000 – 2015
	Perennial crops	Collect Earth	Years 2000 – 2015
	Fallow Lands	Collect Earth	Years 2000 – 2015
GL	Pastures/ Shrubland/ Ferns / Thickets/ Savannas	Collect Earth	Years 2000 – 2015
	Regenerating Shrubs & Bushes / Mountain Pine Ridge	Collect Earth	Years 2000 – 2015
WL	Wetlands	Collect Earth	Years 2000 – 2015
SL	Settlements	Collect Earth	Years 2000 – 2015
OL	Other lands	Collect Earth	Years 2000 – 2015

Table 10. IPCC Categories & Sub-Category Carbon Fraction Values & Sources

CF: Carbon Fraction				
LU	Sub-Category	Value	Range / Error	Source
FL	Broad-leaf Mature Forest	0.47	SD ± 2.51%	Martin & Thomas, 2011
	Broad-leaf Secondary Forest	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
	Pine Forest	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
	Mangroves	0.451	(0.422-0.502)	2013 Wetland Supplement, Table 4.2.
	Plantations	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
CL	Annual crops	-	-	-
	Perennial crops	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
	Fallow Lands	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
GL	Pastures/ Shrubland/ Ferns / Thickets/ Savannas	-	-	-
	Regenerating Shrubs & Bushes/ Pine	0.47	(0.44 - 0.49)	IPCC 2006, V4, Ch4, Table 4.3.Tropical / all
WL	Wetlands	-	-	-
SL	Settlements	-	-	-
OL	Other lands	-	-	-

Clarification Notes:

Martin & Thomas (2011) indicated that carbon fraction was taken from a total of 190 wood samples from 59 native tree species across 46 genera, 26 families, and 12 orders sampled at the Soberania National Park (SNP), a lowland tropical moist forest located in central Panama. This was the value selected as the most representative for Belize in Cho et al (2013) study. [61]

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Table 11. IPCC Categories & Sub-Categories AGB & BGB Values and Sources

R: AGB : BGB Ratio				
LU	Sub-Category	Value	Range / Error	Source
FL	Broad-leaf Mature Forest	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
	Broad-leaf Secondary Forest	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
	Pine Forest	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
	Mangroves	0.49	95% CI: 0.47, 0.51	2013 Wetland Supplement, Table 4.5. Tropical Wet
	Plantations	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
CL	Annual crops	-	-	-
	Perennial crops	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
	Fallow Lands	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
GL	Pastures/ Shrubland/ Ferns / Thickets/ Savannas	-	-	-
	Regenerating Shrubs & Bushes/ Pine	0.37		2006 IPCC, V4, Ch 4. Table 4.4. Tropical rainforest
WL	Wetlands	-	-	-
SL	Settlements	-	-	-
OL	Other lands	-	-	-

Clarification Notes:

IPCC 2006 Default values are used as to date; no country-specific research has been carried out.

Average annual increment in biomass (Equation 2.10, Ch2, V4)

$$G_{TOTAL} = \sum_{i,j} \{ G_W \bullet (1 + R) \}$$

Where:

G_{TOTAL} = average annual biomass growth above and below-ground, tonnes d. m. ha^{-1} yr^{-1}

G_W = average annual above-ground biomass growth for a specific woody vegetation type, tonnes d. m. ha^{-1} yr^{-1}

R = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$.

Table 12. IPCC Categories & Sub-Categories average annual above-ground biomass growth, tonnes, values & Sources.

GW = average annual above-ground biomass growth, tonnes d. m. ha-1 yr-1					
LU	Sub-Category	Value	Range / Error	Notes	Source
FL	Broad-leaf Mature Forest	3.18		PSPs 1, 2, 3, 4, 5, 6, 7 and 23	Cho *et al.*, 2013
	Affected by Fire	4.34		Estimated	
	Affected by Hurricane	6.81		PSPs BZ-2, BZ-3, BZ-4, BZ-27, BZ-28, BZ-29 and BZ-30	Cho *et al.*, 2013
	Affected by Grazing	2.70		Estimated	
	Affected by Logging	2.98		Plots BZ-13 and BZ-19	Cho *et al.*, 2013
	Affected by Infrastructure	3.20		Estimated	
	Affected by Shifting Cultivation	2.54		Estimated	
	Affected by Other Human Impact	2.70		Estimated	
	Broad-leaf Secondary Forest	9.00		Expert Judgment	
	Affected by Fire	9.40		Estimated	
	Affected by Hurricane	9.00		Estimated	

	Affected by Grazing	7.65		Estimated	
	Affected by Logging	9.00		Estimated	
	Affected by Infrastructure	8.55		Estimated	
	Affected by Shifting Cultivation	7.20		Estimated	
	Affected by Other Human Impact	7.65		Estimated	
	Pine Forest	0.18		Mountain Pine Ridge Forest Reserve (BZ-456). The plot has been logged and has also been affected by ground fire	
	Affected by Fire	0.18		Mountain Pine Ridge Forest Reserve (BZ-46)	
	Affected by Hurricane	0.18		Estimated	
	Affected by Logging	0.18		Mountain Pine Ridge Forest Reserve (BZ-46)	
	Affected by Pest	0.16		Estimated	
	Affected by Other Human Impact	0.16		Estimated	
	Mangroves	9.90	95% CI: 9.4, 10.4		2013 Wetland Supplement, Table 4.4.
	Affected by Fire	9.90		Estimated	
	Affected by Hurricane	9.90		Estimated	
	Affected by Logging	9.90		Estimated	
	Affected by Infrastructure	9.41		Estimated	
	Affected by Other Human Impact	9.41		Estimated	
	Plantations	15			2006 IPCC V4, Ch4, Table 4.10 Americas Tectona grandis
CL	Annual crops	-	-	-	-
	Perennial crops	5		Expert Judgment	
	Fallow Lands	11		Validated by expert judgment	2006 IPCC V4, Ch4, Table 4.9 South America (>20 y)

GL	Pastures/ Shrubland/ Ferns / Thickets/ savanna	-	-	-	-
	Regenerating Shrubs and Bushes/ Pine	11		Validated by expert judgment	2006 IPCC V4, Ch4, Table 4.9 South America (>20 y)
WL	Wetlands	-	-	-	-
SL	Settlements	-	-	-	-
OL	Other lands	-	-	-	-

Clarification Notes:

Broad-leaf Mature Forest (undisturbed)

Cho et al 2013 presented the findings on the changes to live aboveground forest carbon in mature intact forest, sampling 2812 trees in 7 Permanent Sampling Plots, each one hectare in size (100 m by 100 m):

Table 13. Broad-leaf Mature Forest AGB Changes & AGC Changes

Plot	AGB Change t.d.m ha^{-1} yr^{-1}	AGC Change Mg C ha^{-1} yr^{-1}	Initial year	last year
1	-5.30	-2.49	1992	1993
2	5.45	2.56	1993	1997
3	4.79	2.25	1993	1997
4	5.03	2.36	1993	1997
5	4.28	2.01	1993	1997
6	4.43	2.08	1993	2010
23	3.57	1.68	1995	2011
Mean	3.18	1.49		
Min	-5.30	-2.49		
Max	5.45	2.56		
SD	3.79	1.78		

Broad-leaf Mature Forest - Hurricane disturbance

Seven hurricane-affected permanent plots were included in Cho et al 2013 study: BZ-2, BZ-3, BZ-4, BZ-27, BZ-28, BZ-29 and BZ-30; each one hectare in size (100 m by 100 m). Censuses took place before and after the hurricane. BZ-2, BZ-3 and BZ-4 were censused in March 1993 and four years later in February 1997. BZ-27, BZ-28, BZ-29, and BZ-30 were censused in 1997 only. All the plots were censused again approximately ten years after Hurricane Iris: BZ-2 in June 2010, BZ-3 and BZ-4 in May 2011, and BZ-27, BZ-28, BZ-29 and BZ-30 between March and May 2011.

Since the hurricane, carbon was sequestered in fresh growth of survivors and new recruits at a mean rate of 3.2 (±0.3) Mg C ha^{-1} yr-1 (6.81 t.d.m ha^{-1} yr^{-1}) (Cho et al 2013, Table 4.5), more than twice the net annual rate of increase observed in the seven study plots between 1992 and 2011. Most of the new carbon sequestered, 2.4 (±0.2) Mg C ha^{-1} yr^{-1} or about 74%, was in recruits. The other 26% or 0.8 (±0.2) Mg C ha^{-1} yr^{-1} was in fresh mass put on by survivors.

Table 14. Annualized carbon sequestration rate for hurricane disturbed MBL

Plot	Annualized carbon sequestration rate (Mg C ha^{-1} yr^{-1})
BZ-2	4.0
BZ-3	3.5
BZ-4	4.0
BZ-27	2.0
BZ-28	2.7
BZ-29	3.8
BZ-30	2.6
Mean	3.2
S.E.M	0.3

Broad-leaf Mature Forest - Logging disturbance

Based on Che et al 2013, change in carbon stocks is 2.98 Mg C ha^{-1} yr^{-1} obtained from Plots BZ-13 and BZ-19. The growth spurt for these forests would be faster directly after logging; however, when the canopy closes then it reverts to a slower growth rate. Usually, the fastest, best-growing trees are normally logged; once removed, the trees left growing, grow at a slower rate, so 2.98 seems reasonable.

Broad-leaf Mature Forest - Fire disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Fires. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.8 and Fraction loss in 0.2, expecting re-growth of secondary forest; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.8] + [11 t.d.m ha^{-1} yr^{-1} • 0.2] = 4.74 t.d.m ha^{-1} yr^{-1}. Because of fire there is a complete renewal of the forest, the growth rate of Regenerating Grassland was chosen, until it reaches some stability after 10 years, when it will be most likely considered again a secondary forest, encompassing the Forest Definition.

Broad-leaf Mature Forest - Grazing disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Grazing. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.85] + [0 t.d.m ha^{-1} yr^{-1} • 0.15] = 2.70 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Mature Forest - Other Human Impact disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Other Human Impact. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.85]+ [0 t.d.m ha^{-1} yr^{-1} • 0.15] = 2.70 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Mature Forest - Shifting Cultivation disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Shifting Cultivation. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.95]+ [0 t.d.m ha^{-1} yr^{-1} • 0.05] = 2.54 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Mature Forest - Infrastructure disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Infrastructure. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.95]+ [0 t.d.m ha^{-1} yr^{-1} • 0.05] = 3.02 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Mature Forest - Mining

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Mining. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [3.18 t.d.m ha^{-1} yr^{-1} • 0.85] + [0 t.d.m ha^{-1} yr^{-1} • 0.15] = 2.70 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest

For secondary broadleaf forests, the growth rate is 9.0 t.d.m ha^{-1} yr^{-1} as decided upon by expert judgment. Standard values cannot be used like other regions because disturbances in Belize play a key factor in the forest dynamics. Forests in Belize have a mix of old mature trees beside very young trees. 9.0 t.d.m ha^{-1} yr^{-1} as a growth rate was chosen because it is not as fast as other secondary forests (the countries studied for the IPCC guidelines have better soils) but faster than hurricane forests, which there is a calculated value based on national data from the permanent sample plots. In about 30 years it is expected that the secondary forest would be able to be classified as a mature forest. *Note for calculations:* After 13 years, when the stock of the Mature Forest is reached, the growth of Mature forest is assigned, assuming a lower growth rate due to forest stability. This assumption was applied using 2000 as year zero.

Broad-leaf Secondary Forest - Fire disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Fires. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.8 and Fraction loss in 0.2, expecting re-growth of secondary forest; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.8] + [11 t.d.m ha^{-1} yr^{-1} • 0.2] = 9.35 t.d.m ha^{-1} yr^{-1}. Because of fire, there is a complete renewal of the forest, the growth rate of Regenerating Grassland was chosen, until it reaches some stability after 10 years, when it will be most likely considered again a secondary forest, encompassing the Forest Definition.

Broad-leaf Secondary Forest - Grazing disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Grazing. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.85] + [0 t.d.m ha^{-1} yr^{-1} • 0.15] = 7.65 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest - Hurricane disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Hurricane. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting re-growth of secondary forest; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.85] + [9 t.d.m ha^{-1} yr^{-1} • 0.15] = 9 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest - Logging disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Logging. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.80 and Fraction loss in 0.20, expecting re-growth of secondary forest; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.8] + [9 t.d.m ha^{-1} yr^{-1} • 0.2] = 9 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest - Other Human Impact disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Other Human Impact. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.85 and Fraction loss in 0.15, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.85] + [0 t.d.m ha^{-1} yr^{-1} • 0.15] = 7.65 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest - Shifting Cultivation disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Shifting Cultivation. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.80 and Fraction loss in 0.20, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.8] + [0 t.d.m ha^{-1} yr^{-1} • 0.2] = 7.20 t.d.m ha^{-1} yr^{-1}.

Broad-leaf Secondary Forest - Infrastructure disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Infrastructure. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [9 t.d.m ha^{-1} yr^{-1} • 0.95] + [0 t.d.m ha^{-1} yr^{-1} • 0.05] = 8.55 t.d.m ha^{-1} yr^{-1}.

Pine Forest

The growth data obtained for Pine Forest in Belize is based on data collected from one plot located in the Mountain Pine Ridge Forest Reserve (BZ-456). The 2017 and 2018 censuses were used for calculation purposes. The growth rate for the plot was 0.083 Mg C ha^{-1} yr^{-1} (0.18 t.d.m ha^{-1} yr^{-1}).

Pine Forest - Fire disturbance

The Mountain Pine Ridge Forest Reserve (BZ-46) plot has been logged and has also been affected by ground fire. It is located within Pine forest, upland in well-drained soils. The growth rate for the plot was 0.18 t.d.m ha^{-1} yr^{-1}.

Pine Forest - Hurricane disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Hurricanes. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.60 and Fraction loss in 0.40, expecting re-growth of secondary pine forest; therefore, the Gw is estimated as: [0.18 t.d.m ha^{-1} yr^{-1} • 0.60] + [0.18 t.d.m ha^{-1} yr^{-1} • 0.40] = 0.18 t.d.m ha^{-1} yr^{-1}.

Pine Forest - Logging disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Logging. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.65 and Fraction loss in 0.35, expecting re-growth of secondary pine forest; therefore, the Gw is estimated as: [0.18 t.d.m ha^{-1} yr^{-1} • 0.65] + [0.18 t.d.m ha^{-1} yr^{-1} • 0.35] = 0.18 t.d.m ha^{-1} yr^{-1}.

Pine Forest - Pest disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Pest. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.90 and Fraction loss in 0.10, expecting re-growth of secondary pine forest; therefore, the Gw is estimated as: [0.18 t.d.m ha^{-1} yr^{-1} • 0.90] + [0.18 t.d.m ha^{-1} yr^{-1} • 0.10] = 0.16 t.d.m ha^{-1} yr^{-1}.

Pine Forest – Other Human Impact disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Other Human Impact. Based on the Collect Earth Assessment and posterior discussions, it was defined that the average Fraction Remaining is 0.90 and Fraction loss in 0.10, expecting re-growth of secondary pine forest; therefore, the Gw is estimated as: [0.18 t.d.m ha^{-1} yr^{-1} • 0.90] + [0.18 t.d.m ha^{-1} yr^{-1} • 0.10] = 0.16 t.d.m ha^{-1} yr^{-1}.

Mangrove Forest

Mangrove Forest - Fire disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Fires. Based on the Collect Earth Assessment and posterior discussions, it was defined that the Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting re-growth of secondary mangrove forest; therefore, the Gw is estimated as: [9.90 t.d.m ha^{-1} yr^{-1} • 0.8] + [9.90 t.d.m ha^{-1} yr^{-1} • 0.2] = 9.90 t.d.m ha^{-1} yr^{-1}.

Mangrove Forest - Hurricane disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Hurricanes. Based on the Collect Earth Assessment and posterior discussions, it was defined that the Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting re-growth of secondary mangrove forest; therefore, the Gw is estimated as: [9.90 t.d.m ha^{-1} yr^{-1} • 0.95] + [9.90 t.d.m ha^{-1} yr^{-1} • 0.05] = 9.90 t.d.m ha^{-1} yr^{-1}.

Mangrove Forest - Logging disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Logging. Based on the Collect Earth Assessment and posterior discussions, it was defined that the Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting re-growth of secondary mangrove forest; therefore, the Gw is estimated as: [9.90 t.d.m ha^{-1} yr^{-1} • 0.95] + [9.90 t.d.m ha^{-1} yr^{-1} • 0.05] = 9.41 t.d.m ha^{-1} yr^{-1}.

Mangrove Forest - Infrastructure disturbance

It is estimated by a weighted average between the fraction of biomass remaining and the fraction loss due to Infrastructure. Based on the Collect Earth Assessment and posterior discussions, it was defined that the Fraction Remaining is 0.95 and Fraction loss in 0.05, expecting no re-growth post-disturbance; therefore, the Gw is estimated as: [9.90 t.d.m ha^{-1} yr^{-1} • 0.95] + [0 t.d.m ha^{-1} yr^{-1} • 0.05] = 9.41 t.d.m ha^{-1} yr^{-1}.

Forest Plantations

The IPCC 2006 Default values for Teak plantations are used. Based on expert judgment, Teak plantations constitute majority of the plantations in Belize. It is important to note that the default growth values might be overestimating the actual growth because Teak Plantations do not grow as favorably as it would in natural areas due to the climatic conditions in Belize; however, there are no national studies to confirm the assumption.

Fallow lands

As previously defined, the fallow land is a new young forest coming from croplands that does not reach the forest definition yet and that, based on expert judgment, has faster growth than a more stable secondary forest. This sort of stability is considered to be reached after about 10 years when the young forest meets the National Forest definition. *Note for calculations:* After 10 years, when the stock of the Secondary Forest is reached, the growth of Secondary forest is assigned, assuming all aspects of the forest definition are also met.

Regenerating Shrubs and Bushes / Mountain Pine Ridge

As previously defined, the regenerating shrubs and bushes is a new young forest coming from lands that suffered a disturbance, such as fire, or coming from abounded pastureland. These lands are in a recovery stage and do not meet the forest definition yet. Based on expert judgment, these regenerating grasslands have faster growth than a more stable secondary forest. This sort of stability is considered to be reached after about 10 years when the young forest will most likely meet the National Forest definition. *Note for calculations:* After 10 years, when the stock of the Secondary Forest is reached, the growth of Secondary forest is assigned, assuming all aspects of the forest definition are also met.

8.1.1 Annual decrease in carbon stocks due to biomass losses in land remaining in the same land-use category (Equation 2.11, Ch2, V4)

$$\Delta C_L = \Delta L_{wood\text{-}removals} + \Delta L_{fuelwood} + \Delta L_{disturbance}$$

Where:

ΔC_L = annual decrease in carbon stocks due to biomass loss in land remaining in the same land-use category, tonnes C yr^{-1}

$L_{wood\text{-}removals}$ = annual carbon loss due to wood removals, tonnes C yr^{-1} (See Equation 2.12)

$L_{fuelwood}$ = annual biomass carbon loss due to fuelwood removals, tonnes C yr^{-1} (See Equation 2.13)

$L_{disturbance}$ = annual biomass carbon losses due to disturbances, tonnes C yr^{-1} (See Equation 2.14)

8.1.2 Annual carbon loss in biomass of wood removals (Equation 2.12, Ch2, V4)

$$L_{wood\text{-}removals} = \{ H \bullet BCEF_R \bullet (1+R) \bullet CF \}$$

Where:

$L_{wood\text{-}removals}$ = annual carbon loss due to biomass removals, tonnes C yr^{-1}

H = annual wood removals, roundwood, m^3 yr^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if assuming no changes of below-ground biomass allocation patterns (Tier 1).

CF = carbon fraction of dry matter, tonne C (tonnes.m.)$^{-1}$

$BCEF_R$ = biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark), tonnes biomass removal (m^3 of removals)$^{-1}$

Table 15. Annual carbon loss in biomass of wood removals

H = annual wood removals, roundwood, tonnes C yr-1			
LU	Sub-Category	Sources	Notes
FL	Broad-leaf Mature Forest	NA	IE
	Broad-leaf Secondary Forest	NA	IE
	Pine Forest	NA	IE
	Mangroves	NA	IE
	Plantations	NA	IE

Clarification Notes:

Losses due to logging are accounted as disturbance; therefore, indicated as Included Elsewhere (IE), because exact volume extraction is not nationally recorded. Through the Collect Earth Assessment, it was clearly identified the fraction of cover loss due to wood extraction. Therefore, the fraction loss was used as the variable "fd" in equation 2.14, and losses of annual wood removals (roundwood), were implicitly calculated in the section of Forest land Remaining Forest Lands and Other lands converted to Forest Lands.

8.1.3 Annual carbon loss in biomass of fuelwood removal (Equation 2.13, Ch2, V4)

$$L_{fuelwood} = [\{ FG_{trees} \bullet BCEF_R \bullet (1+R) \} + FG_{part} \bullet D] \bullet CF$$

Where:

$L_{fuelwood}$ = annual carbon loss due to fuelwood removals, tonnes C yr^{-1}

FG_{trees} = annual volume of fuelwood removal of whole trees, m^3 yr^{-1}

FG_{part} = annual volume of fuelwood removal as tree parts, m^3 yr^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$

CF = carbon fraction of dry matter, tonne C (tonned.m.)$^{-1}$

D = basic wood density, tonnes d.m. m^{-3}

$BCEF_R$ = biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark), tonnes biomass removal (m^3 of removals)$^{-1}$

Table 16. Annual carbon loss in biomass of fuelwood removal

FG_{trees} = annual volume of fuelwood removal of whole trees			
LU	Sub-Category	Source	Notes
FL	Broad-leaf Mature Forest	NA	IE
	Broad-leaf Secondary Forest	NA	IE
	Pine Forest	NA	IE
	Mangroves	NA	IE
	Plantations	NA	IE
FG_{part} = annual volume of fuelwood removal as tree parts			
LU	Sub-Category	Sources	Notes
FL	Broad-leaf Mature Forest	NA	NE
	Broad-leaf Secondary Forest	NA	NE
	Pine Forest	NA	NE
	Mangroves	NA	NE
	Plantations	NA	NE

Clarification Notes:

Losses due to logging are accounted as disturbance; therefore, indicated as Included Elsewhere (IE), because exact volume extraction is not nationally recorded. Through the Collect Earth Assessment, it was clearly identified the fraction of cover loss due to wood extraction. Therefore, the fraction loss was used as the variable “fd” in equation 2.14, and losses of the annual volume of fuelwood removal were implicitly calculated in the section of Forest land Remaining Forest Lands and Other lands converted to Forest Lands.

8.1.4 Annual carbon losses in biomass due to disturbances (Equation 2.14, Ch2, V4)

$$L_{disturbance} = A_{disturbance} \bullet B_W \bullet (1+R) \bullet CF \bullet fd$$

Where:

$L_{disturbances}$ = annual other losses of carbon, tonnes C yr^{-1}

$A_{disturbance}$ = area affected by disturbances, ha yr^{-1}

B_W = average above-ground biomass of land areas affected by disturbances, tonnes d.m. ha^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$.

CF = carbon fraction of dry matter, tonne C (tonnesd.m.)$^{-1}$

fd = fraction of biomass lost in disturbance

Table 17. Annual above-ground biomass of land areas affected by disturbances

B_W = average above-ground biomass of land areas affected by disturbances					
LU	Sub-Category	Value	Range / Error	Notes	Source
FL	Broad-leaf Mature Forest	267.4		Calculated from the database - All 30 plots	Cho et at 2013
	Broad-leaf Secondary Forest	120		Expert Judgment	
	Pine Forest	210.70101.28		Mountain Pine Ridge Forest Reserve (BZ-5446)	
	Mangroves	80.55		Five study sites at Turneffe Atoll	Environmental Research Institute (ERI) of the University of Belize
	Plantations	120		Expert Judgment	
CL	Annual crops	-			
	Perennial crops	25		Expert Judgment – 5 Years old	
	Fallow Lands	55		Expert Judgment – 5 Years old	
GL	Pastures/ Shrubland/ Ferns / Thickets/ savanna	-	-	-	-
	Regenerating Shrubs & Bushes/ Pine	55		Expert Judgment – 5 Years old	
WL	Wetlands	-	-	-	-
SL	Settlements	-	-	-	-
OL	Other lands	-	-	-	-

Clarification Notes:

Broad-leaf Mature Forest – Hurricane Affected

Cho et al (2013) indicated that after severe hurricane disturbance in mature wet tropical forests in southern Belize, and using a tree biomass-estimation equation specifically developed to account for tree damage, they found that live aboveground carbon stocks in trees ≥10 cm DBH are 41% lower than the mature forest, falling from 127 (±7) Mg C ha^{-1} to 75 (±5) Mg C ha^{-1}, across the seven study plots (Cho et al 2013, Table 4.1). This is within the range of values reported for mature Amazonian forest plots (Baker et al., 2004a) and old-growth Nicaraguan rainforests (Mascaro et al., 2005), but slightly lower than values reported for intact old-growth central African forests (Kearsley et al., 2013). Large palms accounted for about 4% (±1) of stand AGC, on average.

Table 18. Summary of Table 4.1 from Cho et al (2013)

Plot	AGB (t.d.m ha^{-1})	AGC (Mg C ha^{-1})	Census Year
BZ - 2	189.4	89	1997 - 2010
BZ - 3	170.2	80	1997 - 2011
BZ - 4	155.3	73	1997 - 2011
BZ - 27	108.5	51	1997 - 2011
BZ - 28	125.5	59	1997 - 2011
BZ - 29	180.9	85	1997 - 2011
BZ - 30	180.9	85	1997 - 2011
Mean		75	
± S.E.M		5	

Broad-leaf Mature Forest – Logging Affected

For this figure, the stocks were measured immediately after logging. It is important to that from 2006, at least 4000 acres of forests are logged, based on data from the long-term forest licenses in Forest Reserves in Belize These could not be seen by Collect Earth, so there is possible underestimation. Plots 29 & 30 logged in 1997 are old-growth forests. For logged plots 11, 13 and 19 the carbon stock after logging is 254. 67 t.d.m ha^{-1}. These plots were measured in 1994 and logged in 1997.

Pine Forest

Biomass was calculated by the sum of all Pine Caribbean trees sampled in the 25-sub plots in 2018 by the Forest Department.

Mangrove: 2014-2017 Turneffe mangrove data

The biomass was estimated by the average of the annual measurements in 2014, 2015, 2016 and 2016 for the plots located in Northeast Turneffe, Northwest Turneffe, West Turneffe, Conservation Zone V. Calabash plot does now include the measurements of 2017.

Table: 19. Mangrove Data for Turneffe

Site Name	t.d.m / Ha	Mg C/ Ha
Northwest	23.6	10.6
Northeast	90.8	40.9
West	73.3	33.1
Zone V	89.9	40.6
Calabash	125.2	56.5
Mean	80.55	36.33
Min	23.6	10.6
Max	125.2	56.5
SD	37.02	16.69

Table 20. The fraction of biomass lost in disturbance for the Land Use Categories

fd = fraction of biomass lost in disturbance			
LU	Sub-Category	Fraction of biomass loss	Notes
FL	Broad-leaf Mature Forest		Collect Earth Assessment and Expert validation
	Affected by Fire	0.20	
	Affected by Grazing	0.15	
	Affected by Hurricane	0.40	
	Affected by Logging	0.20	
	Affected by Other Human Impact	0.15	
	Affected by Shifting Cultivation	0.20	
	Affected by Infrastructure	0.05	
	Affected by Mining	0.15	
	Broad-leaf Secondary Forest		
	Affected by Fire	0.20	
	Affected by Grazing	0.15	
	Affected by Hurricane	0.40	
	Affected by Logging	0.20	

	Affected by Other Human Impact	0.15	
	Affected by Shifting Cultivation	0.20	
	Affected by Infrastructure	0.05	
	Pine Forest		
	Affected by Fire	0.35	
	Affected by Hurricane	0.40	
	Affected by Logging	0.35	
	Affected by Other Human Impact	0.10	
	Affected by Pest	0.10	
	Mangroves		
	Affected by Fire	0.05	
	Affected by Hurricane	0.40	
	Affected by Logging	0.05	
	Affected by Other Human Impact	0.05	
	Affected by Infrastructure	0.05	

Annual change in biomass carbon stocks on land converted to other land-use category (tier 2) (Equation 2.15, Ch2, V4)

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Where:

ΔC_B= annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G= annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L = annual decrease in biomass carbon stocks due to losses from harvesting, fuelwood gathering and disturbances on land converted to other land-use category, in tonnes C yr^{-1}

Annual increase in carbon stocks in biomass, ΔCG (Equation 2.9, Ch2, V4)

The annual increase in carbon stocks in biomass due to land converted to another land-use category was estimated using Equation 2.9 as described above for lands remaining in a category. These estimations include all possible conversion among the 6 IPCC categories.

Table 21. All possible conversions among the 6 IPCC categories

A: area of land remaining converted to a land-use category			
LU	Sub-Category	Source	Notes
FL>No-FL	Forest Lands > Non-Forest Lands	Collect Earth	Years 2000 – 2015
CL> No-CL	Croplands to > Non-Croplands	Collect Earth	Years 2000 – 2015
GL>No-GL	Grasslands > Non-Grasslands	Collect Earth	Years 2000 – 2015
WL>No-WL	Wetlands > non-Wetlands	Collect Earth	Years 2000 – 2015
SL>No-SL	Settlements > Non-Settlements	Collect Earth	Years 2000 – 2015
OL>No-OL	Other lands > Non-Other lands	Collect Earth	Years 2000 – 2015

Initial change in biomass carbon stocks on land converted to another land category (Equation 2.16, Ch2, V4)

$$\Delta C_{CONVERSION} = \sum_{i} \{ (B_{AFTER} - B_{BEFORE}) \bullet \Delta A_{TO\_OTHERS} \} \bullet CF$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTER_i} = biomass stocks on land type *i* immediately after the conversion, tonnes d.m. ha^{-1} B_{BEFORE_i} = biomass stocks on land type *i* before the conversion, tonnes d.m. ha^{-1}

$\Delta A_{TO\_OTHERS_i}$ = area of land use *i* converted to another land-use category in a certain year, ha yr^{-1}

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$

***i* =** type of land use converted to another land-use category

Change in biomass carbon stocks on land converted to another land category was estimated using the values of Area, Biomass and Carbon Fraction as described above for lands remaining in a category.

Annual decrease in carbon stocks in biomass due to losses, ΔCL (Equation 2.11-2.14, Ch2, V4)

The annual decrease in C stocks in biomass due to losses on converted land (wood removals or fellings, fuelwood collection, and disturbances) was estimated using Equations 2.11 to 2.14, as described above for lands remaining in a category.

4.7. Non- CO2 Emissions

This section provides information for estimating carbon stock changes and non-CO2 emissions resulting from fires in the Forest Land (including those resulting from forest conversion) and non-CO2 emissions in the Grasslands. Emissions in croplands were not estimated.

EQUATION 2.27 Estimation of Greenhouse Gas Emissions from Fire

$L_{fire} = A \bullet MB \bullet C_f \bullet G_{ef} \bullet 10^{-3}$

Where:

Lfire = amount of greenhouse gas emissions from fire, tonnes of each GHG (CH_4, N_2O).

A = area burnt, ha

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

Cf = combustion factor, dimensionless

Gef = emission factor, g kg^{-1} dry matter burnt

Table 22. Estimation of Greenhouse Gas Emissions from Fire

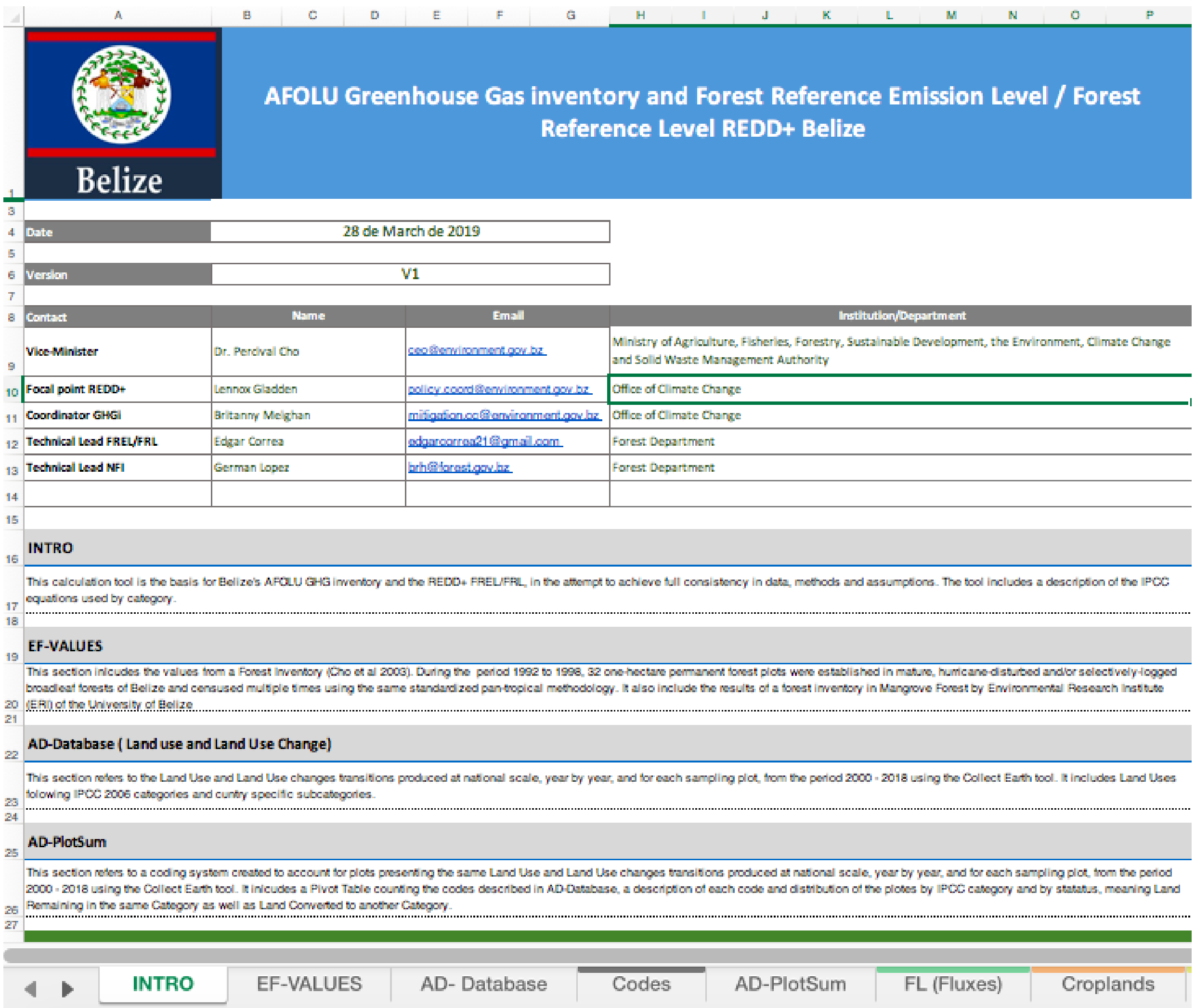
		*MB * Cf*	*Gef CH4*	*Gef N2O*
LU	Sub-Category	Mass of fuel available for combustion * Combustion factor	Emission factor- CH4	Emission factor- N2O
		tonnes ha^{-1}	g kg-1 dry matter burnt	g kg-1 dry matter burnt
FL	Broad-leaf Mature Forest	53.40	6.80	0.20
	Broad-leaf Secondary Forest	24.00	6.80	0.20
	Pine Forest	35.45	6.80	0.20
	Mangroves	3.95	6.80	0.20
	Plantations	NO	NO	NO
GL	Pastures/ Shrublands/ Savannah/ Thickets/ Ferns	-	-	-
	Regenerating Shrubs & Bushes/ Pine	55.00	2.30	0.21

Clarification Notes:

- *MB* Cf* was calculated as Biomass (Bw) multiplied by the Fraction of Disturbance due to fires (Fd)
- Emission factors for CH4 and N2O were taken from 2006 IPCC, V4, Ch2, Table 2.

4.8. DESCRIPTION OF CALCULATION TOOL

- *INTRO*: This sheet provides the overall information such as country contacts, explanation of pools and gases included, and description of the information included in each sheet.



Belize

AFOLU Greenhouse Gas inventory and Forest Reference Emission Level / Forest Reference Level REDD+ Belize

Date	28 de March de 2019
Version	V1

Contact	Name	Email	Institution/Department
Vice-Minister	Dr. Percival Cho	ceo@environment.gov.bz	Ministry of Agriculture, Fisheries, Forestry, Sustainable Development, the Environment, Climate Change and Solid Waste Management Authority
Focal point REDD+	Lennox Gladden	policy.coord@environment.gov.bz	Office of Climate Change
Coordinator GHGi	Britanny Meighan	mitigation.cc@environment.gov.bz	Office of Climate Change
Technical Lead FREL/FRL	Edgar Correa	edgarcorrea21@gmail.com	Forest Department
Technical Lead NFI	German Lopez	brh@forest.gov.bz	Forest Department

INTRO

This calculation tool is the basis for Belize's AFOLU GHG inventory and the REDD+ FREL/FRL, in the attempt to achieve full consistency in data, methods and assumptions. The tool includes a description of the IPCC equations used by category.

EF-VALUES

This section inicudes the values from a Forest Inventory (Cho et al 2003). During the period 1992 to 1998, 32 one-hectare permanent forest plots were established in mature, hurricane-distubed and/or selectively-logged broadleaf forests of Belize and censused multiple times using the same standardized pan-tropical methodology. It also include the results of a forest inventory in Mangrove Forest by Environmental Research Institute (ERI) of the University of Belize

AD-Database (Land use and Land Use Change)

This section refers to the Land Use and Land Use changes transitions produced at national scale, year by year, and for each sampling plot, from the period 2000 - 2018 using the Collect Earth tool. It includes Land Uses folowing IPCC 2006 categories and cuntry specific subcategories.

AD-PlotSum

This section refers to a coding system created to account for plots presenting the same Land Use and Land Use changes transitions produced at national scale, year by year, and for each sampling plot, from the period 2000 - 2018 using the Collect Earth tool. It inicudes a Pivot Table counting the codes described in AD-Database, a description of each code and distribution of the plotes by IPCC category and by statatus, meaning Land Remaining in the same Category as well as Land Converted to another Category.

INTRO | EF-VALUES | AD- Database | Codes | AD-PlotSum | FL (Fluxes) | Croplands

Figure 15. Example of Introduction sheet in the GHGI Tool of Belize

- *EF-VALUES*: This section aims at gathering all the information required to proceed with the calculations indicated in IPCC 2019/2006 guidelines, Volume 4, Chapter 2 (Generic methodologies applicable to multiple land- use categories) and specific variables for Chapters 4 (Forest lands), Ch 5 (Croplands), Ch 6 (Grasslands), Ch 7 (Wetlands) / 2013 IPCC Wetlands Supplement. Information was country-specific when available, or default values from the IPCC or scientific papers. Formulas, data sources and assumptions were indicated. Clarification notes when required were also included.

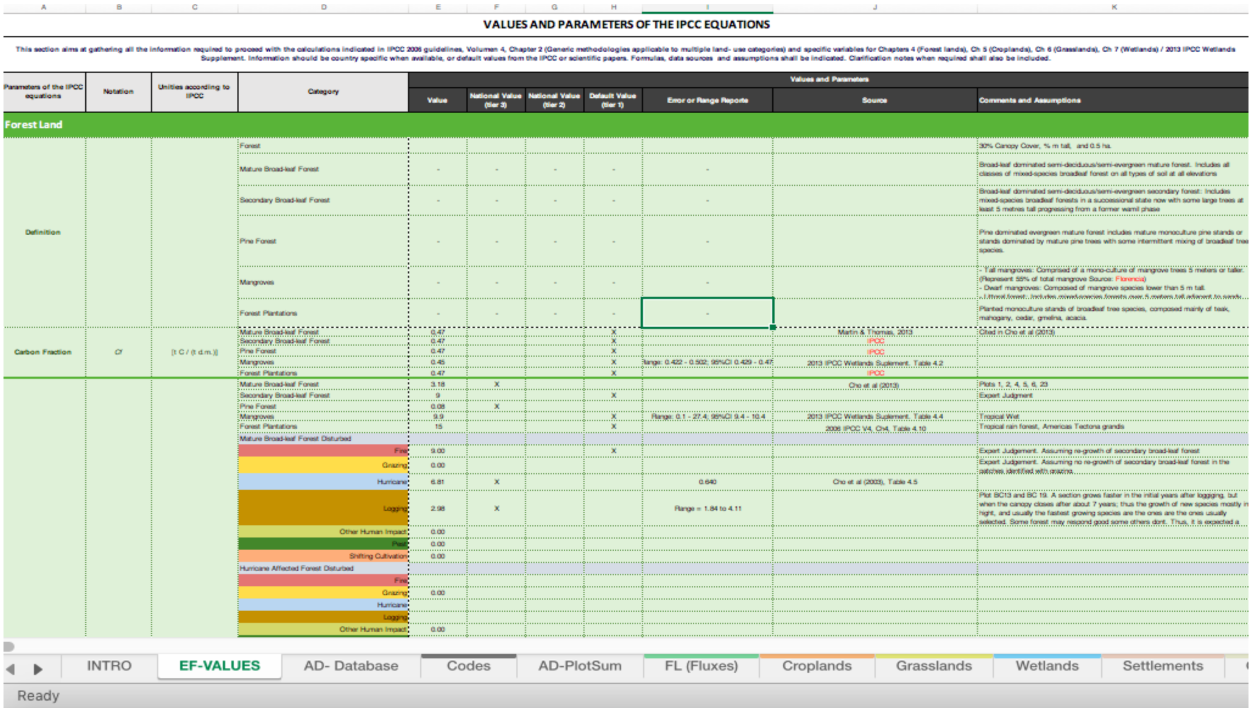


Figure 16. Example of EF- Values Sheet in the GHGI Tool of Belize

- *AD-Database:* This section refers to an extraction of the Total Collect Earth Assessment Database, which only includes ID for all plots, District, Land Use per year, Year of Land Use Change, Primary Disturbance and Year of Primary Disturbance. The main database can be requested from the Belize Forest Department.

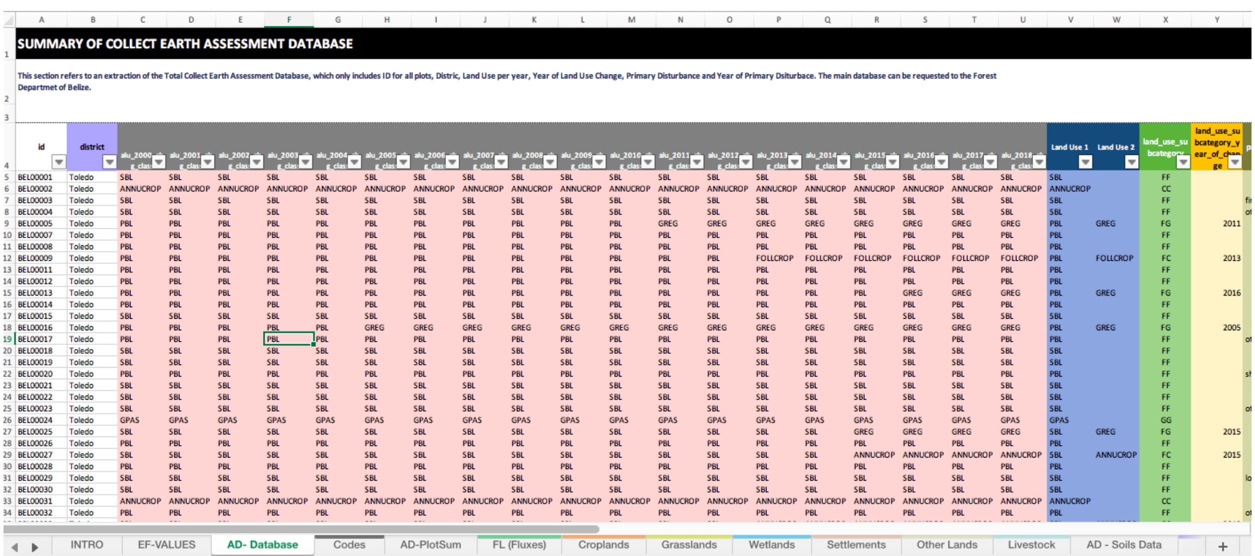


Figure 17. Example of AD-Database Sheet in the GHGI Tool of Belize

- *AD-PlotSum:* This section refers to a coding system created to account for plots presenting the same Land Use and Land Use changes transitions produced at the national scale, year by year, and for each sampling plot, from the period 2000 - 2018 using the Collect Earth tool. It includes a Pivot Table counting the codes described in AD-Database, a description of each code and distribution of the plots by IPCC category and by status, meaning Land Remaining in the same Category as well as Land Converted to another Category.

- *Forest Lands:* This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 4 (Forest Lands). It includes:

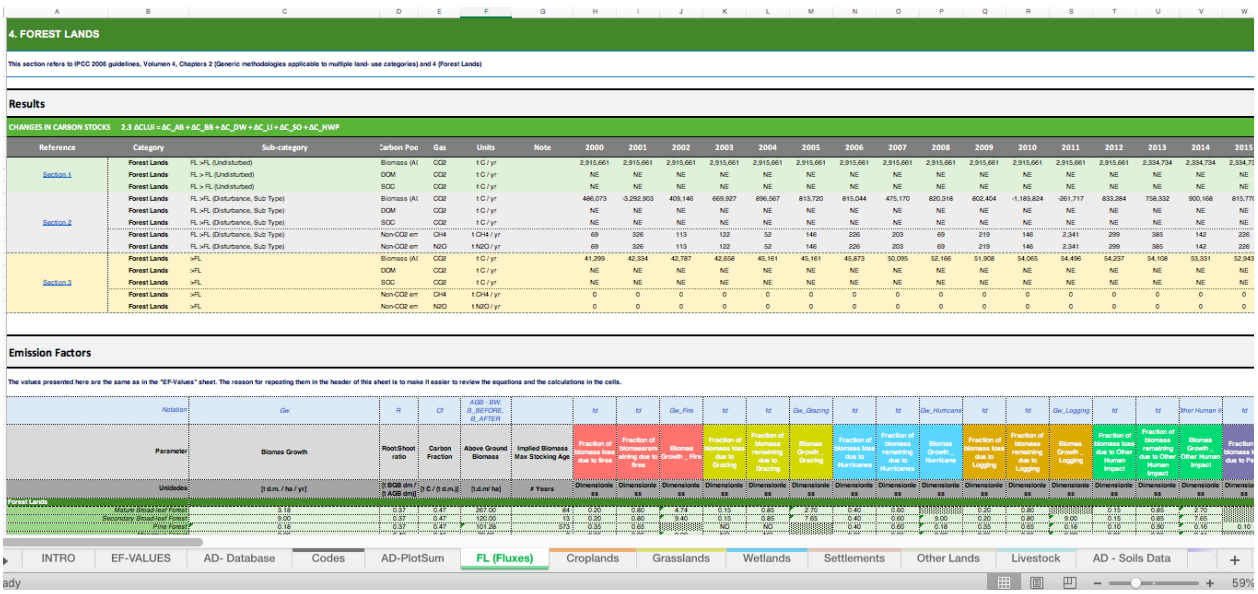


Figure 18. Example of Forest Land Sheet in the GHGI Tool for Belize

  - *Section of Results:* Describes all CO_2 emissions and removals as well as Non-CO_2 emissions (CH_4 and N_2O) from Forest Lands remaining Forest Lands and Other Lands converted to Forest lands.

  - *Section of Emission Factors:* The values presented here are the same as in the "EF-Values" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

  - *Section of Activity Data*: The values presented here are the same as in the "AD-Plot Sum" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

  - *Section 1:* Forest Land Remaining Forest Land: This section estimates Annual change in carbon stocks in 1) Forest land remaining Forest land, For section 1, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG]and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14]. Emissions of Non-CO_2 gases are also calculated related to areas burnt (IPCC 2006, V4, Ch2, Eq 2.27 CH_4, N_2O; CO_2 is not calculated to avoid double accounting). DOM, Litter, and SOC are not included due to a lack of information.

- *Section 2:* This section relates to Forest Land Remaining Forest Land affected by disturbances such as hurricanes, fires, logging, and others. This section also includes the conversion of land from a Forest land class to another Forest land class (e.g. Primary Broadleaf to Regenerating Forests). For section 2, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG]and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14] and the change in carbon stocks in biomass on Forest lands converted to another Forest Type,[ΔConversion] (IPCC 2006, V4, Ch2, Eq 2.15, 2.16). Emissions of Non-CO2 gases are also calculated related to areas burnt [IPCC 2006, V4, Ch2, Eq 2.27 CH4,N2O; CO2 is not calculated to avoid double accounting). DOM, Litter and SOC, and HWP are not included due to a lack of information.

- *Section 3:* Non-Forest Land converted Forest Land: This section estimates Annual change in carbon stocks in Non-Forest Land converted to Forest Land. Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG] and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) and losses due to conversion [ΔConversion] [IPCC 2006, V4, Ch2, Eq 2.9, 2.10, 2.15, 2.16]. Emissions of Non-CO2 gases are also calculated related to areas burnt [IPCC 2006, V4, Ch2, Eq 2.27 CH4, N2O; CO2 is not calculated to avoid double accounting). DOM, Litter, and SOC are not included due to a lack of information.

  For conversion of Grassland or Annual Crop to Secondary Forest, it was assumed -based on expert judgment and the Collect Earth assessment- that transition first occurs where Grasslands convert to Regenerating Grassland and Annual Crops convert to Follow Crops. For the estimation of the carbon stock changes, once one of these conversions was identified, a growth rate was adjusted to show these in-between transitions by reflecting an approximate growth rate for 10 years prior to the conversion.

Croplands: This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 5 (Croplands). It includes:

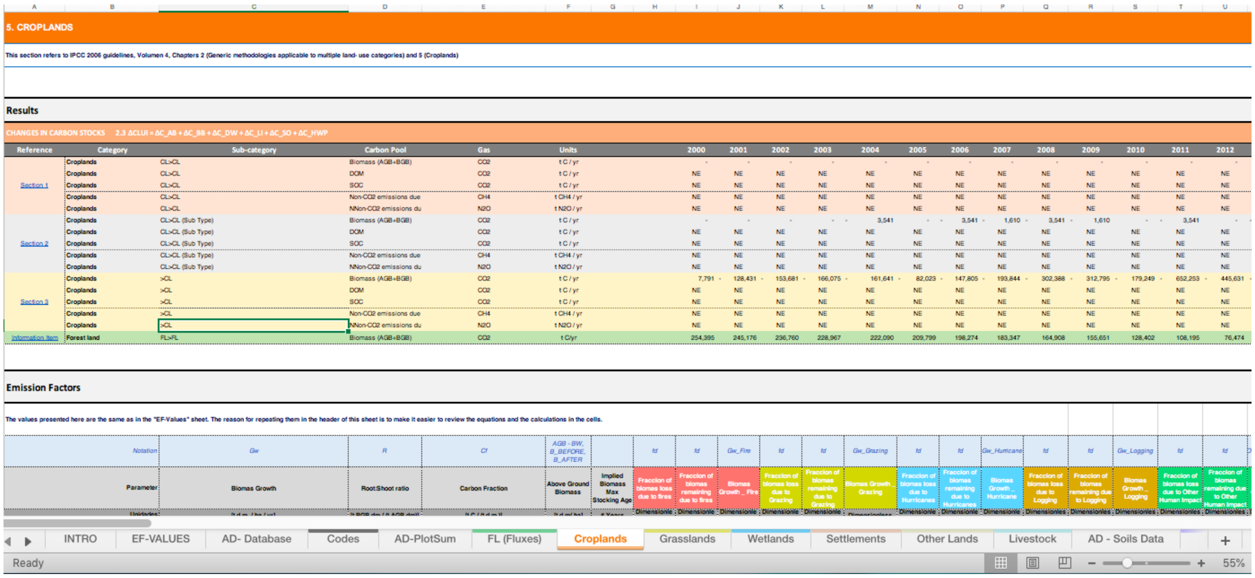


Figure 19. Example of Cropland Sheet in the GHGI Tool for Belize

- *Section of Results:* Describes all CO_2 emissions and removals as well as Non-CO_2 emissions (CH_4 and N_2O) from Croplands remaining Croplands and Other Lands converted to Croplands.

- *Section of Emission Factors:* The values presented here are the same as in the "EF-Values" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section of Activity Data:* The values presented here are the same as in the "AD-Plot Sum" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section 1:* Cropland Remaining Cropland: This section estimates Annual change in carbon stocks in 1) Cropland Remaining Cropland. For section 1, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG]and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14]. Emissions of Non-CO2 gases are also calculated related to areas burnt [IPCC 2006, V4, Ch2, Eq 2.27 CH4, N2O; CO2 is not calculated to avoid double accounting). DOM, Litter and SOC are not included due to a lack of information. This section considers that croplands are stable; therefore, no growth or losses are accounted for.

- *Section 2*: Cropland Remaining Cropland, with changes among cropland categories. For section 2, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG]and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14]. Emissions of Non-CO2, DOM, Litter, and SOC are not included due to a lack of information.

- *Section 3:* Non-Cropland converted to Cropland: This section estimates Annual change in carbon stocks in Non-Cropland converted Cropland. Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG] and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) and losses due to conversion [ΔConversion] [IPCC 2006, V4, Ch2, Eq 2.9, 2.10, 2.15, 2.16]. Emissions of Non-CO2 emissions, DOM, Litter, and SOC are not included due to a lack of information

Grasslands: This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 6 (Grasslands). It includes:

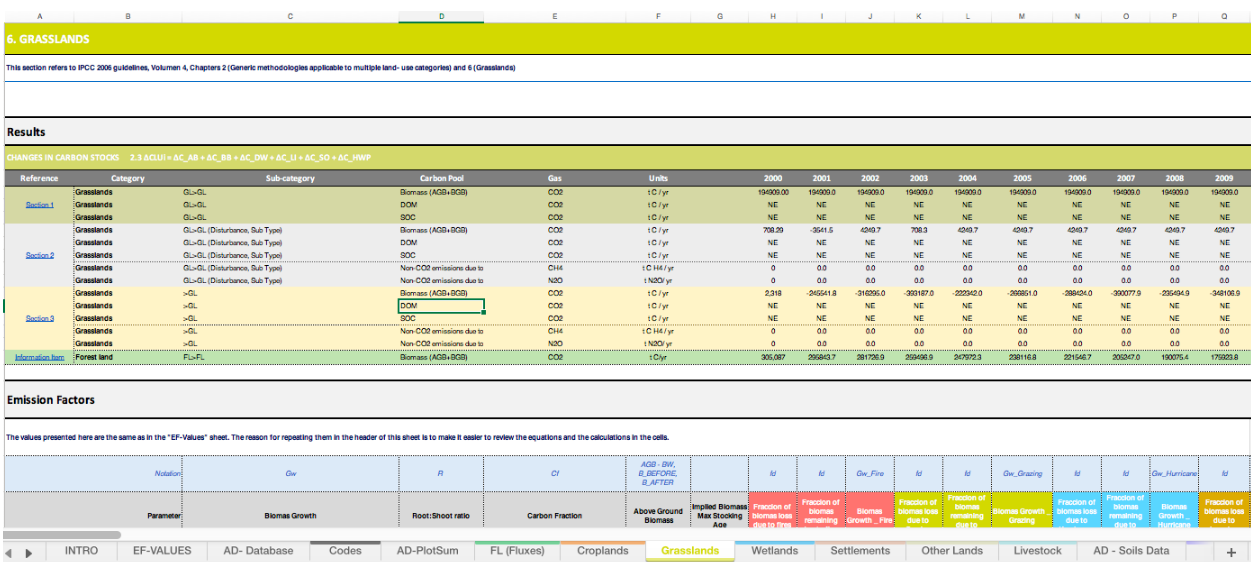


Figure 20. Example of Grassland Sheet in the GHGI Tool of Belize

- *Section of Results:* Describes all CO_2 emissions and removals as well as Non-CO_2 emissions (CH_4 and N_2O) from Grasslands remaining Grasslands and Other Lands converted to Grasslands.

- *Section of Emission Factors:* The values presented here are the same as in the "EF-Values" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section of Activity Data:* The values presented here are the same as in the "AD-Plot Sum" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section 1:* Grassland Remaining Grassland: This section estimates Annual change in carbon stocks in 1) Grassland Remaining Grassland. For section 1, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG] and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14]. Emissions of Non-CO2 gases are also calculated related to areas burnt [IPCC 2006, V4, Ch2, Eq 2.27 CH4, N2O; CO2 is not calculated to avoid double accounting). DOM, Litter, and SOC are not included due to a lack of information.

- *Section 2:* Grassland Remaining Grassland, with changes among cropland categories. For section 2, Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG]and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) [IPCC 2006, V4, Ch2, Eq 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14]. Emissions of Non-CO2, DOM, Litter, and SOC are not included due to a lack of information.

- *Section 3:* Non-Grassland converted to Grassland: This section estimates Annual change in carbon stocks in Non-Grassland converted to Grassland. Annual change in carbon stocks [ΔCB] is calculated by the difference of Gains [ΔCG] and Loses [ΔCL] (removal of fuelwood, roundwood and disturbances) and losses due to conversion [ΔConversion] [IPCC 2006, V4, Ch2, Eq 2.9, 2.10, 2.15, 2.16]. Emissions of Non-CO2 emissions, DOM, Litter, and SOC are not included due to a lack of information.

- *Wetlands:* This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 7 (Wetlands). It includes:

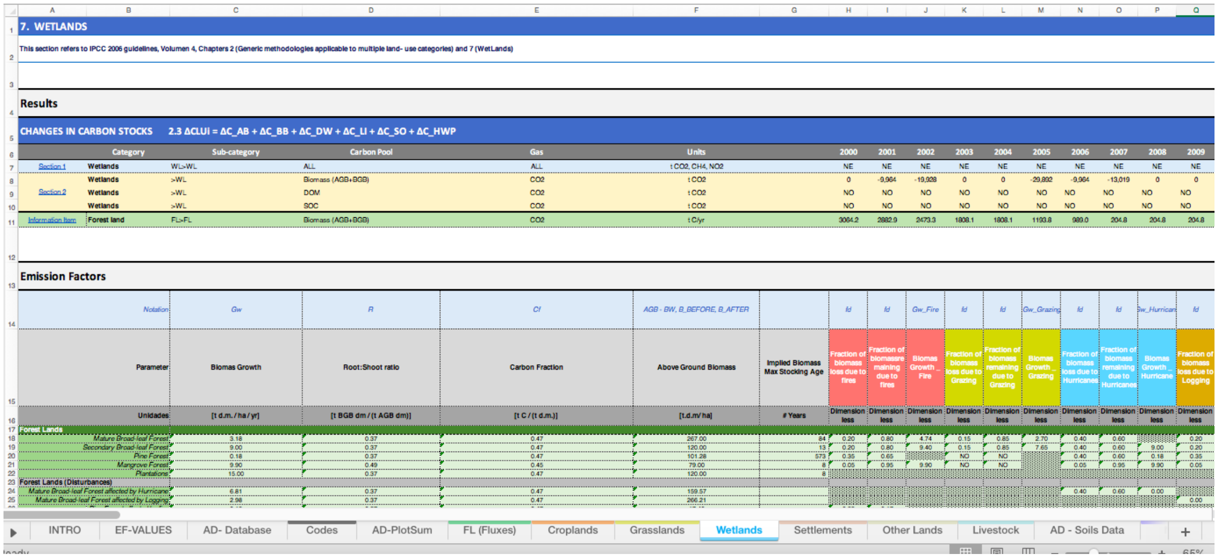


Figure 21. Example of Wetland Sheet in the GHGI Tool of Belize

- *Section of Results:* Describes all CO_2 emissions and removals as well as Non-CO_2 emissions (CH_4 and N_2O) from Wetlands remaining Wetlands and Other Lands converted to Wetlands.

- *Section of Emission Factors:* The values presented here are the same as in the "EF-Values" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section of Activity Data:* The values presented here are the same as in the "AD-Plot Sum" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section 1:* Wetlands remaining Wetlands: This section estimates GHG emissions and removals from wetlands remaining wetlands, specifically CO2 and Non-CO2 emissions from Peatlands Remaining Peatlands. However, due to no available data, this section was not estimated.

- *Section 2:* Other lands converted to Wetlands: this section refers to CO2 emissions on lands being converted for peat extraction, Non-CO2 emissions from lands being converted to managed peatlands, CO2 emissions from Land Converted to Flooded Land and Annual change in carbon stocks [ΔCB] calculated by the difference of Gains [ΔCG] and Loses [ΔCL] and carbon stock changes losses due to conversion [ΔConversion]. Emissions of Non-CO2 emissions, DOM, Litter, and SOC are not included due to a lack of information.

- *Settlements:* This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 8 (Settlements). It includes:

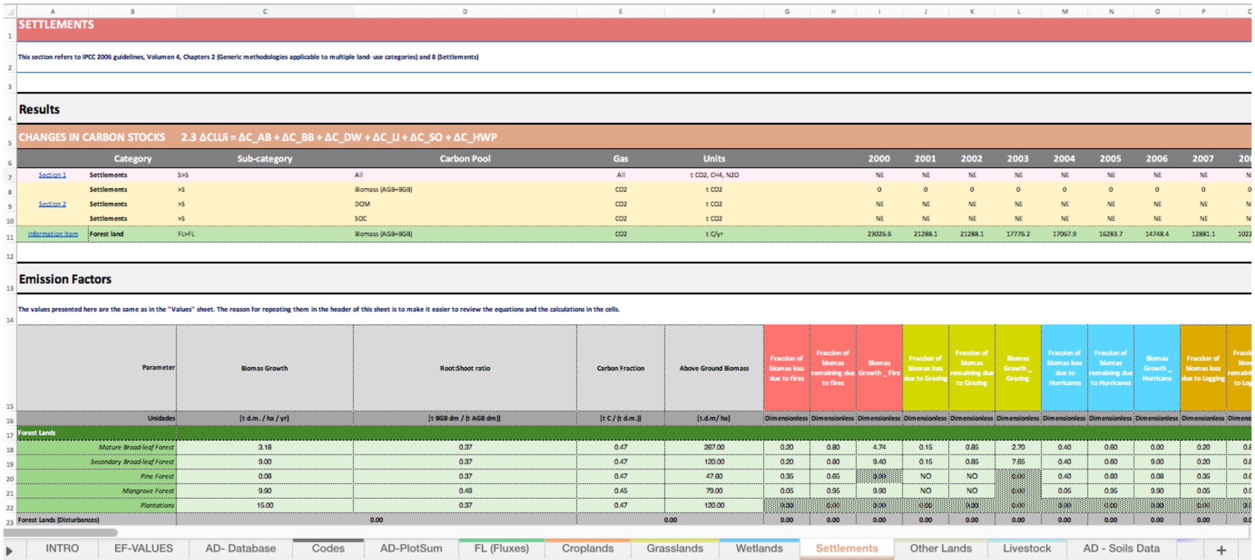


Figure 22. Example of Settlement Sheet in the GHGI Tool of Belize

- *Section of Results:* Describes all CO_2 emissions and removals as well as Non-CO_2 emissions (CH_4 and N_2O) from Settlements remaining Settlements and Other Lands converted to Settlements.

- *Section of Emission Factors:* The values presented here are the same as in the "EF-Values" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section of Activity Data:* The values presented here are the same as in the "AD-Plot Sum" sheet. The reason for repeating them in the header of this sheet is to make it easier to review the equations and the calculations in the cells.

- *Section 1:* Settlements remaining Settlements: this section includes the general method for biomass carbon stock change in Settlements Remaining Settlements [IPCC 2006, V4, Ch8, Eq 8.1]. Emissions of Non-CO2 emissions, DOM, Litter, and SOC are not included due to a lack of information.

- *Section 2:* Other lands converted to Settlements: this section refers to Annual change in carbon stocks [ΔCB] calculated by the difference of Gains [ΔCG] and Loses [ΔCL] and carbon stock changes losses due to conversion [ΔConversion]; [IPCC 2006, V4, Ch2, Eq 2.9, 2.10, 2.15, 2.16]. Emissions of Non-CO2 emissions, DOM, Litter, and SOC are not included due to a lack of information.

Other Lands: This section refers to IPCC 2019/2006 guidelines, Volume 4, Chapters 2 (Generic methodologies applicable to multiple land- use categories) and 8 (Settlements). No GHG emissions or removals are accounted for this section

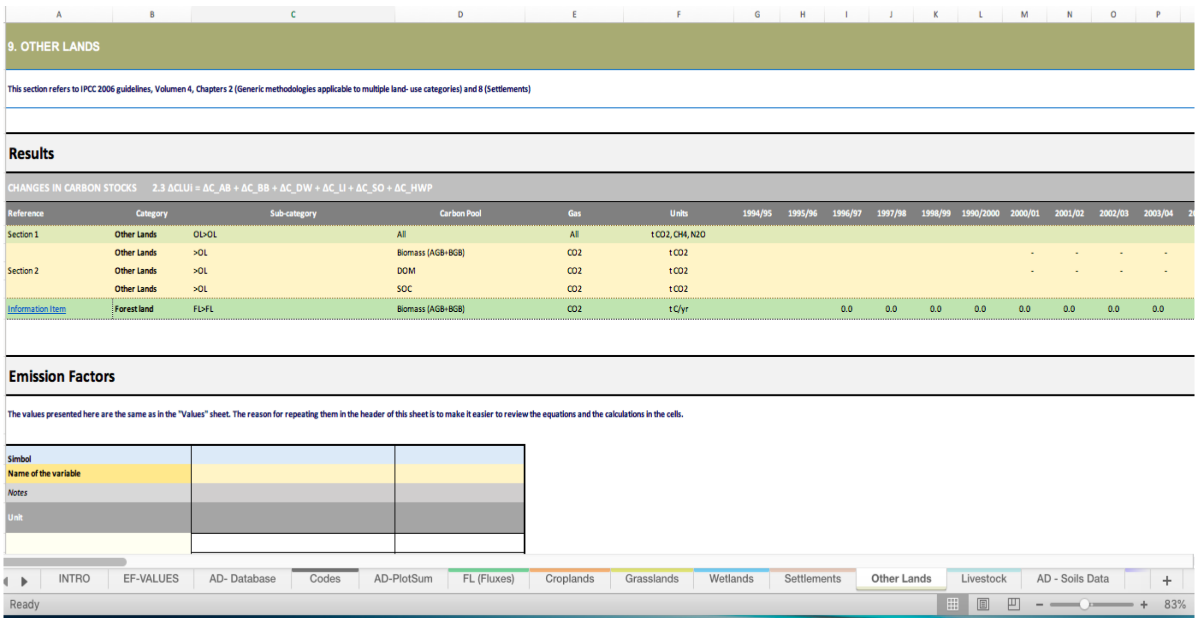


Figure 23. Example of Other land Sheet in the GHGI Tool of Belize

5. INFORMATION ON QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES

5.1. QA/QC of the data collection

This section describes the quality control (QC) and quality assurance procedures implemented for the data analysis of the National Forest Inventory and the Land use and land use change assessment. For the collection of AD using the CE tool, there were 3 phases identified. Below is a summary of the three phases, also included in the CE Land Use Protocol 2019.

PSP Data Collection

Measurements were checked for transcription errors by filtering for records outside expected ranges, e.g. a range of 10 mm to 2500 mm for diameter. Any unusual records were cross-checked against field sheets or against measurements in other censuses. A 'checksum' procedure was also used to ensure consistency between digitized data and field sheets. To detect transcription errors falling within normal data ranges, half of the field sheets from each census were compared against the digitized data (> 5200 trees or 15 %). If any census dataset was found to contain greater than five percent transcription error, the entire dataset was re-checked. Measurements were compared of each tree through time and if change was unusual (e.g. a tree increasing in diameter by more than ten millimeters over a year), the record was examined in greater detail and corrected or voided if necessary.

AD Collection

Phase 1: Having a clear understanding of the quality and the quantity of the data you would like to collect needs to be clear. Having a clear understanding of land use classes and their natural ecological processes is necessary. Furthermore, having a key understanding of the QA/QC activities that would be introduced in the implementation and validation phase. This phase should clearly be defined and endorsed nationally before moving unto phase 2. For Belize, this phase took approximately 7months and the time frame for the collection of data was from 2000 to July 2018.

Phase 2: The implementation phase is the execution phase of this process. This is where the team was assembled, the CE platform ready, the working room prepared and a clear idea of the QA/QC process in place for the monitoring of your progress (training). For Belize we had a team of 14 participants. The implementation phase took 7 weeks. The key task of this phase was for the classification of the total sample plots for Belize, which include an extra 5% of the total plots for QA/QC. At the end of the first week, a review was done by the lead consultant of CE and CFRN. This QA/QC was to see if the operators were doing the classification properly.

Phase 3: The validation phase is where we conducted most of our QA/QC activities. For Belize we conducted different levels and types of QA/QC. This process lasted almost a year due to intensive review of the plots which included 5% of the total plots reassessed by separate operators during the initial classification, one reassessment from uncertain plots identified with Saiku and another reassessment of Secondary Broadleaf Forest and Shrubland Plots. After this reassessment, an intensive review of the plots within excel was done. Also, during this phase, the team used additional tools such as Arc Map to help with the visualization and filtering of plots.

5.2. QA/QC of the data analysis

The technical analysis of the Belize AFOLU GHG Inventory took place from 01 May to 07 June 2019 and was undertaken by Mr. Jongikhaya Witi who participates in UNFCCC TTE analysis and reviews of Annex-I Inventory and BR submissions. He is a member of the UNFCCC roster of experts based on the criteria defined in decision 20/CP.19, annex, paragraphs 2–6.

During the technical analysis, in addition to the written exchange, through the Coalition for Rainforest secretariat, technical clarifications were provided the information reported in the report, Mr. Witi. Following the technical analysis of Belize GHG Inventory, prepared and shared a draft summary report with Belize on 14 June 2019 for its review and comment.

The analysis concluded that the reported information is mostly in adherence with the UNFCCC reporting guidelines on BURs and provides an overview of national circumstances that inform the AFOLU GHG Inventory of Belize and institutional arrangements relevant to the preparation of national AFOLU GHG Inventory on a continuous basis. It is concluded that the information analyzed is mostly transparent.

Belize reported information on the institutional arrangements relevant to the preparation of its LULUCF inventory and that it has taken significant steps to create institutional arrangements that allow for the sustainable preparation of its LULUCF Inventory.

The extent of the information reported by Belize in its national inventory report is described in ANNEX 1 of the review report.

Comments and suggestions were included in the final version of the report.

6. IMPROVEMENT PLAN

The following set of gaps and challenges on institutional arrangements and legislation in view of REDD+ implementation have been identified:

6.1. Institutional arrangements

Improve effective and full coordination among institutions involved in REDD+ implementation

The analysis of the institutional arrangements existing in Belize to manage environmental protection and climate change issues indicated that public sector institutions mainly operate based on individual institutional mandates derived from specific legislation and policies. As Belize's NDC indicates, the implementation of climate change policies and measures require a high level of cross-ministerial coordination and collaboration. REDD+ is a clear example of a matter that is covering several sectors and institutions and MAFFESDI would require a higher degree of collaboration. However, the existing institutional setting does not ensure full coordination and cooperation among agencies. Furthermore, individual government departments, such as the Forest and Fisheries Departments bear multifaceted mandates of ecosystems management, sustainable resource use, monitoring and enforcement. The dualistic role of public service agencies must be also addressed in order to facilitate a focused and targeted approach to climate change, biodiversity conservation, and environmental management.

6.2. Capacity building

Strengthening monitoring and evaluation of national activities

Adequate monitoring and evaluation systems are generally lacking when it comes to policies and strategies achieved under ministerial and departmental mandates. Another challenge is for those policies and strategies that have monitoring and evaluation plans in place but still lacking adequate follow-up or technical capacity within the department and ministries to adequately monitor and evaluate effectiveness. One of the major constraints is the limited staff and the lack of technical capacities in ministries and governmental agencies. The lack of adequate monitoring and evaluation results in the failure to mainstream climate change considerations within national economic and development priorities.

Institutionalizing data exchanges and archiving

Coordination among data providers needs to be strengthened to ensure that collection and reporting of data are done on a regular basis to support reporting responsibilities under the UNFCCC (National Communication and Biennial Update Report) and the Paris Agreement transparency framework (Paris Agreement) and institutional needs. Opportunities should be identified to link data collection needs with other data collection programs such as REDD+ initiatives. Capacity building and training will be an on-going effort at the institutional and technical level. Institutionalizing linkages between GHG inventory estimation with broader Climate Change research is very much needed.

Much effort is being put into searching archives of data stored by other organizations and digitizing those historical paper records. The addition of these records will increase both the spatial and temporal coverage of data under the NFMS stewardship. To enhance the completion of this process further support is needed. Staff members of the NFMS who have the capacity to undertake research studies are used to fulfill the operational demands of the Department such as maintaining operational forecasting and climate services. In order to affect significantly larger and more active participation in research, the NFMS should acquire a greater cadre of appropriately qualified individuals. Therefore, the Belize Forest Department, who is responsible for the measuring of AD, and EFs for the GHGI in the FOLU sector will continue to build capacity and improve their resources for the sustainability of this process.

Partnerships

Formalize the collaboration between FAO and MAFFESDI to include CE/OF activities to enhance the MRV and NFMS of the BFD.

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