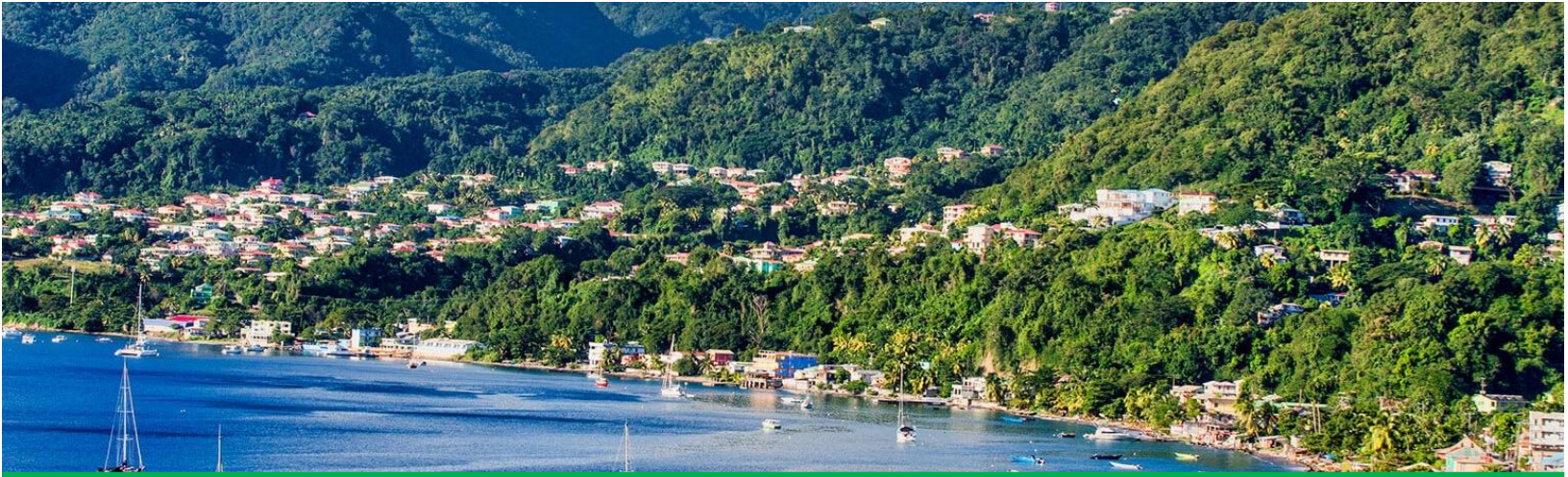




**DOMINICA FOREST
REFERENCE LEVEL /
FOREST
REFERENCE
EMISSIONS LEVEL
2018 -2025**

2023



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Cover Photo: credit Forestry, Wildlife & Parks, Dominica

¹ Photo 1: <https://immigrantinvest.com/en/insider/dominica-sustainable-development-goals-2021/>



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² <https://www.state.gov/countries-areas/dominica/>

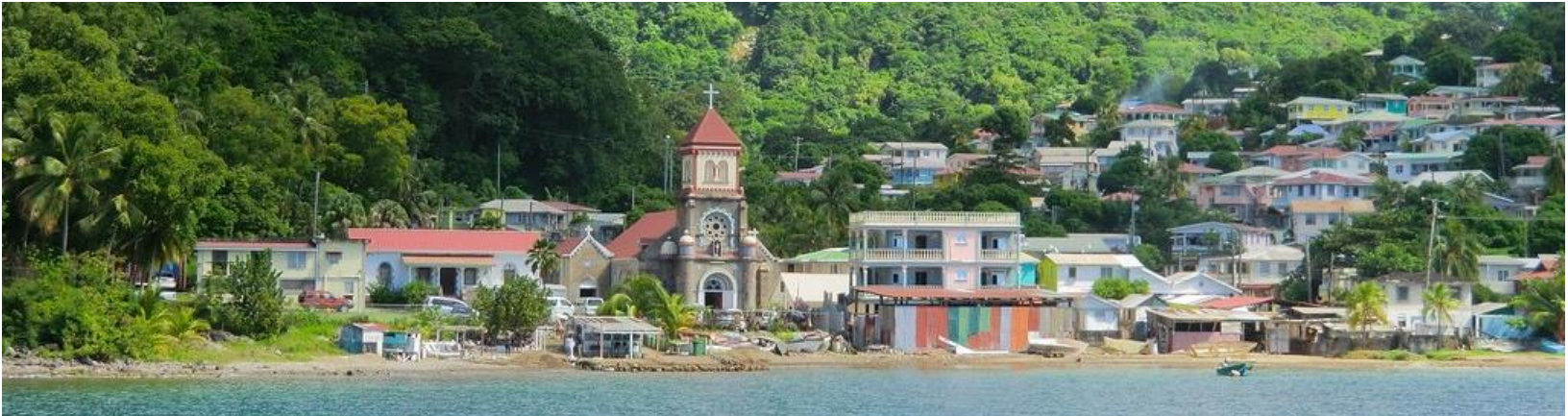


LIST OF ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, Forestry, and Other Land Use
BUR	Biennial Update Report
BTR	Biennial Transparency Report
CfRN	Coalition for Rainforest Nations
CH ₄	Methane
CO ₂	Carbon dioxide
COP	Conference of the Parties
ETF	Enhanced Transparency Framework
FAO	Food and Agriculture Organization (of the United Nations)
FOLU	Forest and Other Land Use
Gg	Gigagrams
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
PGP	Good Practice(s) Guidance
GWP	Global Warming Potential
Ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
INDC	Intended National Determined Contributions
LULUCF	Land Use, Land Use Change and Forestry
LDC	Least Developed Countries
m ³	Cubic meter
MPG	Modalities Procedures and Gridlines
MRV	Monitoring, reporting, and Verification
N ₂ O	Nitrous oxide
NFI	National Forest Inventory
NIR	National Inventory Report
NAP	National Adaptation Plan
NDC	National Determined Contributions

⁴ Photo: <https://www.uncommoncaribbean.com/dominica/having-it-made-in-the-mero-beach-shade-dominica/>

NDVI	Normalized Difference Vegetation Index
PA	Paris Agreement
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RRR+	Reporting for Results-based REDD+
SBSTA	Subsidiary Body for Scientific and Technological Advice
SIDS	Small Island Developing States
TNC	Third National Communication
TOA	Top of Atmosphere
UNFCCC	United Nations Framework Convention on Climate Change



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⁵ Photo: <https://thecommonwealth.org/our-member-countries/dominica>



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1. CONTEXT

In 1994, the Commonwealth of Dominica ratified the *United Nations Framework Convention on Climate Change* (UNFCCC)⁷, hereinafter referred to as “the Convention”, whose ultimate objective is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system; and within a sufficient timeframe to facilitate natural adaptation of ecosystems, ensure food security and sustainable economic development.

At the 21st Conference of Parties (COP21)⁸, a landmark agreement was reached to combat climate change and to accelerate and intensify actions and investments needed for a low carbon future. The Paris Agreement, which builds upon the Convention, has an overall objective to strengthen the global response to the threat of climate change by limiting global temperature rise this century to well below 2°C above pre-industrial levels and to pursue efforts to further limit the temperature increase to 1.5°C through ambitious mitigation actions. In addition, the Agreement establishes measures to increase the ability of nations to adapt to the adverse impacts of climate change and foster climate resilient development through consistent finance flows.

In 2015, in accordance with relevant paragraphs of Decisions 1/CP19⁹ and 1/CP20¹⁰ towards achieving the ultimate objective of Article 2 of the Convention, the Government of Dominica committed through its Intended Nationally Determined Contribution (INDC)¹¹, to a progressive reduction of total greenhouse gas emissions below 2014.

Consistent/in accordance with Decision 18/CMA.1¹² and its annex (the Katowice Climate Package), as well as Article 13 under the Agreement, Dominica provides information under the *Enhanced Transparency Framework*¹³ (ETF), which details a set of Modalities, Procedures and Guidelines (MPGs) to build trust and confidence; and strengthen

⁶ Photo: <https://discoverdominica.com/en/places/68/trafalgar-falls>

⁷ https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

⁸ <https://unfccc.int/documents/184656>

⁹ <https://unfccc.int/documents/8106>

¹⁰ <https://unfccc.int/documents/8611>

¹¹ <https://www4.unfccc.int/sites/ndcstaging/Pages/LatestSubmissions.aspx>

¹² <https://unfccc.int/documents/193408>

¹³ <https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-paris-agreement>



the global response to the threat of climate change. Regarding the forest sector, Dominica also intends to provide information as indicated in Article 5 of the Paris Agreement for REDD+ (Reducing Emissions from Deforestation and Forest Degradation) following the guidance developed since COP13 ensured transparency in the implementation of REDD+ activities. It is important to recall that REDD+ Conference of the Parties (COP) guidance emphasizes the importance of accurate and robust national GHG inventories and puts in place a unique verification process compared to all other sectors responsible for GHG emissions.

Small Island Developing states (SIDS) like Dominica, are on the frontlines of the climate crisis and are among the most vulnerable to its adverse impacts, but at the same time are at the forefront of climate actions. Dominica has taken national, sub-national and sectoral approaches towards its transition to a carbon-neutral, green, climate-smart and climate-resilient nation, with a cross-cutting emphasis on accessing climate change finance. Dominica has established a strong track record for the continual development, implementation and communication of policies and strategies to support climate change adaptation, mitigation, and resilience, with a focus on nature-based solutions.

The Government of Dominica considers it to be an important part of its mission to lead a process of collaboration with others with a view of preserving the nation's forests, rivers, and eco-tourism product, preserving the marine environment and the country's biodiversity; and popularizing even as preserve the nature island concept and brand. It is Government's intention to make an active and deliberate contribution to sustainable development of the natural and built-in environment, giving special attention to the larger environmental issues such as biodiversity, land degradation, climate change and the emission of GHG gases that cause global warming. We will give high priority to pursuing policies and programs that are consistent with well-researched proposals and programs developed by the international community and are consistent with our countries' needs and capacities.

The Government will contribute to ensure that in his or her personal behavior, a consciousness and pride in our Nature Isle is manifested by every Dominican. It is Government's policy that the Nature Isle will take the lead in enshrining green principles as the guide to our national planning, and to inform initiatives in all sectors.

Pursuant the commitments set by the Government; **Dominica** has the honor to present to you the Forest Reference Level for the years 2018-2025 of the country at the national level to be evaluated during the period of 2022.

2. FRL/FREL KEY ELEMENTS

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

- **Paragraph 7.** The FRL/FREL presented by Dominica is expressed in **tons of CO₂ equivalent per year**, to serve as a benchmark for assessing the country's performance in implementing the REDD+ activities.
- **Paragraph 8.** Dominica developed a **single database for the National GHG Inventory, the FRL/FREL and the NDC.** 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 FRL/FREL.
- **Paragraph 9.** In this submission, Dominica includes information and rationale on the development of the FRL/FREL and how the national circumstances were considered.
- **Paragraph 10.** In this submission, Dominica presents an improvement plan, which considers the gradual improvement of methods.
- **Paragraph 11.** Dominica's FRL/FREL is presented at the national level.
- **Annex, chapeau.** the information provided by Dominica is guided by the IPCC guidance and guidelines, specifically the **2006 IPCC guidelines for National GHG Inventories.**
- **Annex, paragraphs (a), (b).** A comprehensive database is attached to this report¹⁵. 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 terms of activities covered, historical emissions and removals are considered for Forest land remaining Forest lands,

¹⁴ Photo: <https://www.experience-dominica.com/post/the-kalinago-people>

¹⁵ ADD LINK



and conversions to and from Forest land. In essence, this is equivalent to measuring and monitoring all activities in the FRL/FREL. However, due to specific country circumstances only removals from conservation, sustainable forest management and enhancement of carbon stocks are included for the whole island; and reduction of emissions from deforestation for only a section of the forest. Reduction of emissions from degradation is not included.

- **Annex paragraph (d).** The forest definition used for the FRL/FREL is the same as for the National GHG Inventory to be included in the 1 Biennial Update Report.



3. REDD+ ACTIVITIES

As indicated in the Decision 1/CP.16, paragraph 71, Dominica has decided to develop a **national** forest reference level (FRL)/ **forest reference emission level (FREL)** in accordance with national circumstances and as a *benchmark* to assess the country's performance in implementing 4 of the 5 the activities referred to in decision 1/CP.16, paragraph 70: **deforestation, conservation, enhancement of forest carbon stocks and sustainable management of forest.**

Definitions for the assessment of the FRL/FREL required defining key REDD+ terminologies within the Dominican national context. The definitions for forest and the three (4) REDD+ activities considered are:

Forest

Forest is defined as forest lands with a canopy cover equal or higher than 60%, with a minimum area extension of 1 ha and woody vegetation of minimum 3m height or higher, including temporary unstocked areas with the potential to reach the forest definition. There are seven (7) forest types on the island: Elfin Forest, Montane Cloud Forest, Montane Rainforest, Semi-evergreen Forest, Semi-deciduous Forest, Dry Scrub Forest and Littoral Forests which vary depending on altitude and location. Characteristics of each forest type are described in section 7.1.

Under the REDD+ Framework for Dominica, the Forest Definition was agreed upon within various consultations held among Forestry, Physical Planning & Agriculture Officers. To fulfil two (2) main objectives:

- To be operational for the Monitoring Reporting Verification (MRV) process, with Monitoring done through Remote Sensing Images.
- In Dominica there is a policy statement of dedicating to increase forest cover as part of climate resilience strategies; thus, we concluded that a high canopy cover threshold is representative of those objectives.

¹⁶ Photo: <https://www.experience-dominica.com/post/the-kalinago-people>



Conservation

Refers to the areas of forest lands remaining forest lands. Conservation includes areas under the Protected Areas System and, as stated in the National Land Use Policy and Plan, any areas identified as sensitive zones for natural resources management that are considered as "specially conserved areas". The priority of the system of protected areas is to effectively manage forests to conserve the natural biodiversity and function, and contributes to the sustainable socio-economic development, resilience and well-being of all citizens and users¹⁷. However, since hurricane Maria in 2017, [these areas were affected either slightly, moderate or significantly damaged, requiring different types and categories of forest management.](#)

Sustainable management of forest

Refers to the areas of forest lands remaining forest lands under management strategies, within the Protected Areas System, in particular in the two forest reserves (Central Forest Reserve and Northern Forest reserve). Since hurricane Maria in 2017, [because of the disturbance suffered](#), these areas are prioritized for restoration, rehabilitation, and reforestation activities. Sustainable management of forest also refers to restoration, rehabilitation, and reforestation activities on farmlands and unallocated state lands¹⁸.

Enhancement of forest carbon stock

Refers to lands converted to forest lands, and lands utilizing agroforestry practices that enhance forest carbon pools.

Deforestation

[Refers to forest lands converted to other lands \(croplands, grasslands, wetlands, settlements, and other lands\).](#)

Forest degradation

[Refers to forest land remaining forest land affected by human disturbances \(logging, shifting cultivation and fires\) and natural disturbances \(tropical cyclones\).](#)

Even though the 5 activities were measured in the historical period (2000-2017), special considerations were taken for the projection period (2018-2025). In 2017, Dominica lost about 85%-90% of their forest cover in the forest lands¹⁹ due to Hurricane Maria, and the remaining 10%-15% was somehow affected leaving mostly the understory. Since then, Dominica efforts have focused on restoring and rehabilitating the forest lands in order to recover mostly tree cover and soils, and ensuring temporary unstocked forest lands are not converted to other land uses to allow the expected natural and assisted regeneration of the forest.

¹⁷ Dominica Protected Areas System Plan Report.

¹⁸ These are state lands where no specific land used have been assigned.

¹⁹ Post-Disaster Needs Assessment Hurricane Maria September 18, 2017. https://www.gfdr.org/sites/default/files/publication/Dominica_mp_012418_web.pdf



Based on expert consultation and their observations after the hurricane, four (4) different categories were used in Dominica to classify the forest.

- 1) No significant damage, which are patches of forest that because of their location and characteristics were not significantly affected by the hurricane.
- 2) Damage I, the stem remained standing but had broken branches or heavy defoliation,
- 3) Damage II: the stem and branches were broken, full defoliation, but trees were not uprooted.
- 4) Damage III: trees were totally uprooted.

The current FRL/FREL scenario is mostly based on the assumptions of natural regeneration supported with assisted regeneration, where country efforts are focused on, and assuming that the regenerating forest (natural or assisted) or the land converted to forest land will not be deforested or degraded, or expected to be very minimal.

These assumptions are based on the facts that the fallen branches, twigs and tree stumps initially hindered any major movement of persons into the forested areas. Few months after the hurricane, access to forest areas became more complicated due to an exposed undergrowth. Razor grass and other fast-growing shrubs, vines and ground ferns covered the forest floor soon forming a web as tall as 10 feet or more in some areas. In isolated instances, where farmlands, which are adjacent to Protected Areas and unallocated state lands were converted initially to grasslands eventually converted back to forest lands due to fast growing pioneer species.

This new farming in remaining forest has been mostly on private lands and represent about 5% in the country. However, worth mentioning is the fact that in those private (forested) land areas firewood, charcoal and lumber production did occur, whether during the process of utilizing the exposed patches of forest for new farm plots or simply salvaging the fallen timber that was accessible. It was observed, in early 2018, that Forest tree species fruiting patterns have changed from locality to locality, especially in the Middleham area (Southern Range), it has also been observed that Gommier (*Dacryodes excelsa*) tree species were fruiting but not as heavy as in Pond Casse, Central Range. Those changes would have been caused by the hurricane wind stress and defoliation, where, the Pond Casse area is more sheltered from the wind so fruiting is more prominent.

A lot of local knowledge was received and considered from many chainsaw operators, from all Forest Ranges, on what they have seen and experienced regarding some of those canopies disturbed of mature trees within Dominica's forests. The majority of the forests are recovering - the upcoming undergrowth, the mature class (the bulk of Dominica's forest with restored canopy cover), the pioneer species, the forested areas located in the COLS or GAPS (protected valleys) and all other forested areas which are rejuvenating after such massive defoliation. It should be noted that a slow mortality rate had already been observed among those mature hardwood species.

Currently, it is observed that the mortality rates may be levelling off or even declining (as most of the trees which were badly affected have already died and will soon deteriorate or break off), as opposed to those which died soon after the hurricane leading up to present (e.g. softer timber species). However, it must be said here that on the elevated windward slopes in the Eastern Range, some of the mature, coping hard wood species have stabilized their recovery growth curve. The tall, defoliated trees can be easily distinguished among the rest of the

recovering/thriving undergrowth forming secondary forest (in certain areas) and pioneer species which have joined together to give back our lush forest appearance.

Therefore, it is considered that for the damage classes I, II, and III, the forest land did maintain the carbon stocks pre-hurricane, and hence, if emissions from deforestation and degradation of these affected areas were to be included in the FRL/FREL, it would have to be based on the remaining biomass carbon stock, for which no data is available, and not the pre-hurricane biomass. Hence, despite degradation continued to happen after the hurricane observed through tree mortality, it is unlikely that emissions from deforestation and forest degradation in the period 2018 – 2025 would be high in these 3 classes zones and, in addition would be highly uncertain. As a result, the deforestation and degradation rates (hectares of the historical period (2000-2017)) were not considered for the FRL/FREL period (2018-2022) for the whole country; only 25% is being used as a reference for deforestation for the “No significant Damage Class”, and no more degradation is assumed.

For the development of the FRL/FREL, Dominica selected a **Land Based Approach**, which means that the REDD+ activities are assessed all together, and therefore, no specific FRL/FRELS were developed by activity, aiming at environmental integrity. Therefore, REDD+ results will be evaluated as an integral outcome of national activities. **Table 1** depicts the source category and associated REDD+ Activity using the IPCC suggested structure. Hence, this directly defines each REDD+ activity for Dominica. Nonetheless, the estimations and results are disaggregated and can be evaluated individually if needed.

Table 1. Depicting associated REDD+ activity and source category

Associated REDD+ Activity	Source Category
Conservation and Sustainable Management of Forest	Forest land Remaining Forest Land, undisturbed and disturbed, under management for natural and assisted regeneration.
Enhancement of C Stocks	Croplands converted to Forest Land
	Grasslands converted to Forest Land
	Wetlands converted to Forest Land
	Settlements converted to Forest Land
	Other lands converted to Forest Land
Deforestation	Forest lands converted to Croplands in the “ No significant damage class”
	Forest lands converted to Grasslands in the “ No significant damage class”
	Forest lands converted to Wetlands in the “ No significant damage class”
	Forest lands converted to Settlements in the “ No significant damage class”
	Forest lands converted to Other lands in the “ No significant damage class”



4. CONSISTENCY WITH THE NATIONAL GHG INVENTORY

In March 2020, Dominica submitted its Third National Communication which reports on the period from 2005 until the end of 2017, and includes an assessment of greenhouse gas (GHG) emissions during this time, together with an update concerning activities that have been undertaken to reduce Dominica's carbon footprint while building climate resilience, in part through measures to implement Dominica's Low Carbon Climate Resilient Development Strategy including through building the legal and institutional capacity to manage impacts from climate change.

For the forest and land use sector, applicable data for Dominica's forest was not available, with no recent census or forest inventory having been undertaken since 1987. This resulted in basing the GHG inventory on default values from the FAO Global Forest Resource Assessment data (FAO STAT). The values from FAO STAT 2000, could not be utilized to calculate the changes in area for the six IPCC land use categories because FAO's categories were different from that described in the IPCC guidelines. Given this information was the only complete land use data source information available for Dominica, Approach 1 was chosen as the best suited methodology for the analysis, because it does not require detailed information on land use changes. For the Emission Factors, Dominica fell into the category of having little or no country specific data available and thus Tier 1 was followed, using 2006 IPCC default values.

Based on these needs, during 2020-2021, the Forestry Division took the lead and developed a national FOLU-GHG Inventory including GHG emissions and removals for all Intergovernmental Panel on Climate Change categories and subcategories at national level, which includes land remaining in same category and conversions to other land uses, considering all lands as managed (2006, 2019 IPCC). It includes the pools above-ground biomass, below-ground biomass, dead wood, and soil organic Carbon. Harvested wood products were excluded due to lack of information.

The information on Activity Data used was obtained from land use and land-use change assessments, which were conducted on the basis of a sampling approach (2006 IPCC, V4, Ch3 approach 3), in which the land-use was determined for each year of the time series 2000 – 2017, derived using the FAO Collect Earth tool. The information on Emission Factors (EFs) was obtained from regional research, scientific literature, and default values of the 2006

²⁰ Photo: <https://inaturalist.ca/taxa/204112-Gecarcinus-quadratus>



IPCC Guidelines and 2019 Refinements to the 2006 IPCC Guidelines. The GHG Inventory was developed using the Foundational Platform calculation tool developed by the Coalition for Rainforest Nations. This tool allows extracting the forest-related information from the GHG inventory to construct the Forest Reference Level and update the National Determined Contributions update report, using the same data, methods, assumptions, and projections, which ensures full consistency among the reports. This GHG Inventory will be included in the next report to the UNFCCC ([1 Biennial Update Report \(BUR\)](#)). A copy of this FOLU-GHG Inventory is attached to this report²¹. This approach meets the requirements of Decision 12/CP.17, paragraph 8 and decision 4/CP.15, paragraph 7.

The information of this updated GHG Inventory (2021) has been already used for the estimations of the Updated National Determined Contributions report (2021).

²¹ [Attach Link to FP](#)



5. FOREST REFERENCE LEVEL OF DOMINICA

5.1 Outline of Forest Reference Level (2018-2025)

The current national FRL/FREL proposed by Dominica is the net balance of greenhouse gas (GHG) emissions and removals in Forest lands remaining forest lands undergoing natural and assisted regeneration, as well as lands converted to Forest Lands after the hurricane Maria in 2017. The analysis is done at national level, following the Gain-Loss method proposed in the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for National GHG inventories, and implementing a country-specific excel calculation tool²³. All lands were considered as managed. It includes the pools above-ground biomass, below-ground biomass, dead organic matter, and soil organic carbon. Dominica acknowledges Decision 4 CP/15, paragraph 7. where “*developing country Parties in establishing forest reference emission levels and forest reference levels should do so transparently taking into account historic data*”; thus, an annual historical analysis from 2000 to 2017 of GHG emissions and removals for Forest land remaining Forest lands undisturbed, Forest land remaining Forest lands disturbed by human (fires, shifting cultivation and logging) and natural events (hurricanes), and conversions to and from Forest Lands is included; however, only as complementary information, because as mentioned previously, historical data does not represent the future expected conditions; therefore, Dominica is adjusting for national circumstances, as also indicated in the same decision (4 CP/15, p7).

The information on Activity Data (AD) used was obtained from land use and land-use change assessment, which was conducted on the basis of a sampling approach (IPCC approach 3) using Collect Earth, in which the land-use condition, including natural and/or human disturbance, was determined for each year of the time series 2000 - 2018. Forest land was stratified by forest type (Montane Forest -Elfin, Cloud montane, Montane Rainforest-, Seasonal Forest -Semi-Evergreen, Semi-Deciduous-, Littoral Evergreen, Dry Scrub). Croplands are reported as annual and perennial crops. Grasslands and Settlements are reported as Woody and Non-Woody. Wetlands do not have further sub-classification and Other lands divided in Other Lands and Mining (see section 7.1).

The information on wood removals was derived from the Collect Earth assessment as cover loss instead of volume loss, as the tool does not allow that estimation. Losses due to Disturbances were also identified including Hurricanes, Fires, Logging and Shifting Cultivation.

²² Photo: <https://associatetimes.com/dominica-pm-roosevelt-skerrit-recalls-torrential-impacts-of-hurricane-maria-at-5th-anniversary/>

²³ This country specific tool is similar to the IPCC working sheets but adapted to capture country specific circumstances.

In order to apply the gain-loss method equations (IPCC 2006, V4, Ch2), the specific country circumstances had to be taken into account. The application of the equations and the emission/removal factors vary depending on the time, specifically before or after the hurricane Maria in 2017, based on the following considerations:

Hurricanes are a major disturbance and have major effects on tropical forests (Zhang, 2021²⁴, Lugo 2008²⁵; Flynn et al. 2010²⁶; Shiels et al. 2015²⁷; Uriarte et al. 2019²⁸). Hurricane Intense and force winds snap stems and defoliates surrounding vegetation, which compounded and aided by persistent heavy precipitation saturate soils which leads to landslides, loosen roots destroy the landscape of the forest and alter forest structure and composition (Uriarte et al. 2019; Hall et al. 2020²⁹; Heartsill Scalley et al. 2010³⁰; Arnone et al. 2011³¹, 2015³²; Lepore et al. 2012³³, 2013³⁴; Heartsill Scalley 2017³⁵).

The forest structure and composition are affected by the immediate damages and mortality caused by the disturbance and altered by the subsequent recovery via species succession and competition (Zhang 2021). Forest damage depends on the intensity of the hurricane: stronger hurricanes with intense winds and heavy precipitation generally cause stem damage and death in tropical forests at a higher rate than weaker hurricanes (Uriarte et al. 2019). Forest damage depends also on the initial condition of the forest, which is constantly modified by previous hurricane disturbances (Boose et al. 2004³⁶).

The damages are usually classified as Damage I if a stem has light defoliation (< 50%), Damage II if a stem has broken branches or heavy defoliation (≥ 50%), Damage III if the trunk or roots are broken (Zhang, 2021).

Based on expert consultation and their observations after the hurricane, four different categories were used in Dominica to classify the forest. 1) No significant damage, which are patches of forest that because of their location and characteristic where not significantly affected by the hurricane. 2) Damage I, the stem remained standing but has broken branches or heavy defoliation, 3) Damage II: the steam and branches are broken, heavy defoliation, and tree was not uprooted. 4) Damage IV: trees are uprooted.

Zhang (2021) found that hurricane-induced mortality varied with species/plant functional types (PFTs) and stem sizes. Early successional trees had the highest mortality. Small stems were protected and had the lowest mortality

²⁴ <https://smartech.gatech.edu/bitstream/handle/1853/66085/ZHANG-DISSERTATION-2021.pdf?sequence=1>

²⁵ https://www.academia.edu/68096783/Visible_and_invisible_effects_of_hurricanes_on_forest_ecosystems_an_international_review

²⁶ http://www.columbia.edu/~mu2126/publications_files/Flynn%20et%20al.%202010.pdf

²⁷ https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2745&context=icwdm_usdanwrc

²⁸ <https://www.nature.com/articles/s41467-019-09319-2>

²⁹ <https://www.nature.com/articles/s41598-020-61164-2>

³⁰ <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1744-7429.2009.00609.x>

³¹ https://www.researchgate.net/publication/258787948_Physically_based_modeling_of_rainfall-triggered_landslides_a_case_study_in_the_Luquillo_Forest_Puerto_Rico

³² <https://onlinelibrary.wiley.com/doi/abs/10.1002/hyp.10609>

³³ https://www.researchgate.net/publication/252395455_Rainfall_Induced_Landslides_in_Puerto_Rico_Invited

³⁴ <https://hess.copernicus.org/articles/17/3371/2013/hess-17-3371-2013.pdf>

³⁵ https://www.researchgate.net/publication/317556438_Insights_on_Forest_Structure_and_Composition_from_Long-Term_Research_in_the_Luquillo_Mountains

³⁶ https://www.researchgate.net/publication/228865153_Landscape_and_Regional_Impacts_of_Hurricanes_in_Puerto_Rico

compared to medium and large stems in a large-stem dominant forest, but they were exposed and had the highest mortality in a small-stem dominated forest. Palms, as they are wind-resistant, had the lowest mortality, followed by mid and late successional trees.

Hurricane Hugo in 1989 caused extensive damages to the forest vegetation, uprooted and snapped 20% of the trees at El Verde in the Luquillo Experimental Forest (LEF), Puerto Rico (Walker 1991³⁷; Walker et al.1992³⁸; Zimmerman et al. 1994³⁹, Scatena & Larsen 1991⁴⁰, Heartsill Scalley et al. 2010) and reduced the aboveground biomass by 50% at Bisley in the LEF (Scatena et al. 1993⁴¹; Heartsill Scalley et al. 2010). Storm Lothar in 1999 reduced approximately 30% of the net biome production in Europe (Lindroth et al. 2009⁴²). A squall line (a band of storms) across Amazonia in 2005 destroyed 542±121 million trees, which is equivalent to 23% of the annual biomass accumulated for the forests in that area (Negrón-Juárez et al. 2010⁴³). Hurricane Katrina in 2005 damaged about 320 million large trees on U.S. Gulf Coast forests, and the damaged trees are equivalent to 50-140% of the net annual U.S. carbon sink (Chambers et al. 2007⁴⁴).

Forests recover from disturbances, but the process of recovery varies with the severity of the disturbance. Both the disturbance effects and growth effects will affect the recovery speed and the final state of recovery. The recovery state includes, but is not limited to, the community population, size structure, species composition, biomass accumulation. The recovery time is the time the forest takes to reach the pre-disturbance state (Walker 1991; Everham & Brokaw 1996⁴⁵; Cole et al. 2014⁴⁶; Heartsill Scalley 2017).

Early successional (pioneer) species establish and recruit in open gaps formed after hurricane disturbances, growing rapidly in the high light environment. Mid successional species, which have intermediate growth rate and are somewhat shade tolerant, gradually substitute early successional species in the canopy as the gaps close. Late successional species, which have low growth rates and are shade tolerant, reach the canopy and become dominant in the plant community as the forest matures until the next disturbance.

In Puerto Rico, after hurricane Hugo (1998), the forest took 20 weeks to recover from defoliation (Walker 1991) and five years to increase the aboveground biomass to 86% of the pre-hurricane level (Scatena et al. 1996⁴⁷). In the succession recovery of the forest after hurricane Hugo, palms had the lowest background mortality and the highest recruitment rate, which make them superior competitors in the forest. Zhang (2021) calibrated a model to

³⁷ Walker, L. R. Tree damage and recovery from hurricane Hugo in Luquillo Experimental Forest, Puerto Rico. Part A. special issue: ecosystem, plant, and animal responses to hurricanes in the Caribbean. *Biotropica* 23, 379–385 (1991). Cited in: Zhang (2021)

³⁸ Walker, L. R., Voltzow, J., Ackerman, J. D., Fernandez, D. S. & Fetcher, N. Immediate impact of hurricane Hugo on a Puerto Rico rain forest. *Ecology* 73, 691–694 (1992). Cited in: Zhang (2021)

³⁹ Zimmerman, J. K. et al. Responses of tree species to hurricane winds in subtropical wet forest in Puerto Rico: Implications for tropical tree life histories. *Journal of Ecology* 82, 911–922 (1994).

⁴⁰ <https://typeset.io/pdf/physical-aspects-of-hurricane-hugo-in-puerto-rico-3s8352v05d.pdf>

⁴¹ <https://www.jstor.org/stable/2388975>

⁴² <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2008.01719.x>

⁴³ <https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2010GL043733>

⁴⁴ <https://www.science.org/doi/10.1126/science.1148913>

⁴⁵ <http://ruby.fgcu.edu/courses/everham/Disturbance/EverhamBrokaw1996.pdf>

⁴⁶ <https://www.nature.com/articles/ncomms4906>

⁴⁷ <https://www.fs.usda.gov/research/treesearch/30470>



represent the stem density, aboveground biomass, plant functional type composition and size structure of the forest in the 25 years of recovery from hurricane Hugo. The simulated results show that a single hurricane disturbance on a forest with wind-resistant initial state will result in a higher aboveground biomass level after 100 years of recovery compared to a less wind-resistant initial state.

Observations on a tropical forest canopy in western Mexico after two hurricanes—category 2 Jova and category 4 Patricia—showed that hurricane Jova destroyed 11% of the aboveground biomass while hurricane Patricia destroyed 23%; the recovery was more rapid after the less intense hurricane Jova (Parker et al. 2018⁴⁸).

Zhang (2021), mentions that plant functional types composition and size structure at recovery are not as dependent on initial state. However, frequent and intense hurricane disturbances in the future will decrease the aboveground biomass accumulation and alter the plant functional types composition. He concluded that frequent and intense hurricane disturbances will increase the abundance of palms and early successional trees but decrease the abundance of late successional trees.

Changes in intensity and frequency of hurricane disturbances, possibly caused by climate change (Bender et al. 2010⁴⁹), could then potentially lead to different forest structure and composition (Wang & Eltahir 2000⁵⁰), which become a different initial condition to further disturbances. Zhang (2021) also studied a scenario under warmer and higher CO₂ concentration climate, and concluded that these conditions will enhance the aboveground biomass accumulation but will have smaller effects on the composition and structure of the forest in comparison to hurricane disturbances. However, the biomass accumulation cannot compensate for the biomass loss due to hurricane disturbances.

Zhang (2021) concluded that:

- 1) the state of the forest at the time of disturbance has effects on the recovery of the forest, especially on the biomass accumulation, but less effect on the composition and structure;
- 2) The severity of the hurricane disturbance has significant impacts on the biomass accumulation, composition and structure of the forest;
- 3) Climate change with higher temperature, humidity, and CO₂ concentration will promote biomass, but not sufficiently to counteract biomass reduction from hurricane disturbances;
- 4) Palms will become more and more abundant in forests that are subject to frequent hurricane disturbances.

⁴⁸ <https://www.washingtonpost.com/archive/politics/1989/09/22/hurricane-hugo-rips-through-south-carolina/598c0c54-2225-4fa0-ab22-e6f6daa91982/>

⁴⁹

https://www.researchgate.net/publication/41111577_Modelled_Impact_of_Anthropogenic_Warming_on_the_Frequency_of_Intense_Atlantic_Hurricanes

⁵⁰ https://eltahir.mit.edu/wp-content/uploads/2014/05/2000-Wang-Eltahir-bio_2a.pdf

Walker (1991), Frangi & Lugo (1991)⁵¹ indicate that defoliation recovers in weeks to months, but forest structure and composition shift over decades following three stages of species succession (Weaver 1989⁵²; Vandermeer and de la Cerda 2004⁵³; Bonan 2016⁵⁴).

In Dominica’s context before Hurricane Maria in 2017, forests cover had a large share of the island and was very ecologically diverse, with more than half being primary forests. Forest ecosystems in Dominica developed under wind-driven severe disturbances, which give a high recovery and adaptation capacity⁵⁵. During Hurricane Maria, in September 2017, mainly massive (extensive) defoliation occurred and not total forest destruction. The proportion of fallen trees in the forest was much less as opposed to the extent of canopy loss occurred. Fallen trees and damaged to understory was mainly caused by trees with heavy crowns compounded/overgrown with huge lianas, vines, bromeliads, ferns, and orchids, other epiphytes increasing the weight, so when they were toppled by the wind the damage was extensive. Twigs/branches were broken off most of which remained on the forest floor (about 3/4 or 75%). The remaining 25%, especially lighter twigs, ended up in the fresh-waterways due to heavy flooding and high velocity of rushing water, transported those debris, especially those along the many Riparian zones, either;

- (1) Exited along the seacoast, estuaries, in the city or within villages, or stuck under bridges.



Figure 1 Mero Beach Forest debris 2017 (Source: Dominica Forestry Division)



Figure 2 Forest tree transported to lower levels 2017 (Source: Dominica Forestry Division)

⁵¹ <https://www.jstor.org/stable/2388248>

⁵² <https://www.redalyc.org/pdf/339/33906807.pdf>

⁵³ <http://www.bio-nica.info/Biblioteca/Vandermeer2004PostHurricaneForest.pdf>

⁵⁴ <https://www.scribd.com/document/384574742/Gordon-Bonan-Ecological-Climatology>

⁵⁵ Dominica’s Forest Note 2020

- (2) Formed mini, temporary dams due to the break-down of the velocity of the rushing water, and remained within the boundaries of the forests and along the river bed/s.



Figure 3 River damming by Forest debris, 2017 (Source: Dominica Forestry Division)

The assessment of disaster post hurricane estimated that 80–90% of environmental resources were significantly affected, particularly forests. Only a few trees in small and very protected pockets retained their leaves. An estimated 20 trees per acre were blown over or destroyed (ACAPs, 2018⁵⁶; PDNA, 2017⁵⁷).

Photograph Scenario Presented by Dominica Forestry Experts, Post Hurricane Maria:



Figure 4 Northern Range, Morne Diablotin National Park, Sept. 2017



Figure 5 Southern Range, Woody Settlement destruction, Sept. 2017

⁵⁶ https://www.acaps.org/sites/acaps/files/products/files/20180131_acaps_disaster_profile_dominica_v2.pdf

⁵⁷ <https://www.gfdrr.org/en/publication/post-disaster-needs-assessment-dominica>



Figure 6 Northern Range damage, Nov. 2017



Figure 7 Northern Range damage, Nov. 2017



Figure 8 Central Range-Emerald Pool damage, Dec. 2017



Figure 9 Northern Range-Coconut farm damage, Dec. 2017



Figure 10 North Range-Cabrits National Park, Nov. 2017



Figure 11 Central Forest Range damage-Emerald pool, Jan. 2017



Figure 12 Central Range -Emerald Pool Nature Trail, Jan. 2018



Figure 13 Defoliated Forest North Range-Morne Turner, April 2018



Shortly after Maria



One Year After Maria

Figure 14 North Range-Indian River (veg. recovery 2017-2018);



Figure 15 Cabrits Eco-trail recovery, April 2018



Figure 16 Central Range-Concord May 2021



Figure 17 Central Range-Concord May 2021



Figure 18 South Range damage-Scott's Head Peninsula, Sept. 2021

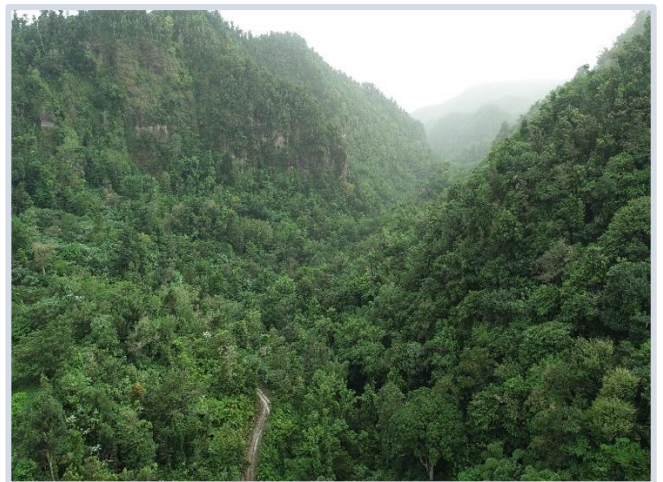


Figure 19 Central Range, July 2022

With regards to the leaf litter, it was observed that some leaves were lost through heavy flooding and blown out of the forest structure, but the majority ended up on the forest floor, evident during forest access route restoration immediately after Hurricane Maria.



Figure 20 Northern Range-Syndicate Eco-trail (leaf litter, wood debris), Jan. 2018



Figure 21 Southern Range debris, April 2018



Figure 22 Southern Range, Middleham, 2018

During and immediately after hurricane Maria, some dead wood was lost due to land erosion, although some remained trapped because of the nature of the destruction. Some rivers changed their courses due to the volume of water or damming along the streams due to landslides. Mainly dead wood on steep slopes was lost to waterways rather than areas of flat land. Approximately 10-20% of dead wood may have reached the ocean. From the remaining 80-90%, about 10% was used for lumber, charcoal, fuelwood, composting, or burnt in heaps, while some sank in the ocean and returned as driftwood. The rest remained in the forest floor and river sides.



Figure 23 African Baobab tree stump recovery from Hurricane David in 1979, Dominica Botanic Gardens

Rotting of trapped dead tree species on the forest floor has provided condition for mushroom growth, worms and beetles, lady bugs and in some areas breeding ground for mosquitoes. Some of the harder dead forest species, like the *Bwa diable* (*Licania ternatensis*), *Chataingnier/s* (*Sloanea spp*), others are falling unto the forest floor so as to help build back the rich topsoil of the environment.

A large-scale landslide inventory was carried out by a team from the University of Twente, using satellite imagery with resolution of 0.5m which were obtained in September 23rd and October 5th, 2017 right after the Hurricane Maria. Apart from these, also a series of Digital Globe Images were used that were collected for the Google Crisis Response through a KML layer. The images were visually interpreted by image interpretation experts, and landslides were mapped as polygons, separating scarp, transport and accumulation areas, and classifying the landslides in types (Figure 24).

A total of 9,960 landslides were identified, which include 8,576 debris slides; 1,010 debris flows; and 374 rock falls, with area of 7.30 km², 2.50 km², and 0.50 km² respectively. The whole area of landslide is 10.30 km², which covers 1.37% of the island. The source of landslides is 3.30 km², and the other 7.0 km² is transportation and deposition area. Almost all the rivers flooded due to intensive precipitation. The flooded area is 13.03 km², which covers 1.74% of the island⁵⁸.

The figure 24 below shows the location of landslides and floods triggered by Hurricane Maria.

⁵⁸ In Dominica: Landslides and floods triggered by Hurricane Maria (18 September 2017). <https://reliefweb.int/map/dominica/dominica-landslides-and-floods-triggered-hurricane-maria-18-september-2017>)



Figure 24 Landslides assessment after hurricane Maria (2017)

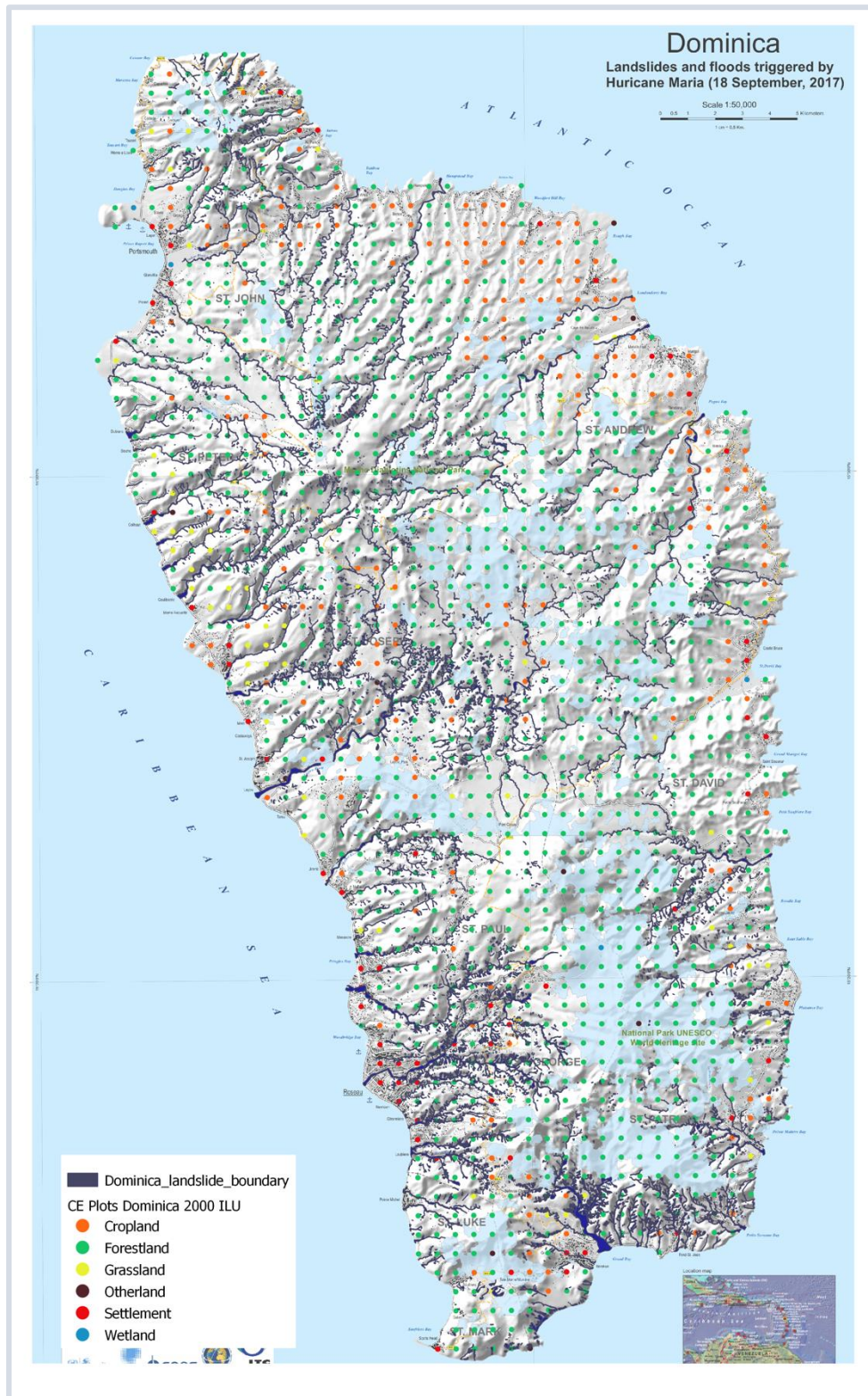


Figure 25 Landslides assessment after hurricane Maria (2017) overlapped with land use assessment sampling grid



National forestry experts indicated that most of the soil was lost along the riparian forests, steep forested lands and already exposed areas. Dominica team tried merging the shapefile of the landslides with the land use sampling plots (Figure 25), but it was identified that most of the landslides did not fall within those plots, so the distribution within the various land classifications was estimated based on the expert judgment, resulting approximately as: Forest lands 50%, Croplands 20%, Grasslands 10%, Settlements 10%, Wetlands 5%, Other lands 5%.

Based on this classification and expert judgment, about 5.3 Km² or 530 ha of soil was lost in Forest lands, with a desegregation by forest type as follows: Elfin and Cloud: 40% (212 ha), Montane Rainforest: 30% (159 Ha), Semi-evergreen forest: 20% (106 ha), Deciduous-Coastal Forest: 10% (53 ha).

Dominica does not have data that preceded the hurricane on forest growth (for the different types of forest physiognomies) that could be used to compare with the dynamics of the forest (including growth) after the hurricane event. Long-term research that studies the effect of hurricanes on tree mortality and growth is very scarce, and hence, there are high uncertainties in this respect (Tanner, 2014)⁵⁹. To understand the effect of the soil condition on forest growth, it would be necessary to understand the impact of the hurricane in the soil.

It has been noticed that scars on the landscape are being recolonized by pioneer tree species and areas appear to be of a light yellowish color due to lack of fertile top-soil conditions in some areas. A new generation of trees are positioning themselves to take advantage of the natural thinning created by the hurricane, example: Bwa blanc (*Simarouba amara*), Maurisif (*Byrsonima martinicensis*), Bwa riviere (*Chimarrhis cymosa*), Ti citon/s (*Ilex* spp), to name a few.

The forest recovered faster before (sooner after the hurricane) than at present and the only significant change in species would probably simply be to a higher prevalence of pioneer species. Even though some of those hard wood species eventually die out, within the undergrowth and mid layer of the forest strata, saplings/wildings/small trees of those hard wood and other mature species will thrive due to increased sunlight thru the canopy loss.

Trying to apply approximate percentages, sooner after the hurricane, mortality rate could have been 5% (5-10% would be rather high considering the nature of Dominica's terrain a lot of trees were protected from the wind); so, naturally at present this would be lower = 1% or 2%.

Dominica's national experts also searched the literature available on landslides in the country to better understand their effect on carbon pools, particularly the soil organic carbon (SOC) pool.

Literature indicates that the total landslide area is characterized by variable physical, chemical and biochemical properties. The upper part of the landslide is strongly eroded and characterized by the least advanced soil cover recovery. Soil organic matter plays a crucial role in the early stages of the formation of soil cover and vegetation.

⁵⁹ Tanner, Edmund V. J., et al. "Long-Term Hurricane Damage Effects on Tropical Forest Tree Growth and Mortality." *Ecology*, vol. 95, no. 10, 2014, pp. 2974–83. JSTOR, <http://www.jstor.org/stable/43493923>. Accessed 3 Jun. 2022.



The changes in the amount of soil organic matter, nutrients and physical properties have different intensification within the range of landslides and strongly influence the processes of soil cover and vegetation restoration.

Landslides, both natural and human induced, can contribute to either carbon export or sequestration in a watershed. If landslides from upper hillslopes bury soils farther downslope, they can protect that soil carbon from entering the atmosphere. On the other hand, in steep terrains, landslides can strip soil and vegetation off a hillslope and deliver that carbon directly to streams and coastline.

In addition, post-disturbance erosion can affect tropical landslides, even after the initial disturbance. When this occurs, landslides represent a net loss of C from the landscape. Soil type, rates of soil output and plant colonization dynamics are the principal factors determining recovery rates for C lost through landslides. Landslides therefore provide a long-lasting horizontal and vertical alteration of C.

One publication (Blonska et al., 2018⁶⁰) highlights that biochemical parameters (dehydrogenase activity and microbial biomass C and N) turned out to be useful tools for the evaluation of changes taking place in the soil after a landslide.

The landslides that take place in forest areas cause the destruction of trees, and they break the continuity of soil cover which results in different physical, chemical and biological properties (Shiels et al. 2006⁶¹; Shiels & Walker 2013⁶²). Deposits of landslides are characterized by high variability of properties, especially the distribution and the amount of soil organic matter.

From these considerations, Dominica finds it highly uncertain and strongly dependent on several assumptions to provide an estimate of the changes in carbon stock in SOC, considering the different types of soil affected, the geomorphology of the region, erosion processes and, more importantly, the loss (or gain) in SOC from landslide. Few estimates have been found of the soil carbon content in soils, and none addressed the most relevant soil types in Dominica (*Smectoid soils; Kandoid soils; Allophane latosolics; and Allophane podzolic*).

⁶⁰ https://www.researchgate.net/publication/318317031_The_effect_of_landslide_on_soil_organic_carbon_stock_and_biochemical_properties_of_soil

⁶¹ https://www.researchgate.net/publication/225796536_Organic_matter_inputs_create_variable_resource_patches_on_Puerto_Rican_landslides

⁶² https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2572&context=icwdm_usdanwrc



Figure 26 Forest devastation scenario depicting loss of soil and trees at riparian zones, Castle Bruce 2022

Therefore, taking all this information into account from local knowledge and local and regional studies, Dominica did the estimations based on the 4 classifications given to forest lands:

- 1) No significant damage, which are patches of forest that because of their location and characteristics were not significantly affected by the hurricane.
- 2) Damage I, the stem remained standing but had broken branches or heavy defoliation,
- 3) Damage II: the steam and branches were broken, full defoliation, but trees were not uprooted.
- 4) Damage III: trees were totally uprooted.

These classifications were given in order to estimate the carbon dynamics in the different carbon pools: above-ground biomass, below-ground biomass, dead organic matter (litter and dead wood) and soil organic carbon; and specifically understand recovery dynamics, losses and transfers among carbon pools.

Tier 1 methods were applied for the “No significant damage’ class 1, applying the same emission and removal factors as before the hurricane and Tier 2 methods were applied to estimate losses due to the hurricane, gains after disturbance and transfers of C among pools (AGB + BGB pool > DOM pool > SOC pool) as follows:

Damage I class, the stem remained standing but has broken branches or heavy defoliation: it is estimated to cover about 60% of the forest. Assumptions include that 5% of the canopy flew away and the other 95% remained on the forest floor. The recovery growth rate is only applied to branches and leaves, and it assumes no changes in the below-ground biomass. The 95% of the canopy on the forest floor is expected to decompose within 5+ years and be transferred annually to the DOM pool. DOM will start transferring to the SOC pool after 5 years.

Damage II class, the steam and branches were broken, full defoliation, and trees were not uprooted: it is estimated to cover about 25% of the forest. Assumptions include that 10 % was used for logs, charcoal, firewood, and a small



percentage burnt, while 15% was lost in the waterways. The recovery growth rate is applied to the whole tree for early successional (pioneer) species established and new recruits in open gaps formed after Hurricane Maria disturbances, growing rapidly in the high light exposed environment. It assumes there were no losses of the below-ground biomass of affected trees while maintaining new establishment of roots for the new trees. The 75% of the canopy that remained on the forest floor is expected to decompose within 100 years and be transferred annually to the DOM pool after 5 years. DOM will start transferring to the SOC pool after 10 years.

Damage III class, the trees were totally uprooted: it is estimated to cover about 15% of the forest. Assumptions include that 10 % was used for logs, charcoal, firewood, while a small percentage was burnt for clearing, and 15% was lost in the waterways. The recovery growth rate is applied to the whole tree for early successional (pioneer) species establish and new recruits in open gaps formed after Hurricane Maria disturbances, growing rapidly in the high light exposed environment. It accounts for the losses of the below-ground biomass of affected trees and the new establishment of roots of the new trees. The 75% of the canopy that remained on the forest floor is expected to decompose within 100 years and be transferred annually to the DOM pool after 5 years. DOM will start transferring to the SOC pool after 10 years.

Bearing in mind all of these specific country circumstances, Dominica did an effort to apply methods that allowed to fulfill the IPCC TACCC principles:

- Transparent, as data sources, definitions, methodologies, and assumptions are clearly described.
- Accurate, as it represents land-use categories, conversions between land-use categories, and [conditions before and after disturbances](#) as needed to estimate carbon stock changes and GHG emissions and removals.
- Consistent, as it allows to represent land-use categories consistently over time, without being unduly affected by artificial discontinuities in time-series data.
- Complete, as all land within the country was included.
- Comparable, as it allowed a full time series analysis using same definitions, methodologies, and assumptions.

5.2 Carbon pools

GHG historical analysis (2000 – 2017) and FRL (2018 – 2025) include the carbon pools: **above-ground biomass, below-ground biomass, dead organic matter, and soil organic carbon.**

Above-ground biomass was obtained from the National Forest Inventory from Saint Lucia (2009), as both islands share the same forest types and there is no recent Forest inventory has taken place in Dominica. Below-ground biomass and dead organic matter were obtained from default values of the 2006 IPCC Guidelines, 2019 Refinement

to the 2006 IPCC Guidelines. Soil organic carbon reference values were obtained from the FAO Global Soil Organic Carbon Map -GSOCmap-, from FAO (2019)⁶³.

5.3 Gases Included

Carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) emissions from biomass burning in forest land categories are included. Emissions in carbon dioxide equivalents (CO₂e) are reported using the **100-year global warming potentials (GWPs)** contained in **IPCC's second Assessment Report (AR 2)**.

5.4 Scale

The scale of the inventory is National. The total land area is 750 square kilometers (km²) (75000 Ha). The country is divided into 10 parishes. A systematic sampling grid of 1605 plots located 750m distance apart was used to allow a national coverage analysis of the island.

5.5 Reference Period

Dominica has decided not to use the historical period (2000-2017) as a reference for the projected period (2018-2025), adjusting to national circumstances. Therefore, projections for 2018-2025 are based on new circumstances that took place in 2018 and the years after, along with assumptions based of local expert knowledge, and local and regional studies for the conditions that allow for tropical forest recovery after hurricane impacts.

5.6 Definition of the FRL/FREL

Historical net GHG emissions and removals average -100,610 tCO₂e from 2001 to 2016 including all carbon pools (AGB, BGB, DOM, SOC), and for CO₂ and non-CO₂ gases (CH₄, N₂O). However, this average does not represent future expected Dominica GHG emissions and removals dynamics. Because of the hurricane Maria in 2017, the emissions in the AGB and BGB pool were much higher than the historical average that year, losing approximated 15 million tCO₂e. However, most of the losses in the AGB_BGB pool were transferred to the DOM pool, estimated about -14.6 million tCO₂e, increasing drastically the C stocks in the DOM pool. In addition, as these historical emissions and removals were based on a forest that does not exist anymore as it was known, the post-hurricane conditions are different, and therefore, the historical average cannot be used to represent the expected future emissions or removals (table 2). As a result, Dominica is proposing a FRL/FREL taking into consideration post-hurricane conditions, mostly based on forest recovery, through natural and assisted regeneration.

⁶³ <https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/global-soil-organic-carbon-map-gsocmap/en/>

Table 2 Forest related net balance of GHG emissions and removals 2001-2017 [tCO₂e]

Year	Net balance emissions and removals [tCO ₂ e]	Net balance emissions and removals in F>F (undisturbed) [tCO ₂ e]	Net balance emissions and removals in F>F (disturbed) [tCO ₂ e]	Net balance emissions and removals in land converted to F [tCO ₂ e]	Net balance emissions and removals in F converted to other land uses [tCO ₂ e]
2001	-126,904	-126,904	0	0	0
2002	-126,904	-126,904	0	0	0
2003	-126,904	-126,904	0	0	0
2004	-126,904	-126,904	0	0	0
2005	-108,344	-126,202	0	0	17,858
2006	-92,256	-124,626	0	0	32,370
2007	-120,136	-124,626	0	0	4,490
2008	-120,136	-124,626	0	0	4,490
2009	-120,136	-124,626	0	0	4,490
2010	-120,136	-124,626	0	0	4,490
2011	-100,917	-124,050	0	0	23,134
2012	-54,120	-120,958	0	0	66,837
2013	-84,072	-119,382	0	-7,712	43,022
2014	-63,177	-117,338	0	-1,541	55,702
2015	-42,133	-113,710	0	-1,541	73,117
2016	-76,582	-113,256	0	-7,696	44,369
2017	780,016	-28,904	730,654	-1,015	79,281
Average	-51,317	-117,326	42,980	-1,147	26,685

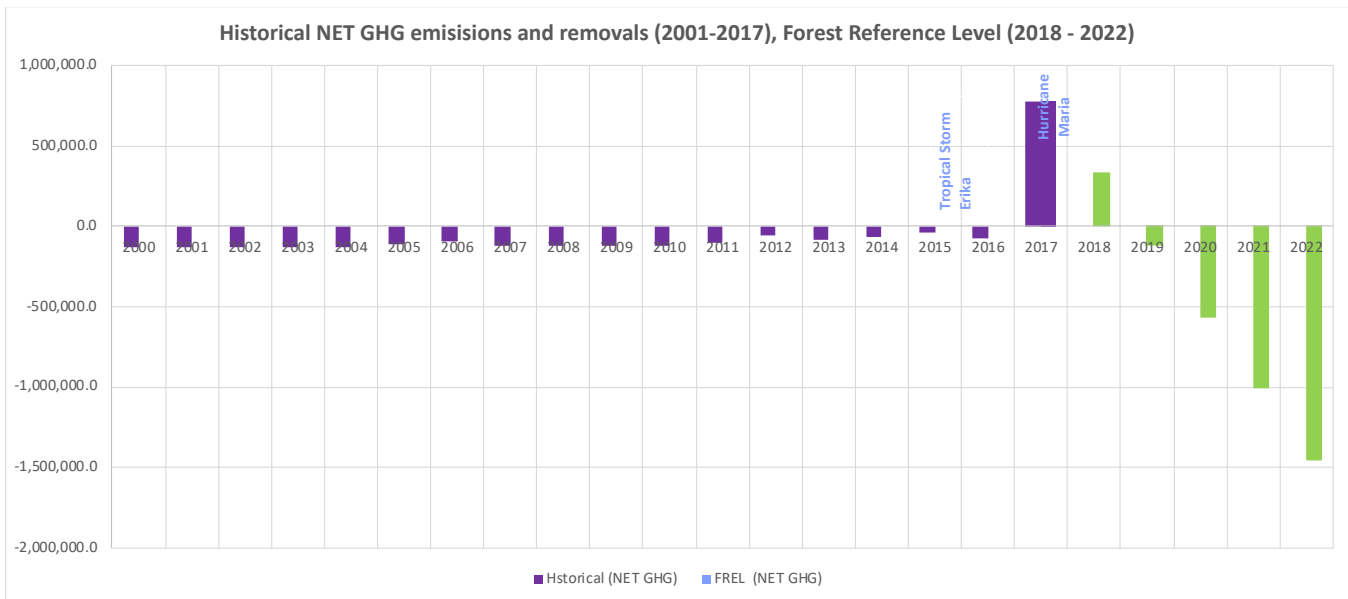
After the hurricane, some forest areas started to regenerate naturally; in other forest areas, restoration, rehabilitation, and reforestation projects have been necessary, for which the Government has drafted multiple projects to support and enhance the forest recovery. It is based on this context that the selected baseline considers the expected C removals due to post-disturbance forest regrowth as natural regeneration starting in 2018, along with the expected C removals of lands converted to forest lands, and the emissions due to deforestation in only the zone of “no significant damage”, estimated to be 25% of the historical deforestation rate. The net annual GHG balance of emissions and removals for the period 2018 -2025 is estimated as -446,983 tCO₂e/yr (table 3). Therefore, Dominica will use the post-hurricane net balance as benchmark for assessing the country’s performance in implementing the activities referred to in decision 1/CP.16, paragraph 70 (figure 28).

 Table 3 Expected annual net GHG emissions and removals [tCO₂e]

Year	Annual Net balance [tCO ₂ e / yr]
2018	-446,983
2019	-446,983

2020	-446,983
2021	-446,983
2022	-446,983
2023	-446,983
2024	-446,983
2025	-446,983
Sum	3,575,860

Figure 27 Historical NET GHG emissions and removals (2001-2017), Forest Reference Level FRL/FREL (2018 - 2022)





6. FOREST SECTOR BACKGROUND

6.1 Forest sector Background

Dominica is considered one of the wettest islands in the Caribbean with its inland receiving on average more than 10,000mm of rainfall annually. The island's rugged and steep terrain gives rise to plenty of perennial streams, rivers, lakes and waterfalls. These coupled with its high rainfall, results in extremely lush vegetation resulting in sixty-five percent of the island area covered by natural vegetation. This lushness together with the island's terrain, provides for areas of high biodiversity and relatively intact ecosystems giving Dominica its reputation as the "Nature Island of the Caribbean".

Dominica's island geography and complex geology have created unique habitats and high species diversity. More than 60% of the island is covered with lush forest and its fauna includes: 179 species of birds, 55 species of butterflies, 20 species of crabs, 11 species of crayfish and shrimp, 3 species of amphibians, 17 species of reptiles (4 snakes), 18 mammal species, 11 stick insect species, and around 45 species of inland fish. It is home to a number of global important species, housing a critically endangered toad and an endangered frog, bird, freshwater fish, and grass species. In addition, it comprises two island endemic bird species, 5 endemic reptiles, one endemic frog species and one endemic butterfly as well as a number of lesser Antilles and regional endemics.

Based on the last land use and land use change assessment (2020) done by the Forestry, wildlife and parks Division, Dominica in 2017 had 57.804 Ha of remaining Forest, mostly montane rainforest 28.131 Ha followed by semi-evergreen forest 10.607 Ha and Deciduous Forest 6,262 Ha (table 4).

Table 4 Forest area change from 2000-2017 [Ha]

	AREA CHANGE [HA]				
	2000	2005	2010	2015	2017
<i>Elfin forest</i>	2,009	2,009	2,009	2,009	2,009
<i>Cloud forest</i>	4,907	4,907	4,907	4,907	4,860
<i>Montane Rainforest</i>	28,271	28,271	28,224	28,131	28,131
<i>Semi-evergreen Forest</i>	10,841	10,841	10,841	10,701	10,607

⁶⁴ Photo: <https://www.lonelyplanet.com/articles/dominica-hiking-passport>



Forestry, Wildlife and Parks Division

<i>Deciduous Forest</i>	6,355	6,308	6,308	6,262	6,262
<i>Dry Scrub Forest</i>	2,103	2,009	2,009	1,822	1,822
<i>Litoral Forest</i>	4,065	4,065	4,065	4,019	4,019
Total	58,551	58,411	58,364	57,804	57,804

Only 747 ha of forest were lost in 17 years, which represents 1.29% of the total forest by 2017 and an annual deforestation rate of 44 ha. In an effort to protect these important ecosystems and their biodiversity, Dominica has established seven protected areas over the years, with a further three areas proposed (figure 29).

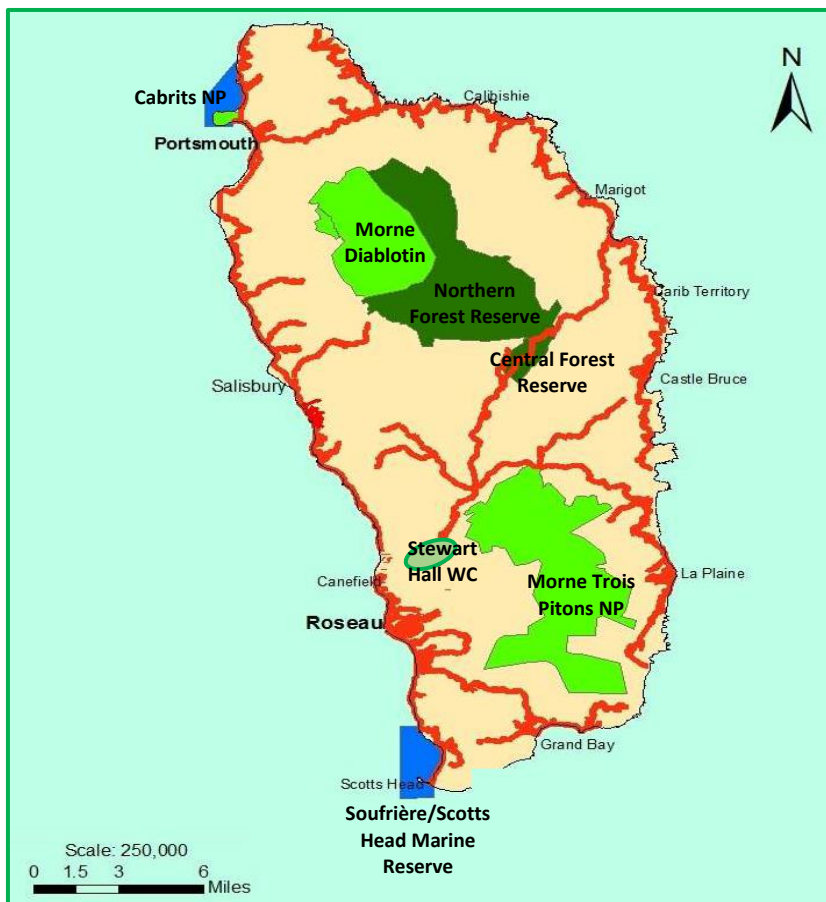


Figure 28 Map of Dominica’s Protected Areas System (Adapted from Dominica’s Biodiversity Strategy and Action plan 2014-2020)

The management of these protected areas are shared over a number of different Institutions (table 5).



Table 5 Area of Protected Areas System [Km2]

Protected Area	Area km2	Year established	IUCN Category	Management Authority	Key feature(s)
Central Forest Reserve	4.1	1952	VI	Ministry of Environment, Rural Modernisation and Kalinago Upliftment (MoE) – Division of Forestry, Wildlife and Parks Division (DFWP)	<ul style="list-style-type: none"> • Oldest Forest reserve • Abundance of gommier
Morne Trois Pitons National Park	68.75	1975	II	MoE-DFWP -National Parks Unit (NPU)	<ul style="list-style-type: none"> • Dominica’s first National Park and a World Heritage Site • Valley of Desolation • Boiling lake • Emerald pool • Boeri lake
Stewart Hall + all Water Catchment	3.18	1975 1995	VI	Dominica Water and Sewerage Company (DOWASCO)	<ul style="list-style-type: none"> • Water catchment areas providing water to island
Northern Forest Reserve	88.14	1977	VI	MoE-DFWP	<ul style="list-style-type: none"> • Watershed conservation area
Cabrits National Park	1.1 (terrestrial) 4.21 (Marine)	1987	II	MoE-DFWP -National Parks Unit (NPU) Ministry of Blue and Green Economy, Agriculture and National Food security (MoAF)- Fisheries Division	<ul style="list-style-type: none"> • Twin peaks of extinct volcanoes • Extensive swamp area • Important wetland
Soufrière/Scotts Head Marine Reserve	5.35	1998	V	MoAF- Fisheries Division SSHMR LAMA	<ul style="list-style-type: none"> • The largest and deepest near shore submarine volcanic crater in the Caribbean.
Morne Diablotin National Park	34.5	2000	II	MoE-DFWP -National Parks Unit (NPU)	<ul style="list-style-type: none"> • Morne Diablotin-highest mountain in Dominica • Picard Gorge
Total Terrestrial Area	199.77				
Total Marine Area	96.56				

The island is characterized by a very youthful and fragile forest landscape, which makes it very susceptible to the effects of land degradation. However, historically Dominica has a strong tradition of conserving its land resource base. In the post-World War II period, the banana industry developed, leading to the introduction of heavy machinery to build infrastructure (e.g. roads) together with increased housing needs related to the expanding economy. Thus, significant pressures were brought to bear on the fragile resource base with increasing levels of land degradation and desertification that is now being compounded by impacts from climate change ⁶⁵.

The general pattern of land use in Dominica has been dictated by topographic limitations. The highest, most rugged elevations in the interior have remained inaccessible and therefore forest cover - which constituted Dominica’s largest carbon sink. The narrow flat floodplains of the major rivers in the country have seen the most intensive land utilization, predominantly agriculture, with hillside cultivation extending into the mid-elevation areas along road access routes. Banana and temporary (vegetable and root) crops, coconut and citrus dominate commercial

⁶⁵ 3.4. Land Use, Protecting Carbon Sinks, and Enhancing the Resilience of Natural Ecosystems:
https://unfccc.int/files/cooperation_support/nama/application/pdf/dominica_low_carbon_climate_resilient_strategy_%28finale%29.pdf



agricultural production in Dominica. Urbanization has been largely confined to the narrow coastal fringe, although newer settlements have been expanding into the interior along the rural road network.

Historically, the majority of the land area in Dominica was parceled into large estates owned by the Crown (mainly unutilized lands in the interior) and private owners (major agricultural estates). As agricultural output from these large estates declined over time the land was subdivided and sold as smaller agricultural parcels and housing lots. By extension, the transition from larger-scale agriculture to small farms has also had implications for implementation of land conservation measures and efforts to enhance the resilience of natural ecosystems to address climate change concerns. As holdings become smaller, farmers tend to cultivate the full acreage within the holding in short-term crops to maximize financial returns.

Dominica's agriculture sector has declined due to weather-related events and fluctuations in world market conditions, but it is still vitally important for rural livelihoods and an important contributor to employment. Tourism is growing, largely based on ecotourism and government support. The Government of the Commonwealth of Dominica (GoCD) is promoting Dominica as a "nature island" destination. Presently, Dominica lacks a timber industry, and the use of non-timber forest products (NTFPs) is not significant. However, the indirect contribution of forestry is very important. Forest resources, especially in its national parks and ecosites, are a key source of the island's high biodiversity and play an important role in attracting tourists. There are close cross-sectoral connections with other sectors as well. Forests in Dominica also have important social dimensions: they have always been connected to the Kalinago (a unique population of pre-Columbian indigenous people) and are considered very important from a history/cultural perspective. Furthermore, an estimated 20 percent of jobs in Dominica are indirectly linked to forestry

Dominica's economy reflects many of the traditional features of a small open economy. This includes a high level of dependence on external trade as a proportion of gross domestic product (GDP), dependence on single sector export products (agriculture) and tourism revenue, high levels of underemployment and unemployment, and dependence on foreign capital (both public and private sector) for investment into productive sectors and for infrastructural development.⁶⁶ The Dominican economy has been dependent on agriculture - primarily bananas - in years past, but increasingly has been driven by tourism as the government seeks to promote Dominica as an "ecotourism" destination mainly because Dominica is recognized to be *"The Nature Island of Caribbean"*.

Climate change has both on-site and off-site effects on land. On-site effects include the lowering of the productive capacity of the land, causing either reduced outputs (crop yields, livestock yields) and/or the need for increased inputs. Off-site effects include changes in water regime, such as decline in water quality and sedimentation of riverbeds and reservoirs, with increased sedimentation rates in rivers being expected in Dominica due to climate change. Moreover, Dominica is located in the hurricane belt and is highly susceptible to hurricanes. On average the island is impacted directly or indirectly approximately once every four years by hurricanes, with on average one hurricane every 15 years hitting it. Dominica has had two Category 5 hurricanes Hurricane David in 1979 and more recently Hurricane Maria in 2017, which was preceded by Tropical storm Erika in 2015. All brought devastation to

⁶⁶ Information from Dominica's INDC.



the island, causing significant damage to the environment, with trees stripped of leaves, damaged, and even uprooted, destroyed housing and infrastructure, led to water shortages and disease and even in some instances death. Many coastal and marine and eco-tourism sites were damaged and high winds, flooding, and sea swells impacted businesses along coastal areas, along rivers, and in the forest reserve.

6.2 National legislation related to Forest sector

Legislation

The **National Parks and Protected Areas Act No. 16 of 1975** amended by Acts 54 of 1986, Act 12 of 1990, Act 8 of 2001 and Act 1 of 2015, is currently the overarching legislation providing for the declaration and management of terrestrial Protected Areas. The Act provides for the declaration of both national parks and PAs (excluding MPA's with the exception of Cabrits NP), leasing of land for PAs and the establishment of a System of National Parks. However only three of the current seven PA's, which are all considered national parks, were established under this legislation (MTPNP, MDNP and CNP) and whose administration, management and control falls under the remit of the MoE. The Act outlines the purposes for which PAs may be declared, and authorizes the MoE, by order, to set aside state lands for PAs in the form of national parks, historic sites, and recreational areas and to develop regulations. The Act also provides for the establishment of a National Parks Service, led by a Director of National Parks (DNP) and an advisory council whose role is to advise Minister on all matters related to the System of National Parks. However, while a National Parks Unit has been set up, there is currently no DNP or park advisory council. The Act authorizes the DNP to prepare management plans for its National Parks which will be open for public review, although to date no plans have been approved. The roles and powers of park wardens is also provided in under this Act. The Act does not however provide for matters related to a protected areas system such as system plan development. Since its enactment a number of Statutory Rules and Orders and regulations related to the PA system have been developed under the National Parks and Protected Areas Act.

- A User Fee Regulation **SRO No. 27 of 1997** amended, **SRO No. 22 of 2008**, **SRO No. 7 2013**. authorizes the National Park to generate revenue from user fee ticket sales, License fees from tour operators, vendors and tour guides. Permits for researchers, media personnel and impounding fees from animals in the Parks as well as Park fines for illegal activities in the Park.
- **The National Parks Regulations, No. 54 of 2003**, outlines the code of conduct in protected areas (hours of operation for visitors, prohibited activities, products permitted to be sold in the park, fees on impounding of animals, offences, fines etc.).
- Amended boundaries for parks established under the Act. **SRO 3 of 2000**, **SRO 24 of 2001** and **SRO 36** provide a description the Morne Diablotin National Park boundary and **SRO 54 of 1986** provides a description of the Cabrits National Park amended boundary.

In order to strengthen the management of all categories of PAs and not just National Parks, Dominica has drafted a new **Protected Areas Bill** to replace the existing National Parks and Protected Areas Act. This Bill provides the legislative framework for the establishment, development and effective management of protected areas which will



supersede existing laws that contradict the Bill. It further repeals National Parks and Protected Areas Act regulations except those that are consistent with the Bill. This bill provides for the for the establishment of a protected areas system and the preparation and implementation of a plan for the system of protected areas as well as individual PA management plans. Under this bill a Protected Areas Authority, whose function will be to coordinate an integrated approach to the management of protected areas will be established to function as a management authority in respect of national parks and any other protected area for which it has management responsibility. The Bill also provides for the establishment of a Scientific Committee providing advice of a scientific nature to the Authority in the discharge of its functions under the Bill. This draft Bill is still under revision and has not yet been approved.

The **Forest Act, 1958** provides for forest management and the establishment of Forest Reserves on Crown Lands and protected forests on private lands. Currently this is the primary legislation for the Central and Northern Forest Reserves. The **Forest Ordinance Cap. 80, 1959** specifically, covers the designation of forest reserves and includes the designation of private lands as protected forest for water or soil conservation or other public purposes. It is under this Ordinance that the **Forest Rules SRO 17, 1972** were established which specifies prohibited activities in forest reserves and gives details on the issuing of licenses and permits for harvesting forest produce, and the declaration of Stewart Hall Water Catchment as protected forest, **Stewart Hall Water Catchment Rules SRO No. 11, 1975**.

The Forestry and Wildlife Act No. 12 of 1976, amendments **No. 35 of 1982** and **No. 12 of 1990** provides for the protection and management of wild fauna and the management of their forest habits and provides for the creation of wildlife reserves. Under this Act, a wildlife reserve could be declared within the boundaries of an existing PA and the address PA management through various prohibited activities such the introduction of alien species without a permit and hunting in national monuments. This Act however, is not currently linked to other legislation addressing species protection or to the national obligations under conventions such as CITES or CBD.

Relevant regulations further established under this Act are:

Forestry and Wildlife (Fees) Regulations No. 19 of 2014, under section 53 of the Forestry and Wildlife Act, prescribes fees to be paid for seasonal hunting and fishing licenses as provided in Table 5.

Water Catchment Rules of 1995, under the Forestry and Wildlife Act, declare all water catchment areas as protected forests and managed by the Dominica Water and Sewerage Company Ltd. (DOWASCO). Water Catchment Rules include all regulations on prohibited acts, control of dwelling houses and other.

The **Physical Planning Act (2002)** mandates that persons or agencies must apply to develop land and construction practices and includes provisions for prohibitions on land use activities that causing environmental damage. It was established to ensure all development is carried out in an environmentally sustainable manner and requires the preparation of environmental impact assessments for development projects. This Act considers national parks and protected areas as a land for conservation purposes through the preparation of land use/development plans and is likely the most relevant for the establishment and management of any buffer zones surrounding PA's.

Tourism (Regulations and Standards) Act, 2001. This Act recognizes that the PAs form the base of the ecotourism product, and as such, ensures that all services offered at all national parks and marine management areas will focus primarily on tourists.



Other relevant legislation indirectly related to PA's and their management

- Land Acquisition Act, 1953.
- Crown Lands Ordinance and the Crown Lands Regulations, 1961
- Maritime Areas Act, 1981
- Beach Control Act, 1966, 1990
- Environmental Health Services Act, 1997
- Protection of New Varieties of Plants Act, 1999
- Pesticide Control Act, Pesticides Control (Prohibition) Regulations 2020

National Policies

National Resilience Development Strategy 2030- is the overarching framework which provides the road map and guidelines for taking the country to where it ought to be by 2030. Its vision is for Dominica to be the *“First Climate Resilient Country in the World”*. One of the main objectives of the Strategy is to promote sustainable tourism development through the protection, conservation and development of the natural environment within its carrying capacity. It highlights several ways in which it will implement this which include collaborating with relevant agencies to promote the designation of specific areas, including conservation areas, for the development of tourism and coordinating the maintenance, development and management of the national parks, nature sites and trails. Thus, the Protected Areas System will play an important role in the country achieving its resilience development goals.

National Biodiversity Strategy and Action Plan (NBSAP) 2014-2022-As part of its UNCBD agreement the Government of the Commonwealth of Dominica along with the other signatories developed a NBSAP. The national biodiversity strategy sets out Dominica's vision for biodiversity and defines the broad policy and institutional measures that they will take to fulfil the objectives of the Convention. It also provides an action plan to achieve the strategy taking the 20 Aichi targets into account. This is the primary national policy as it relates to PA's. One of its four main objectives is *“To ensure that the basis for development is through the sustainable use of terrestrial and marine biological resources”* with a target for this objective being *“By 2020, at least 15% of terrestrial, inland water and 15% of coastal and marine areas especially areas of particular importance for biodiversity and ecosystem service, are conserved through comprehensive ecologically representative and well-connected systems of effectively managed protected areas and other means and integrated into the wider land and seascape”*

National Land Use Policy, 2014- provides direction for all land use decisions and describes how best to manage development to improve quality of life for Dominicans, through economic and social development, protecting human health and safety, and conserving the natural environment. The National Land Use Policy, enabled under the Physical Planning Act, 2002, represents the overarching policy that guides the development of the National Physical Development Plan. The National Land Use Policy is highly supportive of the protection of the national parks and recognizes the importance Protected Areas to Dominica's Nature Island brand. Protected Areas are incorporated under the national polies specifically by enhancing the vitality of forest reserves and national parks, **ensuring** National Parks are highly valued by citizens and tourists, and to protect and strengthen public access National Parks.



Physical Development Plan, 2016 -acts together with the National Land Use Policy guide planning for future land use and development in Dominica. Overall, its vision is for well managed settlements, agricultural lands, rivers, forests, coastal zones, and biodiversity. It recognizes the importance of National Parks and Forest Reserves to the natural environment, towards climate change mitigation and adaptation and to Dominica's identity. It prescribes the area adjacent to National Parks and Forest Reserves and marine zones as a transition zone and sets out considerations for development within these zones. It proposes the establishment of a third Marine reserve, Salisbury Marine Reserve and considers key species' nesting sites into its plan for land, development areas specifically turtles and parrots nesting sites.

The **National Tourism Policy** – defines the vision and direction of the Dominica's tourism sector. Its vision is for sustainable tourism which includes the national tourism policy is essential to define the vision for tourism and the direction protecting the natural resources and scenic, heritage and cultural features of the country. It states the importance of environment-based natural attractions, facilities, amenities, services and supporting infrastructure and maintaining and enhancing Dominica's pristine environment is one its guiding principles. It has objectives directly related to the system of Protected Areas, specifically to work in partnership with parks management to manage and plan for the sustainable use of the national parks, nature sites and the other protected areas while at the same time maintain the integrity of the resources as it offers quality experiences to visitors.

The Tourism Master Plan 2012-2022 -provides a framework for the development of the tourism sector in Dominica, identifying priority areas for tourism development, related tourism facilities and supporting infrastructure. The potential and opportunities across Dominica's Protected Areas System in growing the country's tourism sector are well recognized in this Master Plan. The plan identifies several areas and plans for tourism development across the country. Specific plans for tourism development within the system of Protected Areas have been highlighted in the previous section 2.1.3.

The **Forest Policy Statement for the Commonwealth of Dominica (2010)** - was developed in order to guide the sustainable management of Dominica's forest resources, while maintaining or improving the present area of forest cover. The Policy covers all of Dominica's forested areas, including Forest Reserves, National Parks, Unallocated State Lands, Carib Territory, and Privately Owned Land. The Policy addresses natural forests, plantations, as well as deforested, degraded forests and agro-forests.

International Commitments⁶⁷

The multilateral environmental agreements (MEAs) directly or indirectly relevant to protected areas that have been signed by the Government of Dominica are:-

- UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage, 1972, ratified 1994
- United Nations Convention on Biological Diversity (CBD), ratified 1994

⁶⁷ National Environmental Summary Commonwealth of Dominica 2010.



- Cartagena Protocol on Biosafety to the Convention on Biological Diversity, 2000, ratified 2004
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973, ratified 1995
- United Nations Framework Convention on Climate Change (UNFCCC), 1992, ratified 1994;
- United Nations Convention to Combat Desertification (UNFCCC), 1994, ratified 1997
- United Nations Convention on the Law of the Sea (UNCLOS), 1982, ratified 1991
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, ratified 1978
- Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention), 1982, ratified 1990
- International Convention on Civil Liability for Oil Pollution Damage, acceded 2001

6.3 Institutional Overview

The management of Dominica's Protected Areas is shared across two Ministries, two local management authorities and a public utility, with no overarching or co-ordination mechanism, making the overall management of the Protected Areas System complex and fragmented (figure 30).

Under the National Protected Areas Act 1976, and the Forestry Act, 1958 the **Ministry of Environment, Rural Modernization and Kalinago Upliftment (MoE)** is responsible for establishing and managing national parks, protected land and forest reserves. It is the Forestry, Wildlife and Parks Division (DFWP) under this Ministry that is responsible for the management and/or administration of the three National Parks, (MTPNP, MDNP and Cabrits NP) and the Central and Northern Forest reserves. The SHWC is managed by the Dominica Water and Sewerage Company Ltd. (DOWASCO) under the Memorandum of understanding "*To undertake a Joint Management Approach for all the Lands Forming Part of the Stewart Hall Water Catchment Protected Forest*" signed with the MoE-DFWP in 2013. However, currently all water catchments fall under the responsibility of DOWASCO (SRO.11,1995).

Several smaller units fall under the DFWP with the largest National Park's Unit responsible for the three National Parks. The administration and management of the two forest reserves falls under the Conservation, Protection & Maintenance Unit. There is also the Forest Administration Unit and includes the Research and Monitoring Unit, the Environmental Monitoring and Research Unit and Clerical Staff. Lastly, the Forest Management Unit is responsible for all forest resource use as well as the establishment of forest plantation, reforestation programmes and agro-forestry.

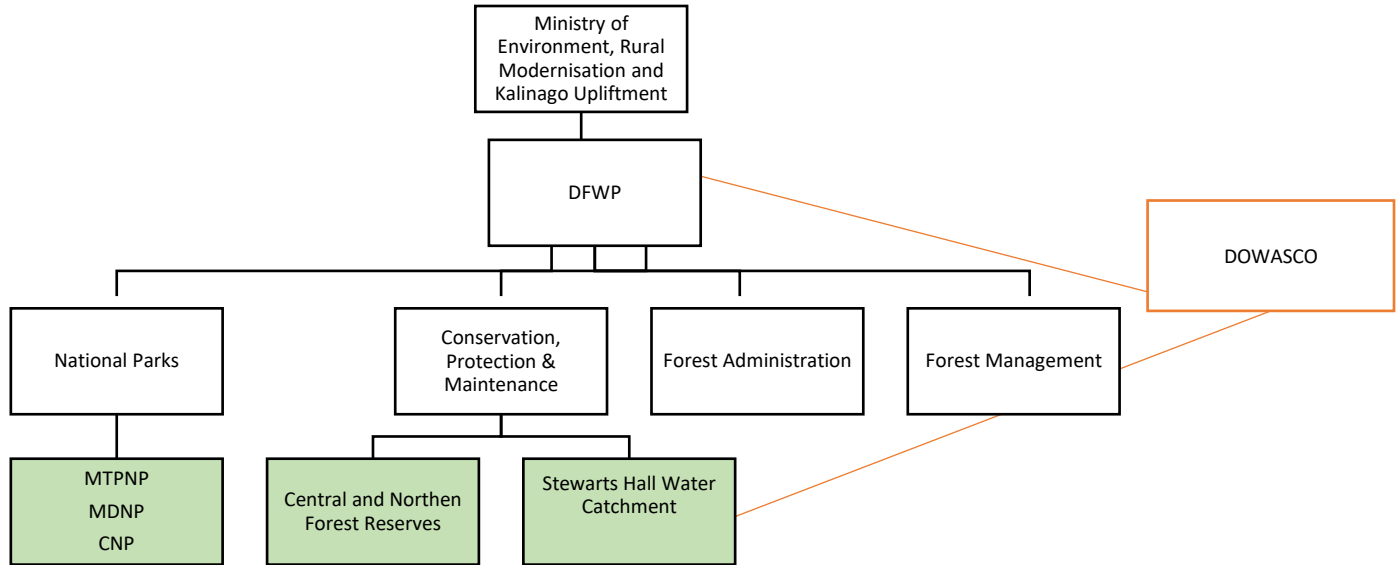


Figure 29 Diagram showing the current institutional set up for managing the PA system. Green boxes represent the PA's that constitute the current PA system. Black lines indicate the legally mandated management structure and orange lines indicate formal agreements

6.4 Procedures and arrangements for the preparation of the FRL

A brief description of procedures and arrangements undertaken to collect and archive data for the preparation of the FREL is included, with information on the role of the institutions involved (Table 6).

Schedule of FRL/FREL tasks

The process started with review of reports and datasets, data collection, selection, processing and analysis, QC/QA procedures, and finalized with a compilation of the FRL/FREL. The process was completed by internal and external independent review.



Table 6 FRL tasks

Stages	Responsible
Identification and formation of the team	DFWP
Allocation of tasks	DFWP
Technical training	CfRN
Data collection	DFWP/ Ministry of Agriculture, Food and Fisheries / CFRN
QC/QA procedures	DFWP/ CFRN
Data analysis	DFWP/ CFRN
Compilation of the FREL	DFWP/ CFRN
QC/QA procedures	DFWP/ CFRN
Independent review	CfRN RRR+IP
Improvement plan	DFWP

DFWP: Forestry, Wildlife and Parks Division CfRN: Coalition for Rainforest Nations. CfRN RRR+ IP: Coalition for Rainforest Nations Independent Panel of Review.

Means of data acquisition and management

Data acquisition

Activity Data:

- On August 29th – 230th 2019, 12 Dominican national experts from the Forestry, Wildlife and Parks Division and Division of Agriculture (Ministry of Agriculture, Food and Fisheries) attended a training by CfRN aimed at increasing knowledge about standardized tools to be used for AFOLU GHGI preparation. Specifically, focus was given at collecting Activity Data through a Collect Earth Campaign, where key steps were discussed such as the protocol for standardizing interpretation and Land Use and Land Use Change Transition Matrix structure for quality control purposes. Furthermore, best practices and lessons learnt with other RRR+ countries were shared with the view to enhance south-south knowledge. Forest definition was discussed and agreed by all participants as well as the sub-divisions for all 6 IPCC categories of land use.
- On November 11th-15th 2019, 3 national experts from the Forest DFWP, and 1 from Agriculture, attended a joint-training with St.Lucia, Belize and Panama, led by CfRN, aimed at increasing knowledge



Forestry, Wildlife and Parks Division

about GHG tools and IPCC guidelines to be used for AFOLU-GHG inventory preparation. Specifically, focus was given to collecting Activity Data through a Collect Earth Campaign, where experts from Belize and Panama led a South-South exchange for the assessment of Land Use and Land Use Changes following the IPCC methods, resulting in a consistent time series as the main input for the GHG Inventory. The information collected is to be used in the preparation and submission of AFOLU-GHG Inventories to the UNFCCC via National Communications (NCs), Biennial Update Reports (BURs), Biennial Transparency Reports (BTRs); also, as a basis for a potential REDD+ Forest Reference Emission Levels/Forest Reference Levels (FREL/FRL).

List of data providers, roles, and responsibilities

Table 7 List of data providers, roles and responsibilities

Institution	Division / Department	Name	E-mail	Role (Data Provider/Data Archiving/ QA/AC/Inventory Prep)
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Minchinton Burton	directorforestry@dominica.gov.dm	Director Forestry, Wildlife and Parks Division - Coordinator
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Bradley Guye	guyeb@dominica.gov.dm	Technical Lead, Activity Data Collection for LULUC 2000-2018, GHGi Preparation, Documentation, QC, Archives.
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Machel Sulton	machelsulton@hotmail.com	Activity Data Collection for LULUC 2000-2018, GHGi Preparation, Documentation, QC, Archives.
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Ricardo Dominique	ricardom13@gmail.com	Activity Data Collection for LULUC 2000-2018, GHGi Preparation, Documentation, QC, Archives.
Ministry of Blue and Green Economy	Agriculture	Nekelia Gregoire	gregoirenekelia@gmail.com	Activity Data Collection for LULUC 2000-2018.
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Felix Eugene	felixegene09@gmail.com	Technical Support
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Sheldon Simmon	sheldonsimmon@gmail.com	Technical Support
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Cyrille John	johnca63@hotmail.com	Technical Support



Forestry, Wildlife and Parks Division

Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Francisco Maffei	maffeif@dominica.gov.dm	Technical Support
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Richie Laville	richieville2@gmail.com	Technical Support
Ministry of Environment, Rural Modernisation and Kalinago Upliftment	Forestry, Wildlife and Parks Division	Nigel Harve	nigelharve@gmail.com	Technical Support

Data management

All the relevant datasets that have been used during the analysis have been documented. The archives database contains; (a) all inputs datasets and datasheets; (b) country-specific excel calculation tool, including GHG emission and removals estimates (c) manuals and protocols, (d) literature reviewed, (e) completed QA/QC templates and protocols, and (f) all reports and documentation. Archives are held by the Forestry Division.



7. Methodologies for estimating GHG emission and removals

7.1 Activity Data

The information on Activity Data (AD) used was obtained from land use and land-use change assessment, which was conducted on the basis of a sampling approach (IPCC approach 3) using Collect Earth, in which the land-use condition, including natural and/or human disturbance, was determined for each year of the time series 2000 - 2018. Forest land was stratified by forest type (Montane Forest -Elfin, Cloud montane, Montane Rainforest-, Seasonal Forest -Semi-Evergreen, Semi-Deciduous-, Littoral Evergreen, Dry Scrub). Croplands are reported as annual and perennial crops. Grasslands and Settlements are reported as Woody and Non-Woody. Wetlands do not have further sub-classification and Other lands divided in Other Lands and Mining.

The information on wood removals was derived from the Collect Earth assessment as cover loss instead of volume loss, as the tool does not allow that estimation. Losses due to Disturbances were also identified including Hurricanes, Fires, Logging and Shifting Cultivation, specifically on Forest lands.

7.1.1 Land Representation Approach

According to the 2006 IPCC guidelines, Dominica implemented the Land Representation Approach 3, as it is characterized by spatially-explicit observations of land-use categories and land-use conversions, tracking patterns at specific point location. It is a sampling approach, different to wall-to wall approach (maps), using the Collect Earth tool.

In order to use the sampling approach, clear definitions of land uses were needed. Thus, a workshop took place on August 29-31, 2019. 12 national experts from forestry, agriculture and statistics participated. During this workshop the following land uses were agreed (figure 31).



Figure 30 Preparation workshop with Dominica national experts

⁶⁸ Photo: <https://www.kempinski.com/en/dominica/cabrits-resort-kempinski-dominica/local-information/nature-playground/>

7.1.2 Land Use Classes

Dominica followed 2006/2019 IPCC guidelines structure for the FOLU sector, including the six main land uses proposed: Forest lands, Cropland, Grassland, Wetlands, Settlement, and other lands (Table 8).

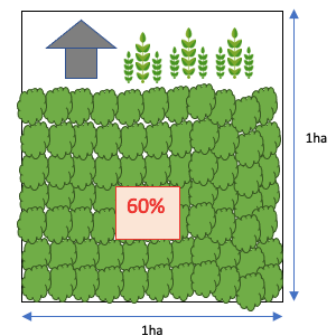
Table 8 Land Use classes and sub-categories for Forest land

IPCC categories		sub-categories			Location
Level 1		Level 2	Level 3	Code	m.a.s.l
Forest land	F	Elfin and Cloud Forest	Elfin forest	FELF	>900
			Cloud montane	FLOUD	701-900
		Montane Rainforest	Montane Rainforest	FRAIN	301-700
		Semi-Evergreen Forest	Semi-Evergreen Forest	FEVER	201-300
		Coastal Forest	Semi-Deciduous Forest	FDEC	101-200
			Dry Scrub	FDRYS	0-100 (west)
			Littoral Evergreen	FLIT	0-100 (east)
Croplands	C	Perennial crop		CPER	
		Annual crop		CANNUALC	
Grassland	G	Grasslands		GGRASS	
Wetland	W	Wetlands		WWET	
Settlement	S	Urban areas		SSET	
		Woody settlements		SWOODS	
Other land	O	Other land		OOTHER	
		Mining		OMIN	

7.1.3 Land Use Classes Definitions

Level 1: Forest (F)

Forest is defined as forest lands with a canopy cover equal or higher than 60% (aprox 1.5 acres), with a minimum area extension of 1 ha and woody vegetation of minimum 3m height or higher, including temporary unstocked areas with the potential to reach the forest definition.



Level 1: Croplands (C)



Crop lands and agroforestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. 1 ha area with more than 20% cover of any type of planted crop, but less than 60% cover of forest or 20% cover of infrastructure.

Level 1: Grasslands (G)

Open areas covered mostly by grasses or sedges, but other herbs and low shrubs are also present. Individual trees or small clumps of trees and taller shrubs may also be present. This vegetation class is most common near areas of Deciduous Seasonal Forest and is usually a result of extreme disturbance to that forest class. Abandoned gardens in wetter areas can temporarily take on this form, but quickly develop into secondary forest. This forest class is defined as a 1 ha area with more than 20% cover of any type of grassland, but less than 60% cover of forest or 20% cover of infrastructure.

Level 1: Wetlands (W)

Land that is covered or saturated by water for all or part of the year and does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed subdivision and natural rivers and lakes, reservoir of water, freshwater swamp seasonal (permanently depending on rainfall) and permanently muddy areas fall into this class. This class is defined as a 1 ha area with more than 20% cover, but less than 60% cover of forest or 20% cover of infrastructure.

Level 1: Settlements (S)

1 ha area with at least 20% cover of infrastructure (houses, roads, etc.), but less than 60% forest canopy cover.

Level 1: Other Lands (O)

Bare area with less than 20% cover of grasses, shrubs, trees, wetland, crops or infrastructure and all land areas that do not fall into any of the other five categories. Mining is classified as other land category.

7.1.4 Land sub-classes Definitions

Level 1: Forest lands (F)

Due to the lack of a recent National Forest Inventory, Dominica has used Saint Lucia's forest classification and definitions as described in Gravenon (2009) and complemented with country specific circumstances, as both Islands share the same conditions and forest types⁶⁹. It is important to note that Dominica is already initiating

⁶⁹ Gravenon R. (2009). National Forest Demarcation And Bio-Physical Resource Inventory Project Caribbean – Saint Lucia: The Classification Of The Vegetation Of Saint Lucia. FCG International Ltd in association with AFC Consultants International GmbH



a new national forest inventory, expected to be finalized by 2024. Once the information is available, descriptions and characteristics will be updated.

Level 2: Elfin and Cloud Forest

Level 3: Elfin forest

Slopes are extremely steep, rainfall is very heavy, there is little wind and landslides are very common. The steepest areas are covered with tree ferns and palms, with canopy height of about 4-6m, with some scattered taller trees on slightly less steep areas. Canopy cover is often quite complete on gentler slopes, but broken on steep slopes; ferns, mosses, ground anthuriums, vines, and epiphytes vary from absent to abundant; trees with buttresses and prop roots are present in some areas and absent in others. At ground level, it varies from humid, quite dark, and still, to rather breezy and bright. This variation results from natural factors, especially slope gradient, exposure to the prevailing wind, altitude (and therefore rainfall), and recent climatic disturbances. 3m high. Tropical or subtropical broad-leaved evergreen shrubland (includes bamboos and tuft-trees). In the windiest spots, at an elevation above 900 meters, a shrubland vegetation class dominates. Relatively few species are found in this vegetation type: mainly a mixture of bromeliads, sedges and grasses and shrubs, with many Lesser Antillean endemics.

Level 3: Cloud montane

This vegetation class is found on at an elevation of 700m or higher. The canopy is about 8m high with occasional much taller trees. Terrestrial ferns, anthuriums, bromeliads, and epiphytes are very common; moss cover is often several centimeters thick. Cloud and mist cover, with heavy rainfall, is predominant, with only occasional and short periods of sunshine. Some species found in Montane and Lower Montane Rainforest are also found here.

Level 2: Montane Rainforest

Lower Montane Rainforest merges with Semi-evergreen Seasonal Forest at lower elevations and with Montane/ Cloud Montane Rainforest at higher elevations. Trees are evergreen because there is no water deficit most years in any month. In general, trees of all heights are found, without clear divisions into separate canopy layers. Although there may be a shrub, fern and herbaceous (mainly Anthurium) ground cover, this forest class is easy to walk through (if one ignores the incline) except where the canopy has been destroyed and ferns, vines and shrubs colonize the clearing.

Away from the edge of the forest, on comparatively gentle slopes without much wind, occasional very tall trees, reaching 45m, are found among the main 30-m canopy. This distinctive forest is often called the *Dacryodes-Sloanea* alliance and is often over-emphasized as being the „typical“ rainforest. Exposed ridges often have a dwarfed vegetation because of high winds. Landslides are a natural phenomenon in Lower Montane Rainforest and can be seen at various stages of recovery.



In comparison to Semi-evergreen Seasonal Forest, the mean canopy height, wind, and incline are greater and there is a greater abundance of vines, epiphytes, ferns and mosses. The trees are more tightly packed, and the trees can be much wider in girth. This forest class has been recorded from 100- 680m above sea level.

Slopes are extremely steep, rainfall is very heavy, there is little wind and landslides are very common. The steepest areas are covered with tree ferns and palms, with canopy height of about 4-6m, with some scattered taller trees on slightly less steep areas. This class is poorly differentiated from Lower Montane Rainforest in terms of species, but it has a very characteristic appearance. It is found only on very steep slopes at high elevation: where the slope is gentler Lower Montane Rainforest replaces it.

Level 2: Semi-Evergreen Forest

Occupies the zone between Deciduous Seasonal Forest and Lower Montane Rainforest. It is characterized by upper canopy trees with rather thin, often broad, and quite often compound leaves, which may lose some, but not all, of their leaves during a dry spell. There are no, or very few, epiphytes, ground ferns and mosses. Rare forest, all secondary. Upper canopy trees with thin, broad and compound leaves. Might lose some leaves during dry season. This forest class is found in agriculture areas, river valleys below Lower Montane. In comparison with Deciduous Seasonal Forest, this forest class has a higher canopy and greater canopy cover and trunks with a greater girth. It occurs in less windy areas, and generally at a higher elevation.

Level 2: Coastal Forest

Level 3: Semi-Deciduous Forest

It merges inland with the Semi-evergreen Seasonal Forest: the upper slopes of high hills are often covered by Deciduous Seasonal Forest and their lower slopes, leading to ravines, covered by Semi-evergreen Seasonal Forest. This class is defined as deciduous because the taller trees tend to lose all their leaves in most dry seasons, although the smaller trees and shrubs are evergreen. Its overall appearance during a normal dry season is of a more or less leafless canopy. Lowland or sub-montane drought deciduous. It is characterized by patchwork with small gardens, recently coppiced areas, shrub, small and large trees. They are also found in some hills as natural with smaller trees and this forest class reaches an elevation up to 700m. [In Dominica, the Deciduous Forest is usually a dense canopy cover with mature forest species reaching approximately 35-40ft \(10-12m\) in height.](#)

Level 3: Littoral Evergreen

Behind sandy beaches, rocky cliffs and pavements, an evergreen forest or shrubland is found, especially on the Atlantic coast. The harsh conditions caused by wind, salt-spray, often a thin soil and a water deficit even



during most of the wet season, favour an evergreen arborescent flora with thick leathery leaves. *Coccoloba uvifera* (wézen, siwiz, sea grape) is commonly present in this vegetation class.⁷⁰

Level 3: Dry Scrub

This type of vegetation is found on the west coast of the island in a narrow zone between littoral rock and cliff vegetation and Deciduous Seasonal Forest or Littoral Evergreen Forest. It consists of forest trees, shrubs, cacti and sometimes grassy spaces influence by human activity (invasives, cleared zones, for animal grazing).

Level 1: Croplands (C)

Level 2: Perennial Crop

Land under permanent or medium-term crops. It is the land that during the reference year was mainly planted with crops which occupy it for a long period of time, and which do not have to be planted after each harvest. It includes all tree crops (bearing or not) banana, plantains, coconut, etc. In case of permanent crops inter-planted with temporary crops that land was reported here.

Level 2: Annual Crop

Land under temporary crops only. It is the land used exclusively for crops with a growing cycle of under one year, which needs to be newly sown or planted for further production after the harvest. It also includes some crops which remain in the field for more than one year and their harvest destroys the plant like cassava. Most common crops according to 2007 Agriculture Census⁷¹ were: tannia, dasheen, christophene, sweet potatoes, yam, cassava, tomato, peas, sweet pepper, cucumber, ginger, chives.

Level 1: Settlements (S)

Level 2: Urban areas

Development in relation to any land carrying out of building, engineering, mining or other operations in, on, over or under any land, the making of any material change in the use of any land or buildings, or the subdivision of any land, and “develops” and “developer” shall be construed accordingly.

Level 2: Woody Settlements

⁷⁰ For Dominica, the same classification as the National Forest demarcation and bio-physical resource inventory Project Caribbean – Saint Lucia. The classification of the vegetation of Saint Lucia (2010), was used

⁷¹ <http://www.malff.com/images/stories/Census%20Data/2007%20Census%20of%20Agriculture%20Summary%20Report.pdf>

A woody settlement is defined as a rural community with woody trees where both forest types and perennial crops are interspersed. 1 ha area with more than 20% cover mixed with woody trees but with less than 60% cover of forest.

7.1.5 Disturbances:

In general forests in Dominica have suffered physical damage as a result of hurricanes over the past few decades. A number of factors reduce the natural resilience of Dominica's forests ecosystems and increase their vulnerability to climate change and climate variability. Many natural hazards periodically affect or threaten Dominica, among them hurricanes, earthquakes, volcanic eruptions, storm, surges, and landslides. These natural disasters can be attributed as one of the root causes of biodiversity loss in Dominica.

Hurricane David in 1979 caused significant impacts on the island's forest resources, causing damage to in excess of 50% of the trees in the southern half of the island. Hurricanes cause loss of habitat and food supplies for wildlife species and result in wildlife mortality. An indirect resultant effect Hurricane David was the conversion of wildlife habitat to agriculture. In accessible areas the toppled trees provide an opportunity to more easily clear land for farming, resulting in a further fragmentation of wildlife habitat⁷².

Hurricane Dean in 2007 caused extensive defoliation resulting in loss of up to 35 percent of the forest cover over the eastern forest range (FAO, 2007)⁷³.

In August 2015, tropical Storm Erika triggered catastrophic floods and mudslides. Hundreds of homes were left uninhabitable and thousands of people were displaced; the entire town of Petite Savanne was evacuated and subsequently abandoned as a result of the storm. Flooding and landslides severely damaged transport infrastructure and substantially diminished the productive capacity of agriculture and tourism. The main airport was badly damaged.

In September 2017, Hurricane Maria made landfall in Dominica as a Category 5 hurricane with maximum sustained winds of 165 mph (265 km/h). These winds, the most extreme to ever impact the island, battered the roof of practically every home, with half the city flooded, cars stranded, and stretches of residential areas "flattened" it was indicated "total devastation". Its ferocious winds defoliated nearly all vegetation, splintering or uprooting thousands of trees and decimating the island's lush rainforests. The agricultural sector, a vital source of income for the country, was completely wiped out: with 100% of banana and tuber plantations was lost, as well as vast amounts of livestock and farm equipment (figure 32).

⁷² Dominica Low-Carbon Climate-Resilient Development Strategy 2012-2020

⁷³ <https://reliefweb.int/report/dominica/fao-agricultural-damage-assessment-mission-dominica-following-hurricane-dean>



Figure 31 Trees stripped by Hurricane Maria in the interior of Dominica, October, 2017⁷⁴

As a result of climate change, it is expected that the intensity of hurricanes will also increase, causing more severe damage, with potentially longer-term consequences for the integrity of the forest structure and canopy. Forest destruction from hurricanes recovers slowly with ecological implications such as landslides and soil loss and consequent socio-economic impacts such as impact on water quality and availability, and possible short to medium term tourism impacts.

7.1.6 Planning the land use assessment

After the experts decided on the land use categories that would be used to estimate the land use change over the years, clear classification criteria were needed to standardize the interpretation. Three main characteristics were selected.

a) Forest type by elevation.

As described in the previous section, forest types in Dominica are directly linked to elevation and location; therefore, the following figure was used to standardize the criteria of selection of a forest type (figure 33):

⁷⁴ Source: <https://www.nybooks.com/daily/2017/12/28/dominica-after-the-storm/>



Figure 32 Land uses by elevation and location developed during preparation workshop

Then, clear and unified elevations were assigned (table 9), including transition zones among forest, to allow a harmonized interpretation. Despite the clear criteria, it was acknowledged that because of the topography, some of these might not apply and the expert observation was given relevance at the moment of the interpretation; for instance, in the case of forests in valleys or cliff areas.

Table 9 Dominica's forest types and elevation ranges [m,(feet)]

	Predominantly m.a.s.l	Predominantly f.a.s.l	Transition m (feet)	Location
Dry Scrub	0-100	0-328		West
Littoral Evergreen Forest	0-100	0-328		East
Transition			70-130 (229-427)	
Seasonal Deciduous	101-200	329-656		all over
Transition			170-230 (557-755)	
Seasonal Semi Evergreen	201-300	657-984		all over
Transition			270-330 (856-1082)	
Montane – Rainforest	301-700	985-2297		all over
Transition			650-730 (2133-2395)	
Montane – Cloud Forest	701-900	2298-2952		all over
Transition			870-930 (2854-3051)	
Montane – Elfin forest	>900	>2953		Concentric rings around the island



m.a.s.l.: meters above sea level, f.a.s.l.: feet above sea level

b) Possible and Impossible land use changes

The next step in the discussion was agreeing what type of land use changes can and cannot happen. This included understanding which forest types can be affected by; for example, which type of crops, or which ones are more subject to conversion to settlements or any other land use that is different from Forest lands. The main goal was to standardize what the disturbance factors are and where Forests are more subject to conversion to Croplands, Grasslands, Wetlands, Settlements and Other Lands. Moreover, which disturbances, both natural and anthropogenic, have affected the islands such as hurricanes, fires in croplands for slash and burn, fire in grasslands for clearing the land for pasture, natural wildfires, pests etc. The result of the discussion can be seen in [figure 34](#):

Vertical: Land Use, Horizontal: Land Use Change	Forest Lands									Croplands		Grasslands	Wetlands	Settlements	Other Lands	Disturbances			
	Elfin	Montane Forest	Rainforest	Semi-evergreen	Semi-Deciduous	Dry Scrub	Littoral	Plantation	Tree Crops	Annual Crops	Grasslands	Wetlands	Settlements	Mining?	Hurricane/Storm	Fires	?	?	
Elfin	x																		
Montane Forest	x	x																	
Rainforest	x		x																
Semi-evergreen	x		ok	ok					ok	ok	ok	ok	ok	ok					
Semi-Deciduous	x		ok	ok	ok				ok	ok	ok	ok	ok	ok					
Dry Scrub	x		ok	ok	ok	ok			ok	ok	ok	ok	ok	ok					
Littoral	x		ok	ok	ok	ok	ok		ok	ok	ok	ok	ok	ok					
Plantation	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Tree Crops	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Annual Crops	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Grasslands	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Grasslands(grazing)	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Fumarol Veg (?)	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Abandoned lands	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Wetlands	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Settlements	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					
Other Lands Mining?	x		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok					

Legend :
 x Transition not possible in 1 year
 ok Transition seen in 1 year
 in color the land remaining in the same category

Figure 33 Land use and land use change matrix indicating possible and impossible land use changes developed during preparation workshop

c) Hierarchy for land use classification

A hierarchy for the land use categories was established for the visual interpretation during the CE/OF Assessment. This will allow determining the land used depending on the percentage of land use cover ([table 10](#)).

Table 10 Hierarchy of land use classification for Dominica for the visual interpretation in the 2019 CE Assessment

Land Use	% Minimum
Forest Lands	60%
Croplands	20%
Grasslands	20%
Wetlands	20%
Settlements	20%
Other Lands	20%

According to the 'hierarchy of land use classification', if a sample plot had 60% or more forest canopy, its land use was classified as "forest". If a sample plot has less than 60% of forest cover, a determination was made to classify the sample plot according to the hierarchy. For example, if a plot only has 10 % forest, 20 % of grassland, 20 % of cropland, and 50 % of other lands, according to the hierarchy, the classification was cropland (figure 35).

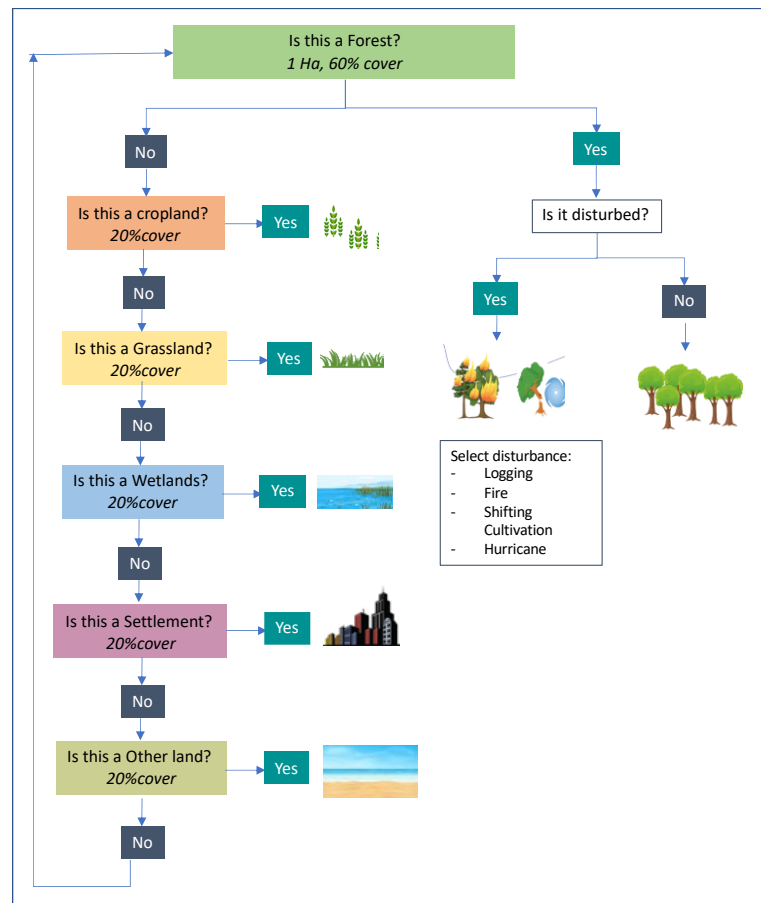


Figure 34 Diagram flow of land use classification hierarchy

7.1.7 Project Design

Based on the information collected during the workshop, the plot size, sampling grid and survey were designed.

Plot Size: The size of the plot was decided to be 1Ha, to allow consistency with the Forest definition. This, along with the samples, 49 of them, facilitated counting the percentage of land use cover, as indicated in the hierarchy diagram (figure 36).



Figure 35 Sampling plot size of 1Ha

Distance among plots: Based on the experience and lessons learnt of Panama and Belize who have recently done their Collect Earth assessment, using grids of 3km by 3km and 1.5 km by 1.5 km (Panama) and Belize (1km by 1 km), Dominica planned to use a high sampling intensity, balancing country size, representatives of the samples, time and interpreters availability. As a result, a sampling of 750m by 750 m was selected (figure 37).

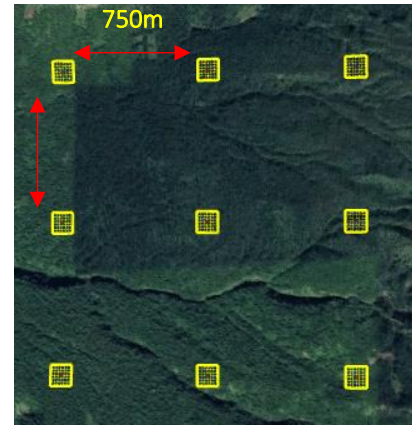


Figure 36. Plot size and distance among plots

National grid: Based on the previous analysis and criteria, a 750m by 750m national systematic grid consisted of 1605 sampling plots of 1Ha was selected. These sampling points were visually evaluated (figure 38).

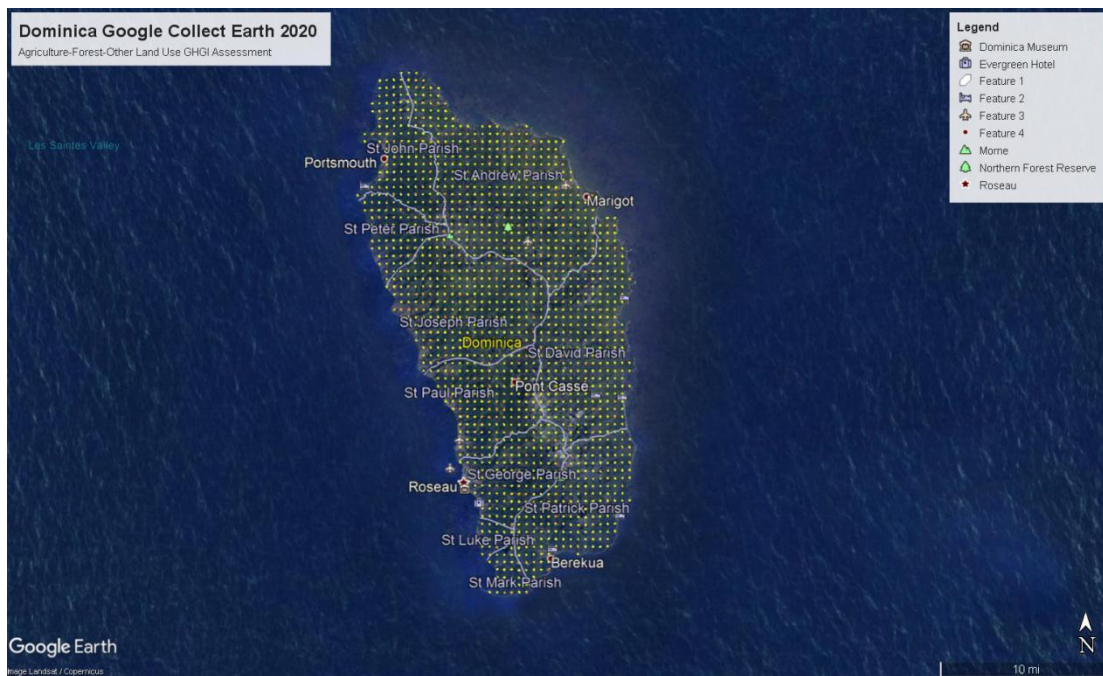


Figure 37 Dominica's grid (collect earth)

Design of the Survey. For collecting the land use, land use changes, year of land use conversion, disturbance and year of disturbance, a country specific survey was designed that could capture all the information required. This survey included the six IPCC land uses (Forest lands, Croplands, Grasslands, Wetlands, Settlements and other lands). It also included the sub-categories of land use as previously described (e.g Elfin forest, annual crop), and disturbances (hurricanes, logging, fires, shifting cultivation). This survey was displayed in each of the sampling plots and interpreters must fill it with the information of each plot on an annual basis. If no land use change or



disturbance was recorded, the same information as the previous year was included. Figure 39 shows how the survey was seen when selecting a plot for assessment.

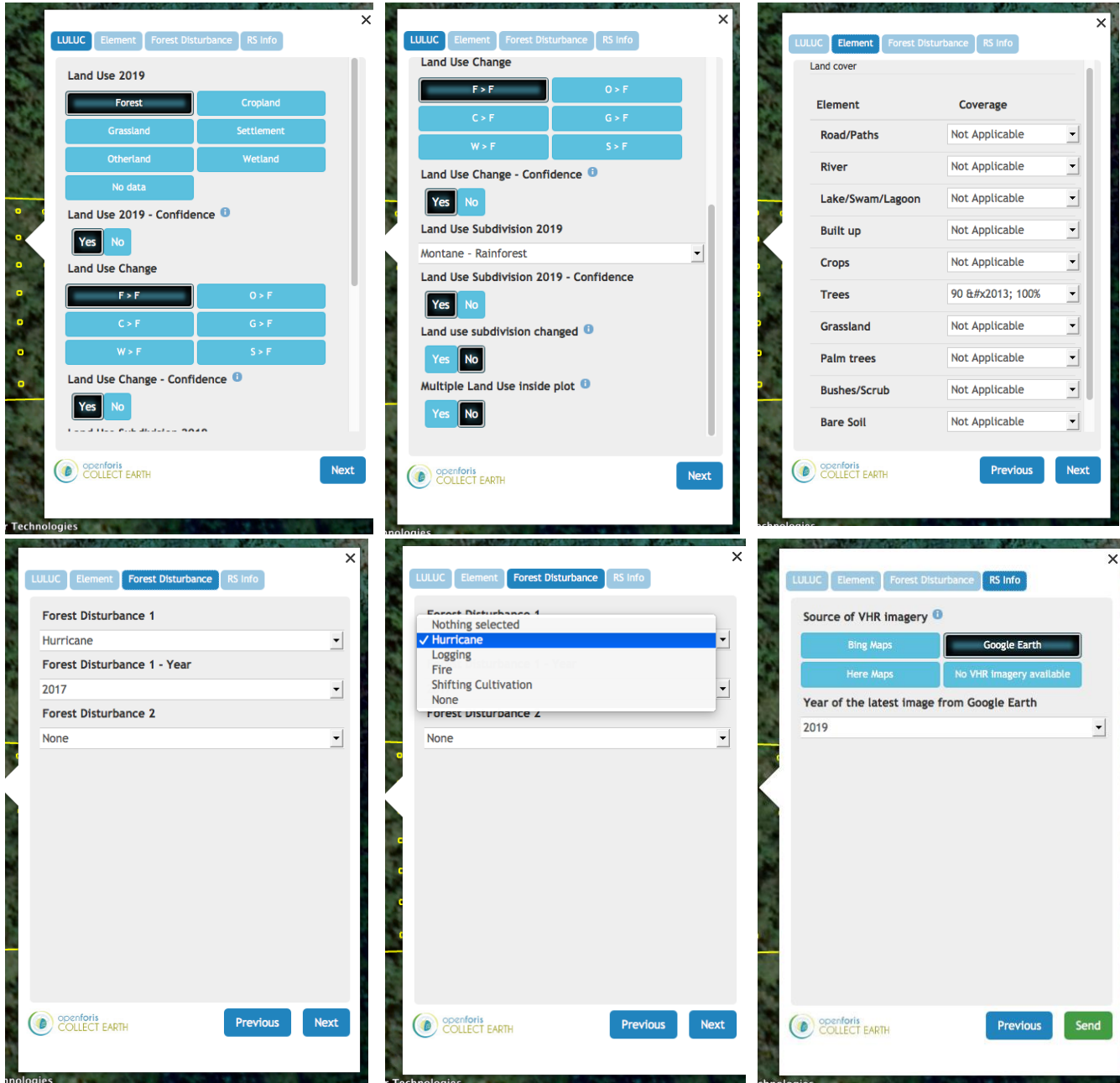


Figure 38. Collect earth survey

7.1.8 Open Foris Collect Earth Desktop

Training on how to use Collect Earth Desktop: On November 11th-12th 2019, 3 national experts from the Forest DFWP, and 1 from Agriculture, attended a joint-training with St.Lucia, Belize and Panama, led by the Coalition for Rainforest Nations, on Collect Earth Desktop (figure 40). Collect Earth is a user-friendly, Java-based tool that draws upon a selection of other software to facilitate data collection. Collect Earth uses a Google Earth interface in conjunction with an HTML-based data entry form. Forms can be customized to suite country-specific classification schemes in a manner consistent with guidelines of the Intergovernmental Panel on Climate Change (IPCC).



Figure 39 Training of Dominica team on Collect Earth online

Collect Earth facilitates the interpretation of high and medium spatial resolution imagery in Google Earth, Bing Maps and Google Earth Engine. Google Earth's virtual globe is largely comprised of 15-meter resolution Landsat imagery, 2.5m SPOT imagery and high-resolution imagery from several other providers (CNES, Digital Global, EarthSat, First Base Solutions, GeoEye-1, GlobeExplorer, IKONOS, Pictometry International, Spot Image, Aerometrex and Sinclair Knight Merz). Collect Earth synchronizes the view of each sampling point across all three platforms. The tool enables users to enter data regarding current land use and historical land use changes. Users can determine the reference period most appropriate for their land use monitoring objectives.

Standardization of the interpretation

An important aspect regarding interpretation, is that all interpreters have the same criteria for selecting a land use or a disturbance. In addition of the previous criteria (elevation, location, possible and impossible transition matrix and hierarchy), different images were visualizing all together to ensure coherent classification among interpreters. Some examples of the plots used for training are included below (figures 41 to 60):

Level 1: FOREST LAND (F)

Level 2: Elfin and Cloud Forest

Level 3: Elfin forest

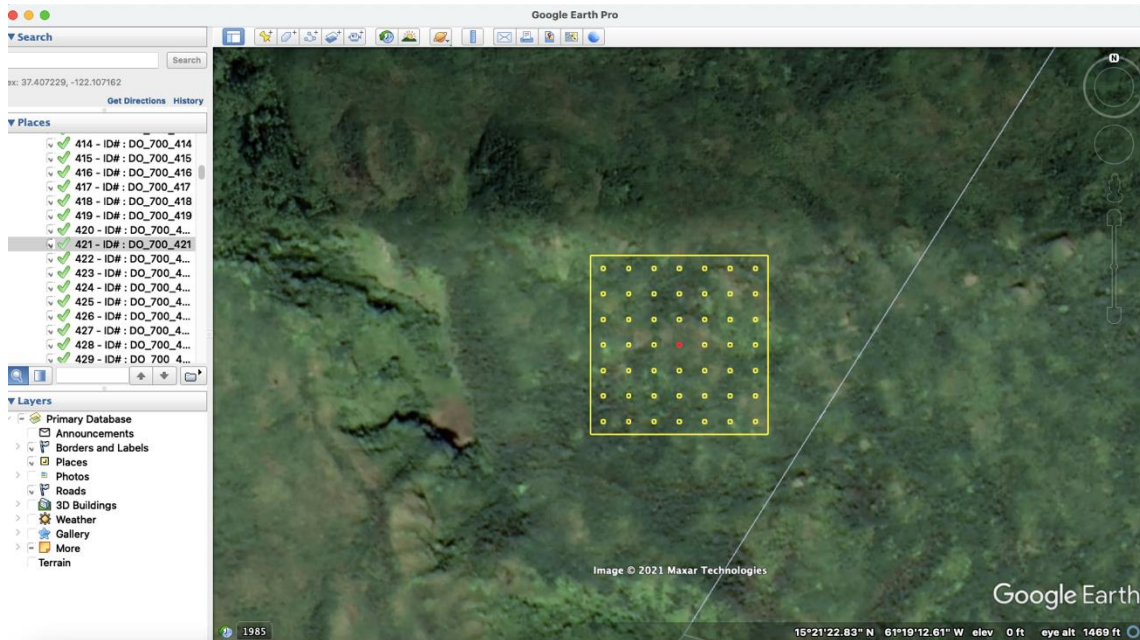


Figure 40 Visualization of Elfin forest in a high resolution image before disturbance

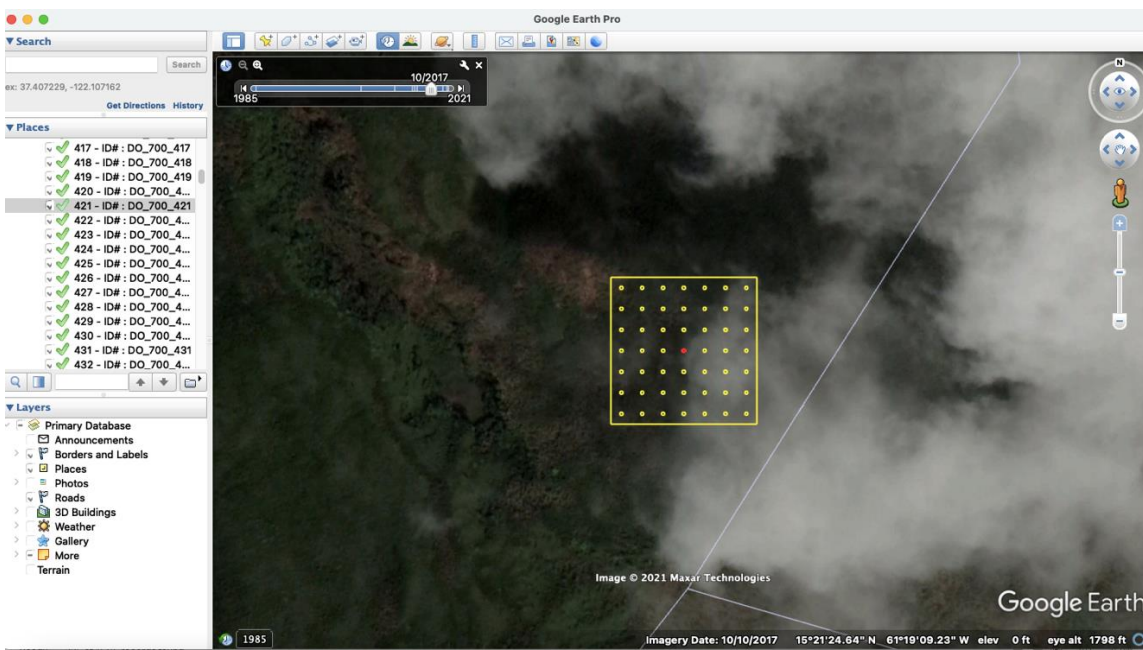


Figure 41 Visualization of Elfin forest (same plot) in a high resolution image after hurricane disturbance

Level 3: Cloud montane

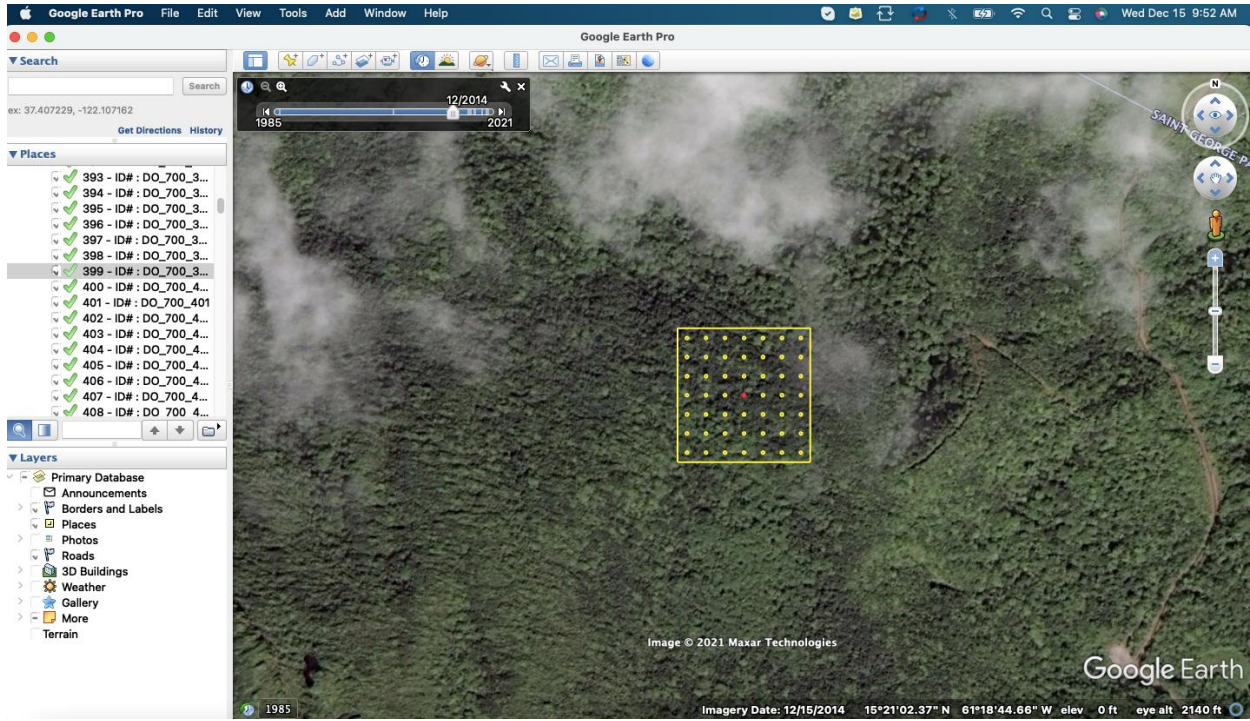


Figure 42 Visualization of Cloud montane forest in a high-resolution image before disturbance

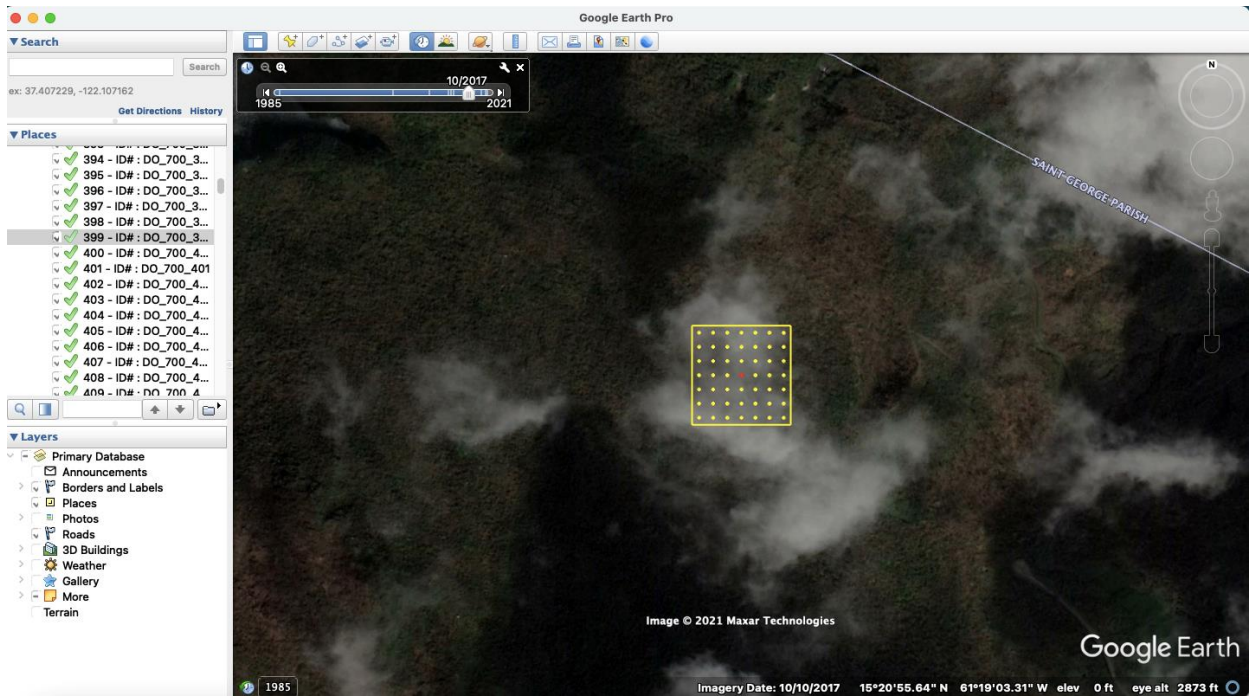


Figure 43 Visualization of Cloud montane forest (same plot) in a high-resolution image after hurricane disturbance

Level 2: Montane Rainforest

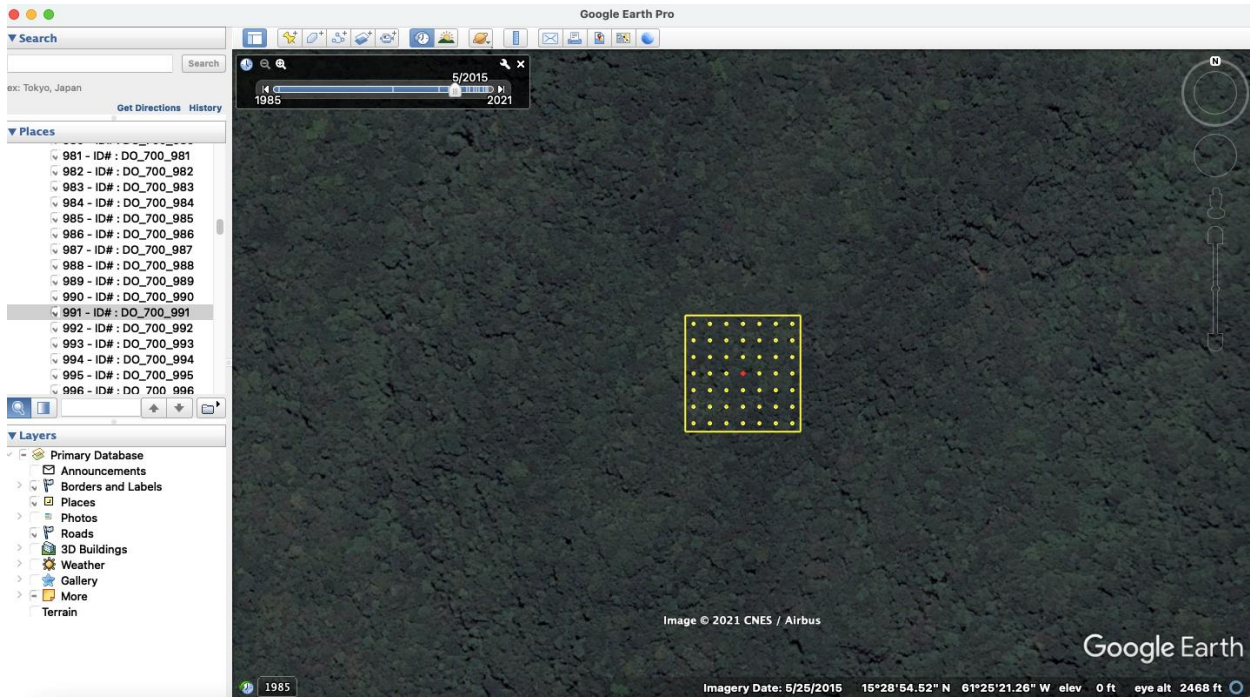


Figure 44 Visualization of Montane rainforest in a high-resolution image before disturbance

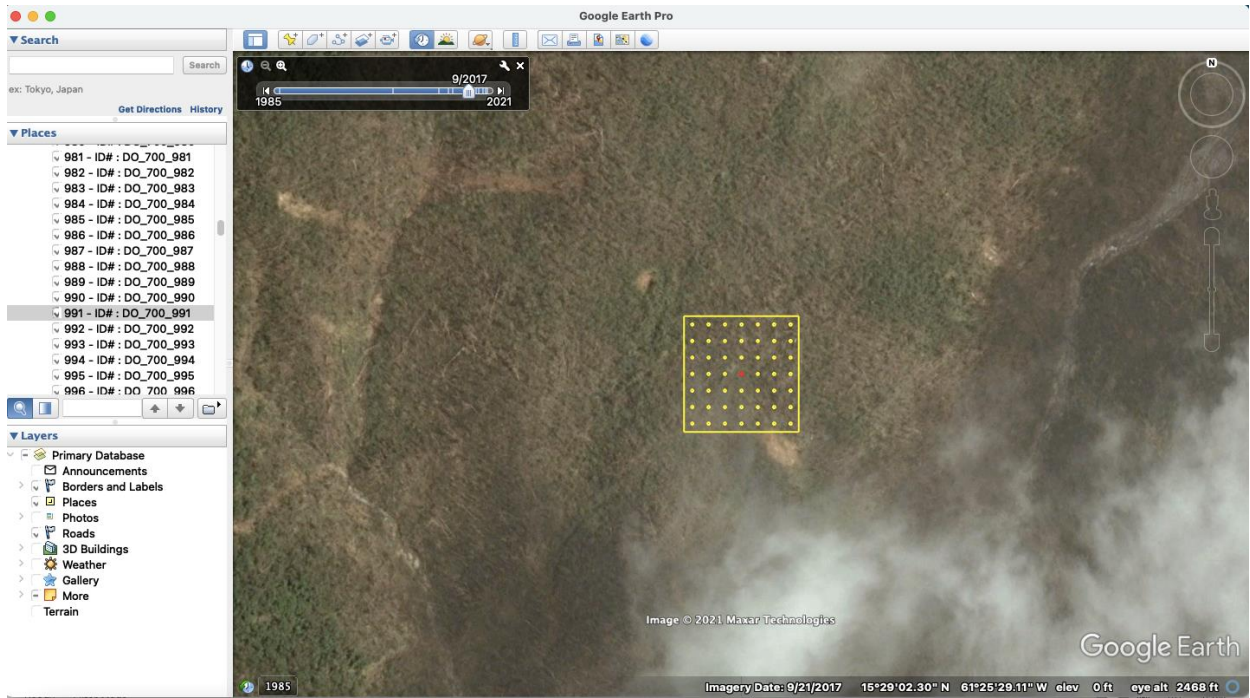


Figure 45 Visualization of Cloud montane forest (same plot) in a high-resolution image after hurricane disturbance

Level 2: Semi-Evergreen Forest

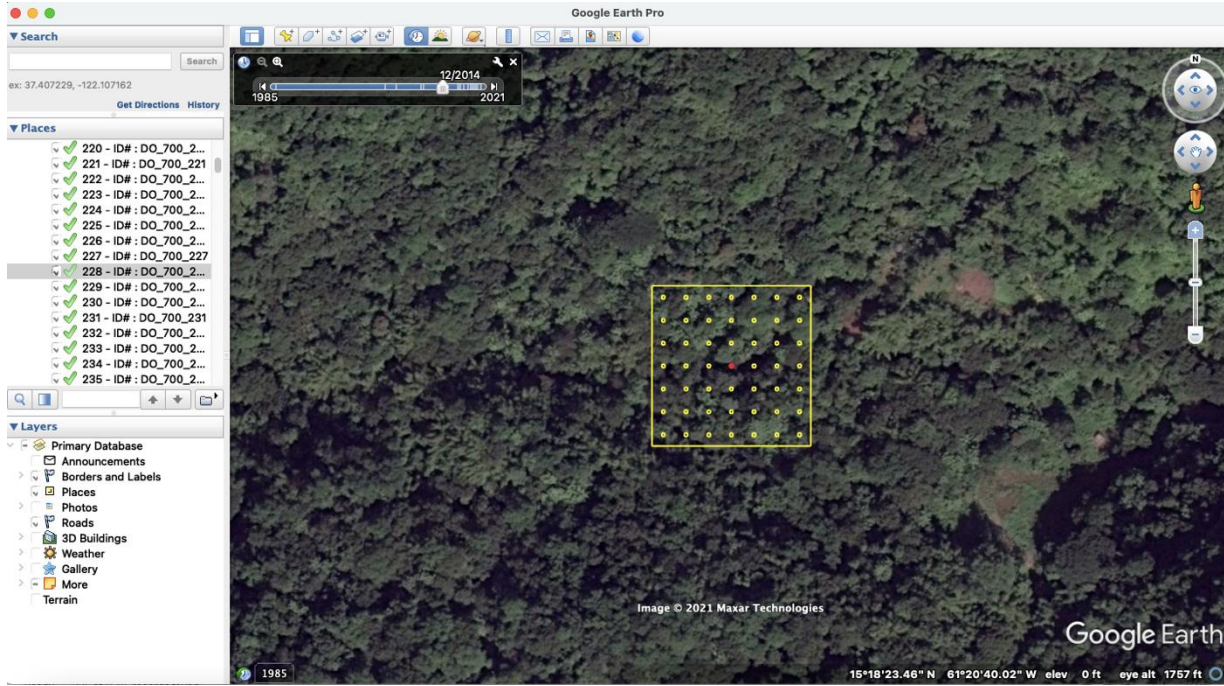


Figure 46 Figure 18 Visualization of Semi-evergreen forest in a high-resolution image before disturbance

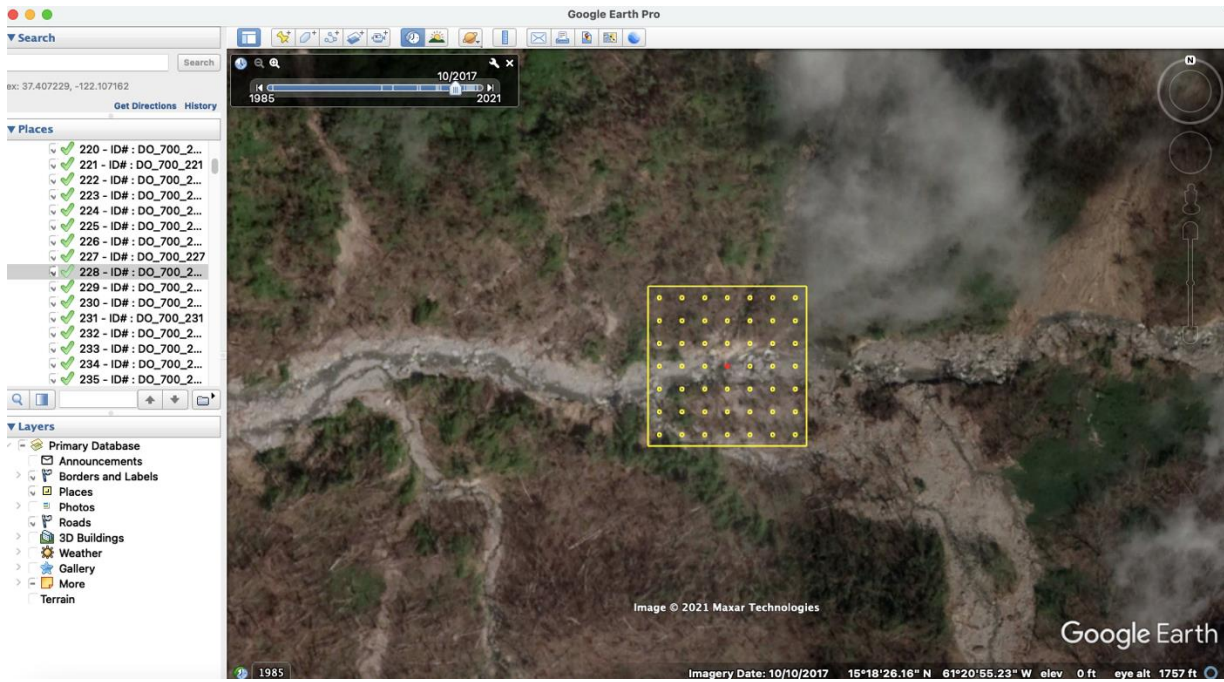


Figure 47 Visualization of Semi-evergreen forest in a high-resolution image after hurricane disturbance

Level 2: Coastal Forest



Level 3: Semi-Deciduous Forest

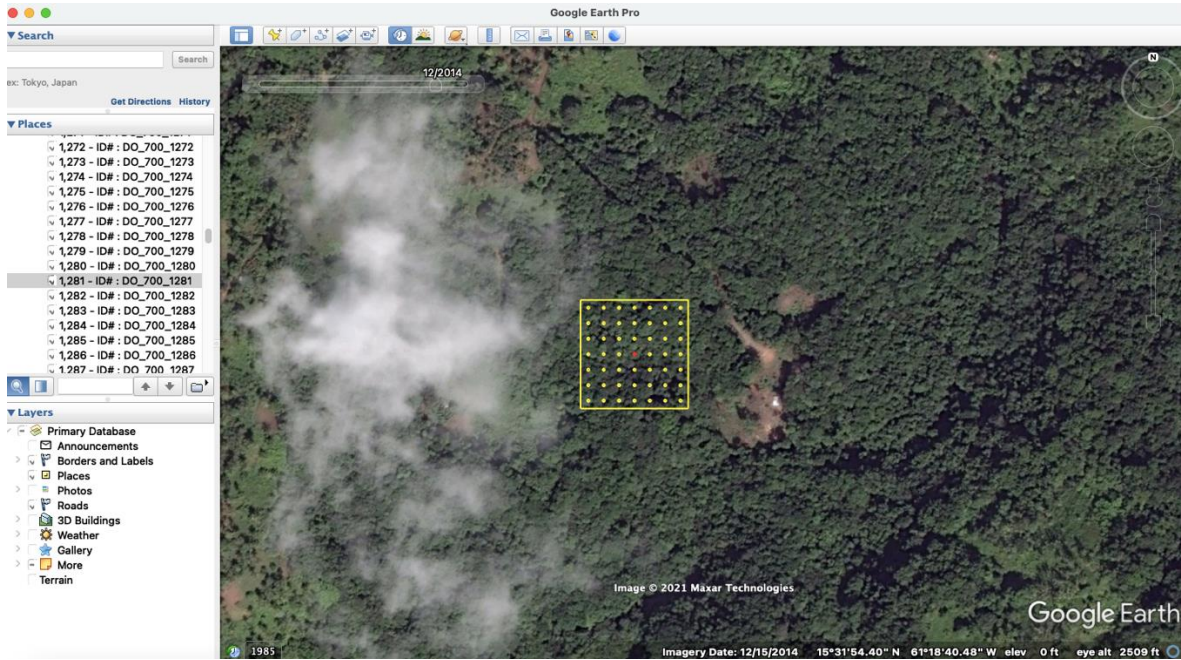


Figure 48 Visualization of Semi-deciduous forest in a high-resolution image before disturbance

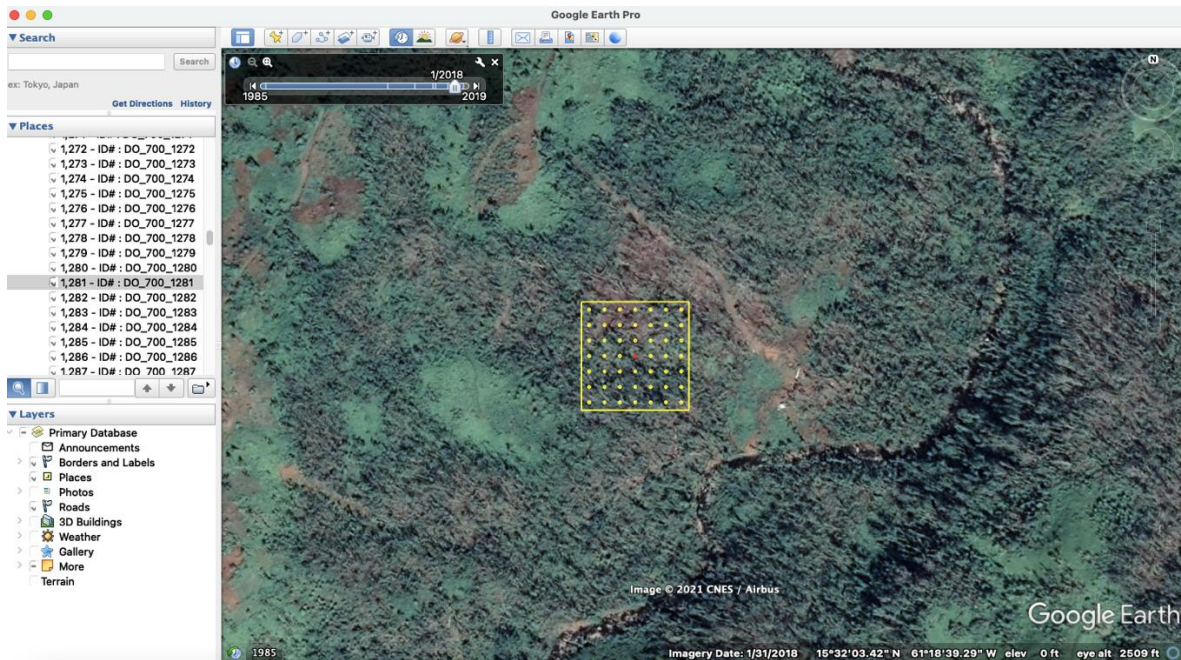


Figure 49 Visualization of Semi-deciduous forest (same plot) in a high-resolution image after hurricane disturbance

Level 3: Littoral Evergreen

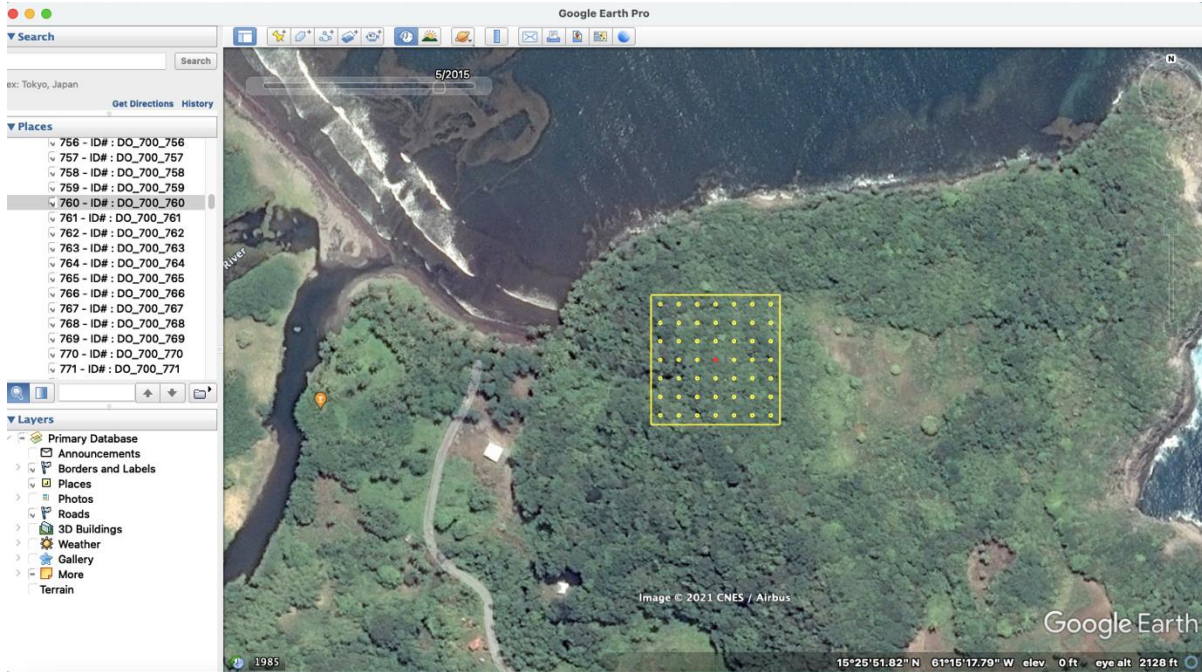


Figure 50 Visualization of Littoral evergreen forest in a high-resolution image before disturbance

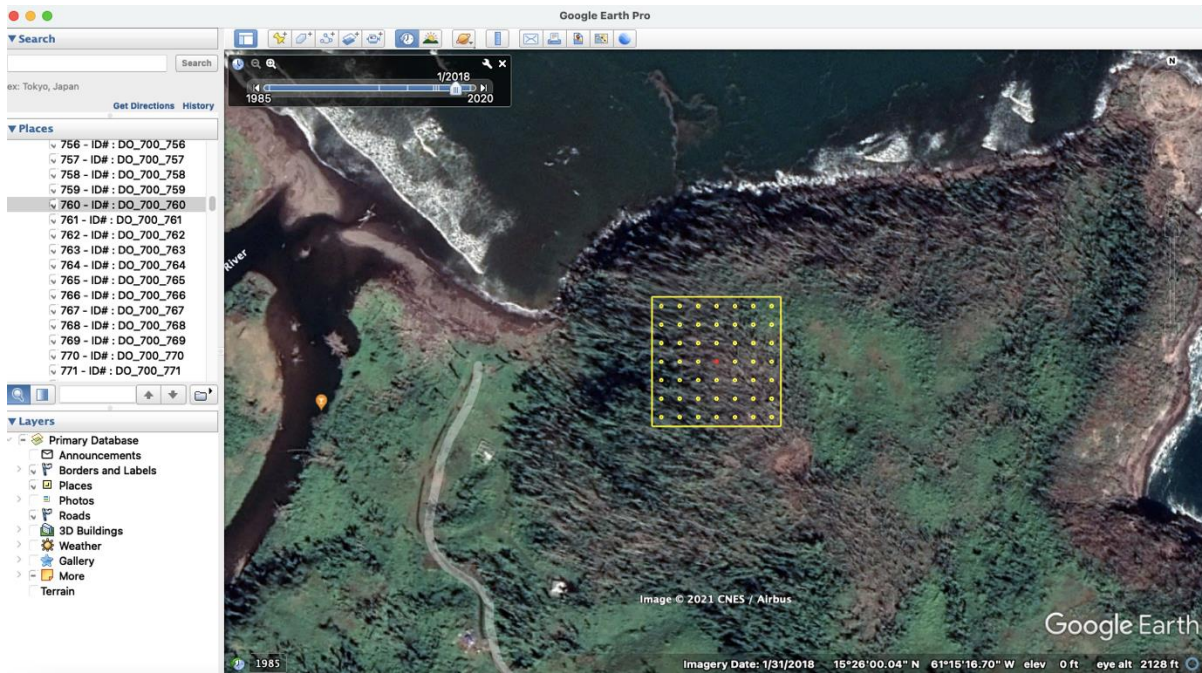


Figure 51 Visualization of Littoral evergreen forest in a high-resolution image after hurricane disturbance

Level 3: Dry Scrub

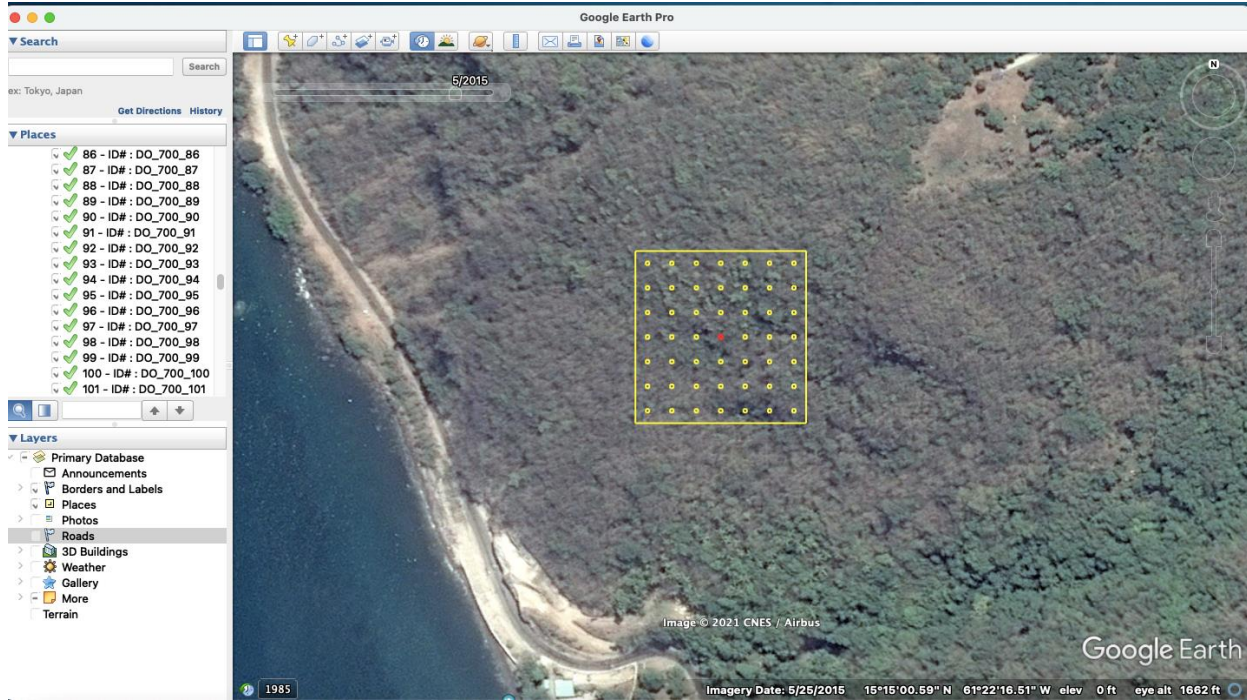


Figure 52 Visualization of Dry Scrub forest in a high-resolution image after before disturbance

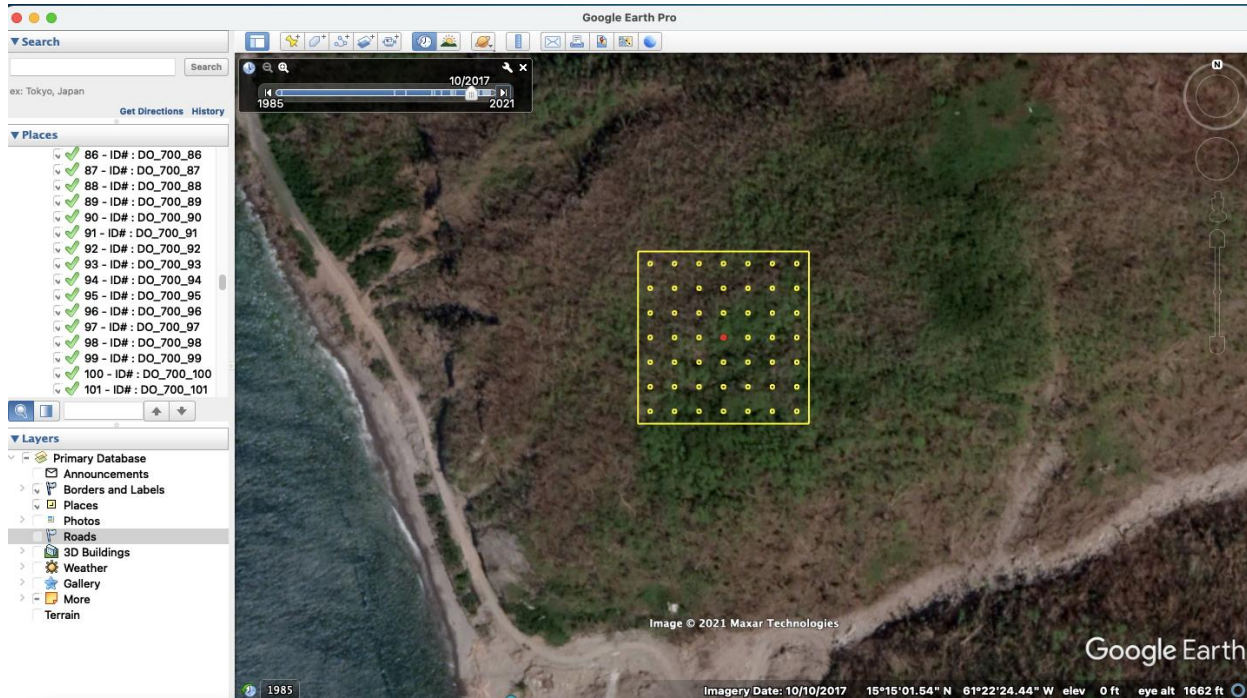


Figure 53 Visualization of Dry Scrub forest (same plot) in a high-resolution image after hurricane disturbance

Level 1: CROPLANDS (C)



Level 2: Perennial Crop

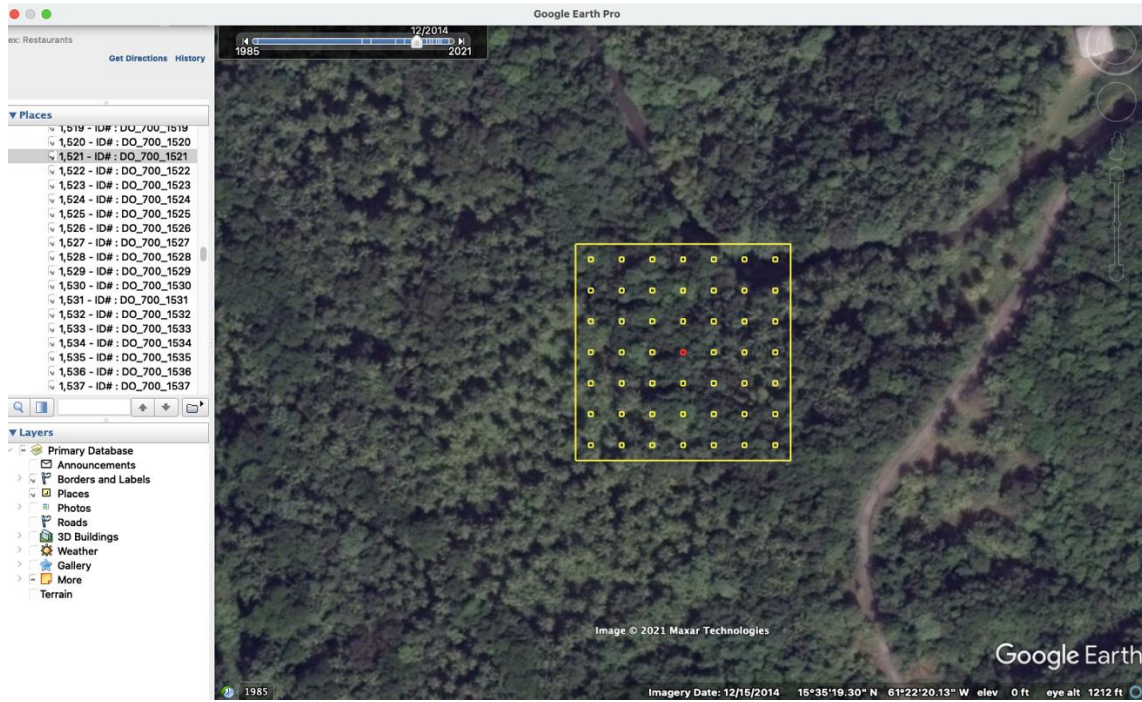


Figure 54 Visualization of perennial crop in a high-resolution image

Level 2: Annual Crop

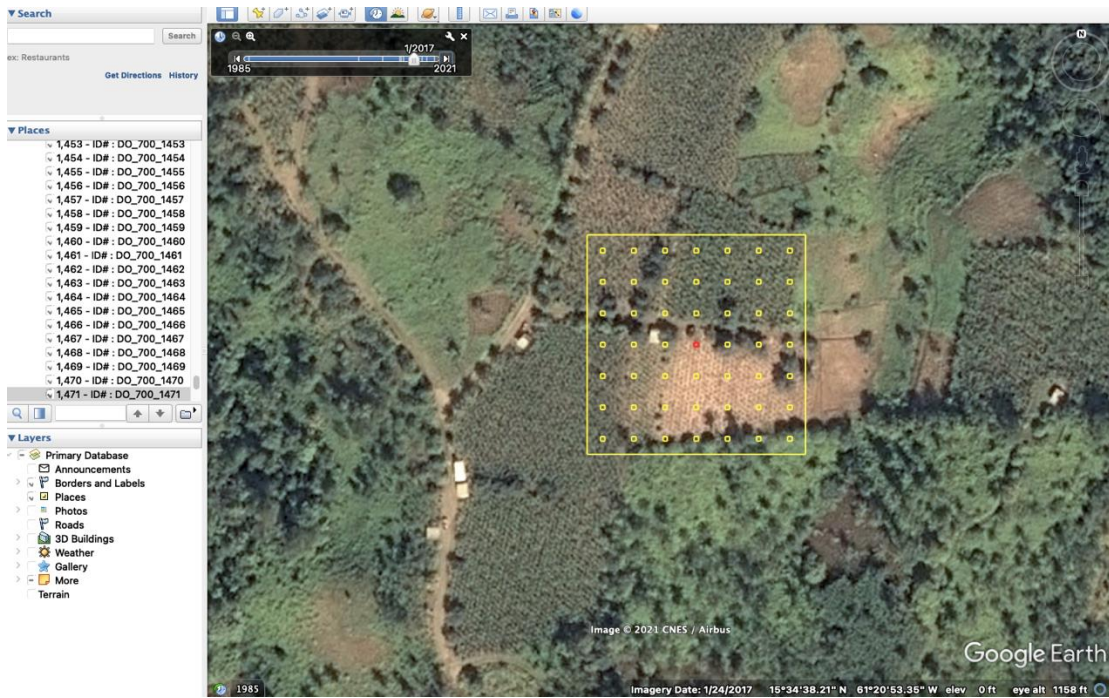


Figure 55 Visualization of annual crop in a high-resolution image



LEVEL 1: GRASSLANDS (G)

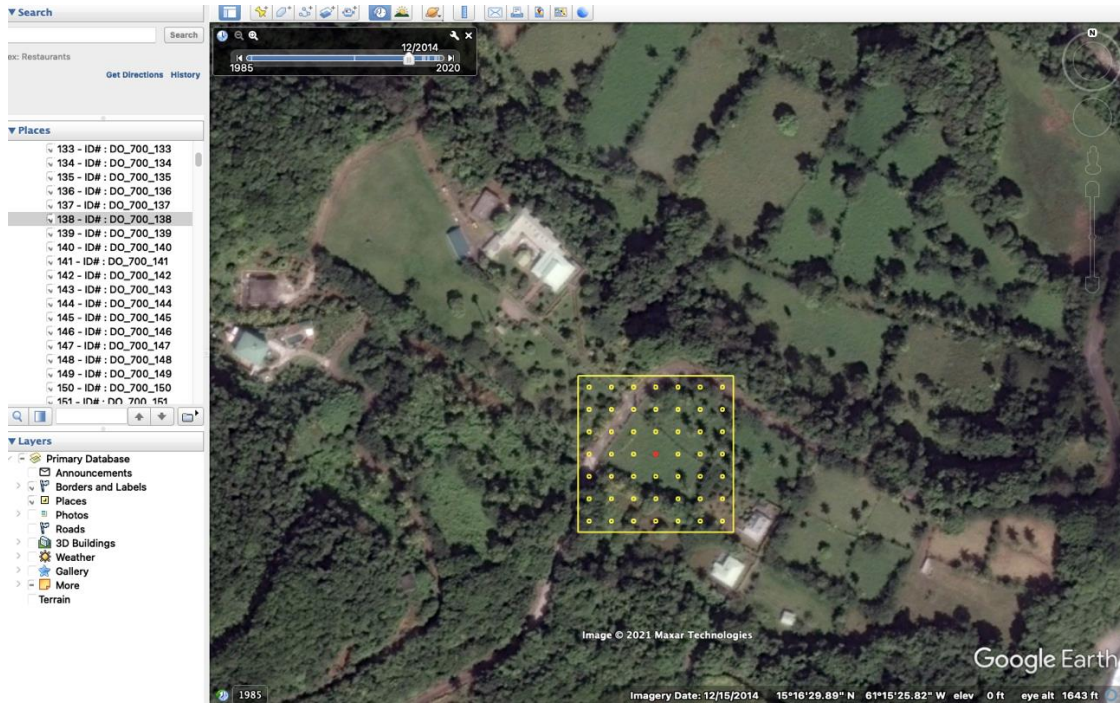


Figure 56 Visualization of grasslands in a high-resolution image

LEVEL 1: SETTLEMENTS (S)

Level 2: Urban areas

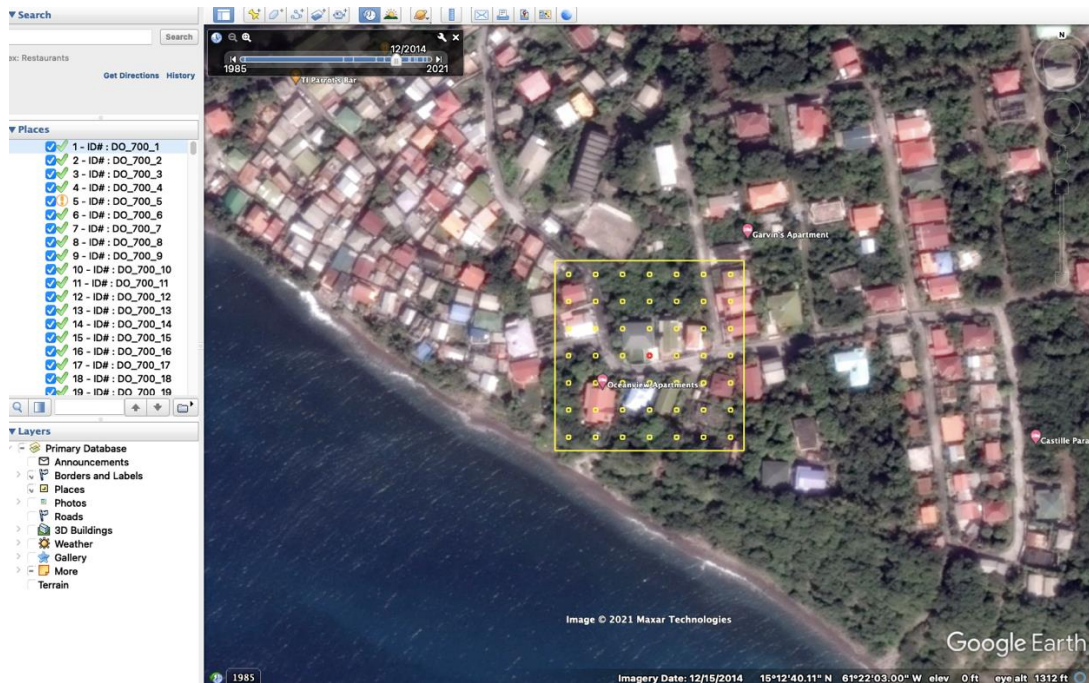


Figure 57 Visualization of settlements in a high-resolution image



Level 2: Woody Settlements

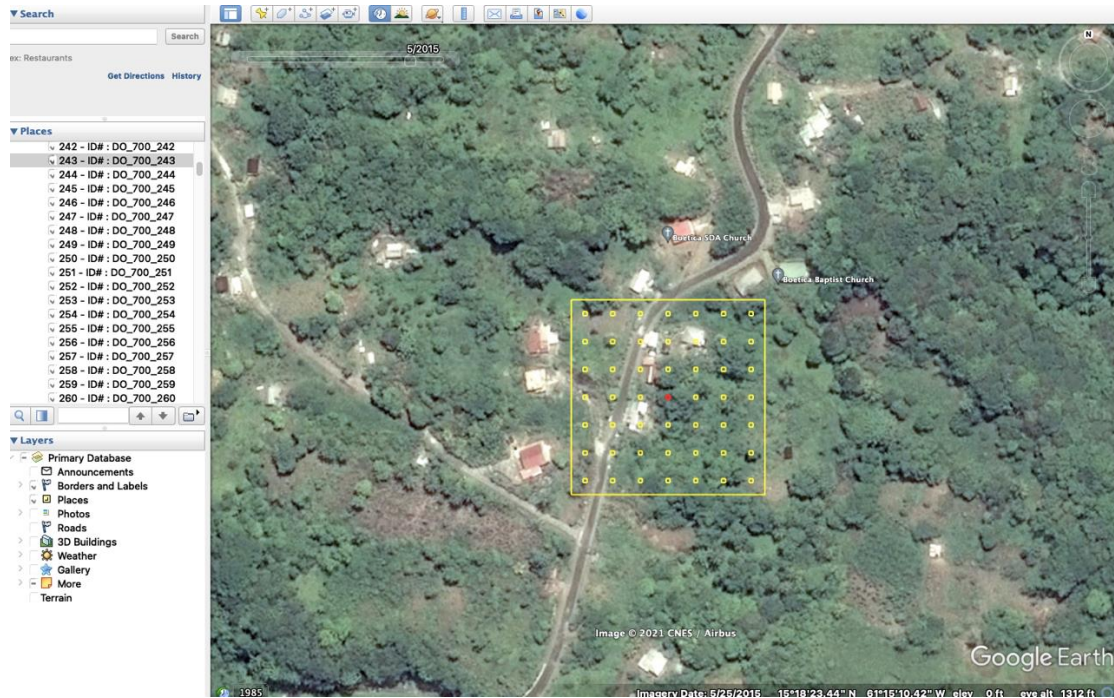


Figure 58 Visualization of woody settlements in a high-resolution image

LEVEL 1: OTHER LANDS (O)

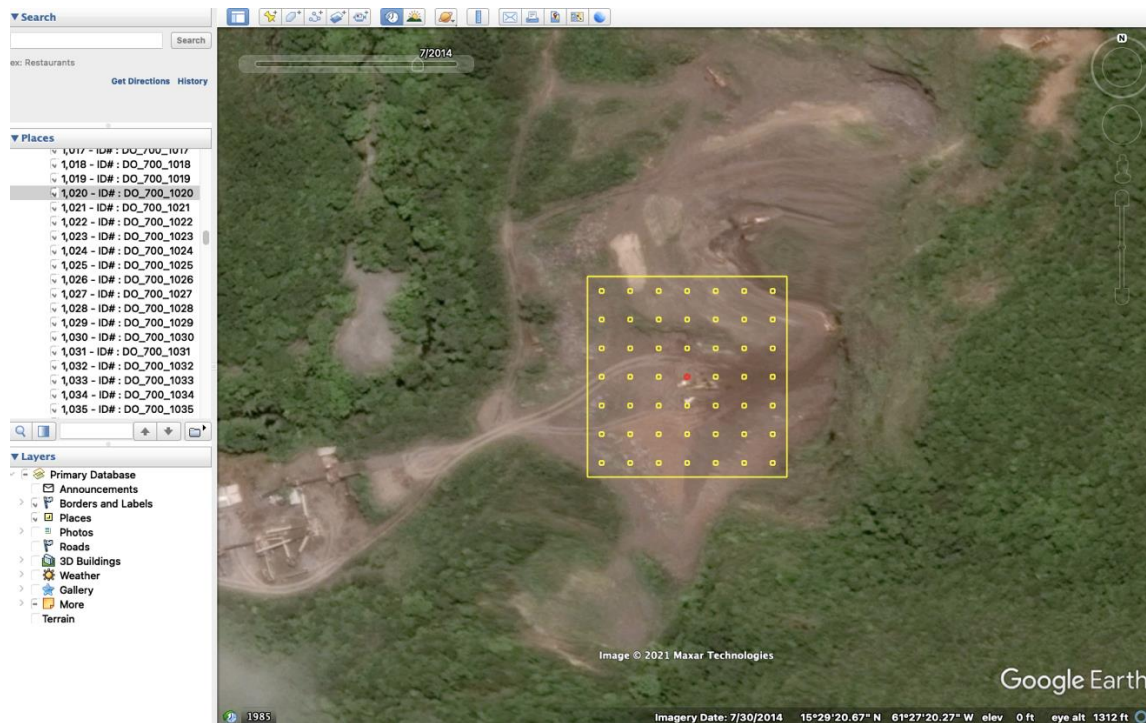


Figure 59 Visualization of other lands (mining) in a high-resolution image

7.1.9 Plot analysis with support images (Sentinel, Landsat 8, Landsat 7, Vegetation Indices)

The 1605 plots were divided into 4 groups. Each interpreter analyzed its assigned plots following the steps indicated in the diagram below (figure 61), which provides an overview of the key steps for assessing land use with Collect Earth and its supporting software:

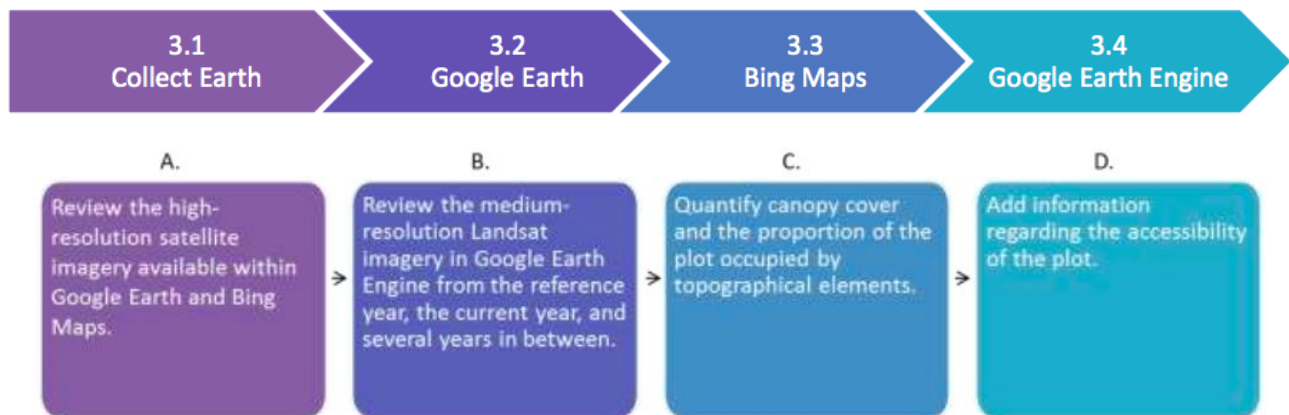


Figure 60. Support images used in CE

Microsoft's Bing Maps presents imagery provided by Digital Globe ranging from 3m to 30cm resolution. Google Earth Engine's web-based platform facilitates access to United States Geological Survey 30m resolution Landsat imagery. Through Bing Map, high spatial resolution satellite imagery from Digital Globe can be viewed and used for land use assessments. Collect Earth plot locations have been linked with Bing Maps because the latter web mapping service has a slightly different geographic coverage. Through Google Earth Engine is the Landsat Greenest-Pixel top of atmosphere (TOA) reflectance composite. These composites, which are available for Landsat 4, 5, 7 and 8, are created by drawing upon all images of a site for a full calendar year. The greenest pixels, with the highest NDVI (normalized difference vegetation index) value, are compiled to create a new image. These composites are particularly useful in tropical forest areas that may be prone to frequent cloud cover. This infrared color composite presents forest with a reddish-brown color and agriculture, grass, and shrubs in lighter shades of orange. Water appears purple and urban areas are shades of blue and green. This composite, pools information from bands that are sensitive to different types of reflectance.

The vegetation indices are indicators that describe the greenness — the relative density and health of vegetation — for each picture element, or pixel, in a satellite image. Collect Earth displays through Google Earth Engine Playground a set of time-frame charts with different vegetation indices to help the user identify possible trends and seasonality for the area of interest.

Historically Imagery

For the annual analysis, interpreters used the historical tool, which allows seeing images from different years, which could be visualizing either high-resolution images (figure 62), or images from Landsat 7, Landsat 8, and Sentinel 2 (figure 63).

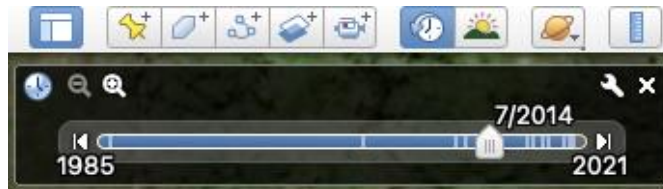


Figure 61. Historical imagery

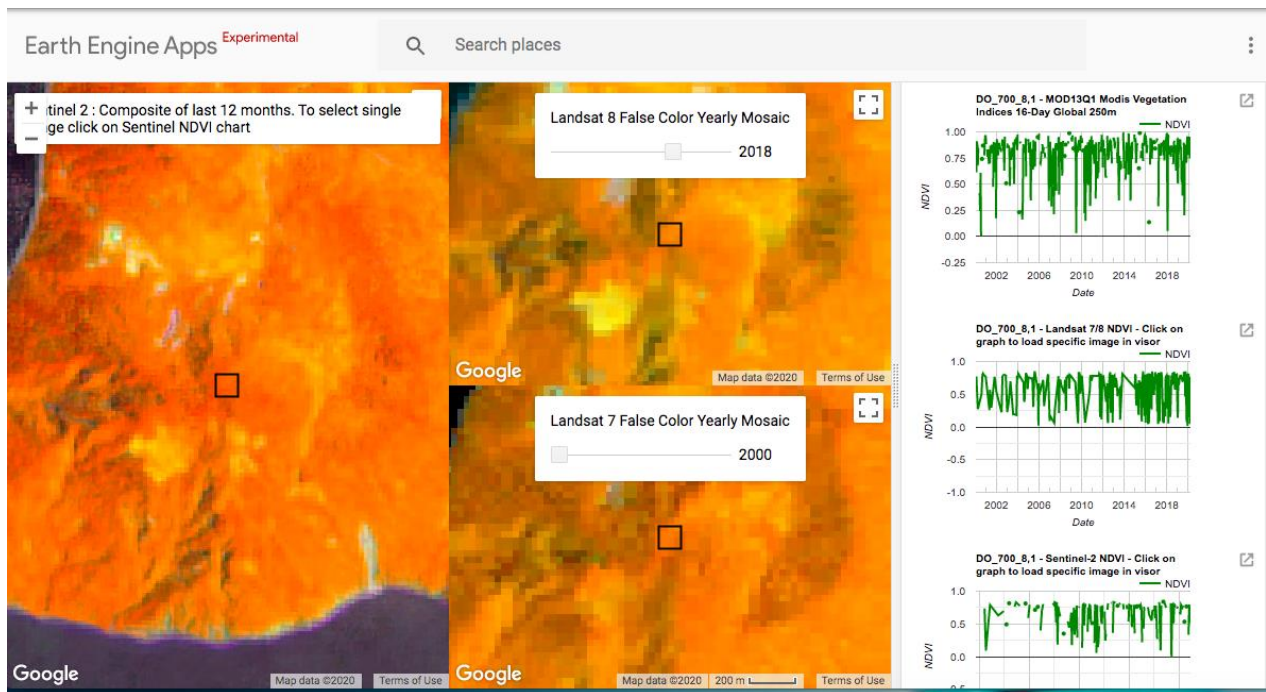


Figure 62. Examples of the use of Google Earth Engine

7.1.10 Collect Earth database with results of the interpretation

After the assessment was finished, a CVS database from the Collect Earth assessment with all information recorded for each of the 1605 plots from 2000 to 2017 was extracted. Each of the plots includes the time series indicating the land use (figure 64), whether the plot remained in the same land use category or if there was a land use conversion, and year of conversion, and if there was a disturbance and year of the event.

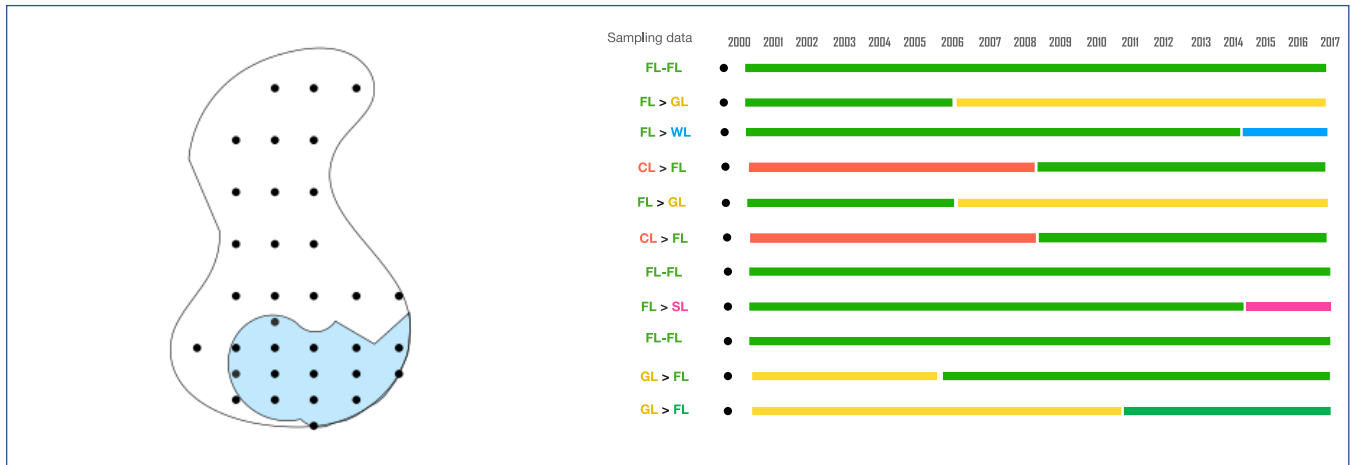


Figure 63 Plot by plot analysis of land use and land use change

7.1.11 Quality Control of the Activity Data

Several rounds of Quality Control took place while developing the Collect Earth Assessment. Plots misidentified were corrected by the National Interpreters (4) and two experts leads from Panama and Belize. The Matrix of impossible transitions of Land Use and Disturbances developed before the assessment was used to identify the errors during the assessment. Elevation ranges previously agreed as well as influence of location in forest types was also used to identify errors (for example, a coastal forest in >1000 m.a.s.l). Posterior to the assessment that took place in Saint Lucia, the technical lead did a full reassessment of all plots, and it was compared to the information previously collected. Different plots were revised and corrected if necessary.⁷⁵

7.1.12 Data processing _ Area estimation

For data analysis of the 1605 plots, a coding system was created to aggregate plots with the same land use or land use change (figure 65).

⁷⁵ As part of the uncertainty analysis, a percentage of error interpretation will be given.



Figure 64 Grouping plots with the same land use dynamic.

Codes depict a single trajectory or dynamic of each plot informing land use, land use change (if any) and disturbances (if any). These trajectories in the form of a code were created to simplify the analysis as it sums up all plots with the same trajectory, represented in the same code, reducing considerably the number of plots for which IPCC equations were applied (figure 66).

How do codes work?

Codes were created to quickly understand the land use changes and disturbances observed in Collect Earth plots. Codes are composed of three sections:

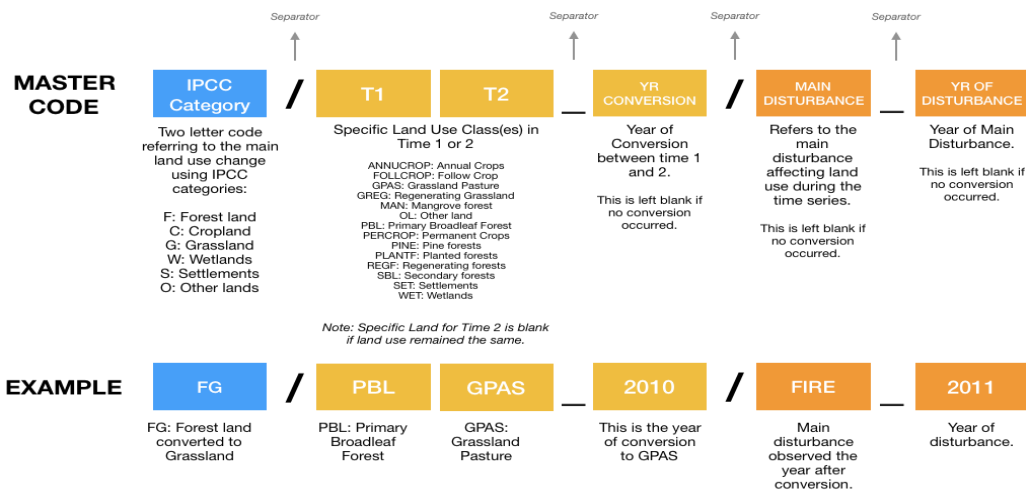


Figure 65 Coding system of land use dynamics

Once the code was applied to each of the 1605 assessed plots, information was summarized on the form of a pivot table (table 11). Then, area that each trajectory was calculated by multiplying the number of plots of each trajectory by the expansion factor, which was calculated dividing the total surface of the country (75000 Ha) by the total number of plots of the grid (1605 plots), equal to 43.76 Ha, meaning that each 1Ha plot represents an area of 43.76 ha, area that is distributed surrounding the plot.



Table 11 pivot table summarizing all land use dynamics and area estimation.

STEP 2 - AREA ESTIMATION (Plot count * Exp. Factor)		
	1605	75000
Row Labels	Count of Transition Coding	Area [Ha]
CC/CANNUAL	130	6074.8
CC/CPER	84	3925.2
CF/CANNUAL>FRAIN_2013/Hurricane_2017	1	46.7
CG/CANNUAL>GGRASS_2014/_	1	46.7
CG/CPER>GGRASS_2014/_	1	46.7
CG/CPER>GGRASS_2018/_	1	46.7
CG/CPER>GWGRASS_2017/_	1	46.7
CS/CANNUAL>SSET_2016/_	1	46.7
CS/CPER>SSET_2014/_	1	46.7
FC/FCLOUD>CANNUAL_2011/_	1	46.7
FC/FDEC>CANNUAL_2005/_	1	46.7
FC/FDSCRUB>CANNUAL_2011/_	1	46.7
FC/FEVER>CANNUAL_2017/_	1	46.7
FC/FEVER>CANNUAL_2018/_	1	46.7
FC/FRAIN>CANNUAL_2013/_	1	46.7
FF/FELF/Hurricane_2017	43	2009.3
FF/FCLOUD/Hurricane_2017	104	4859.8
FF/FRAIN/Hurricane_2017	600	28037.4
FF/FEVER/Hurricane_2017	225	10514.0
FF/FEVER/Shifting Cultivation_2015	1	46.7
FF/FDEC/Hurricane_2017	134	6261.7
FF/FDSCRUB/Hurricane_2017	39	1822.4
FF/FLIT/Hurricane_2015	1	46.7
FF/FLIT/Hurricane_2017	85	3972.0
FG/FDEC>GWGRASS_2012/_	1	46.7
FG/DSCRUB>GWGRASS_2005/_	1	46.7
FG/FEVER>GWGRASS_2015/_	2	93.5
FG/FEVER>GWGRASS_2016/_	1	46.7
FG/FLIT>GGRASS_2015/_	1	46.7
FG/FRAIN>GGRASS_2014/_	1	46.7
FO/DSCRUB>Mining_2014/_	1	46.7
FO/FRAIN>OOTHER_2017/_	1	46.7
FS/DSCRUB>SSET_2011/_	1	46.7
FS/DSCRUB>SWSET_2005/_	1	46.7
FS/DSCRUB>SWSET_2014/_	1	46.7

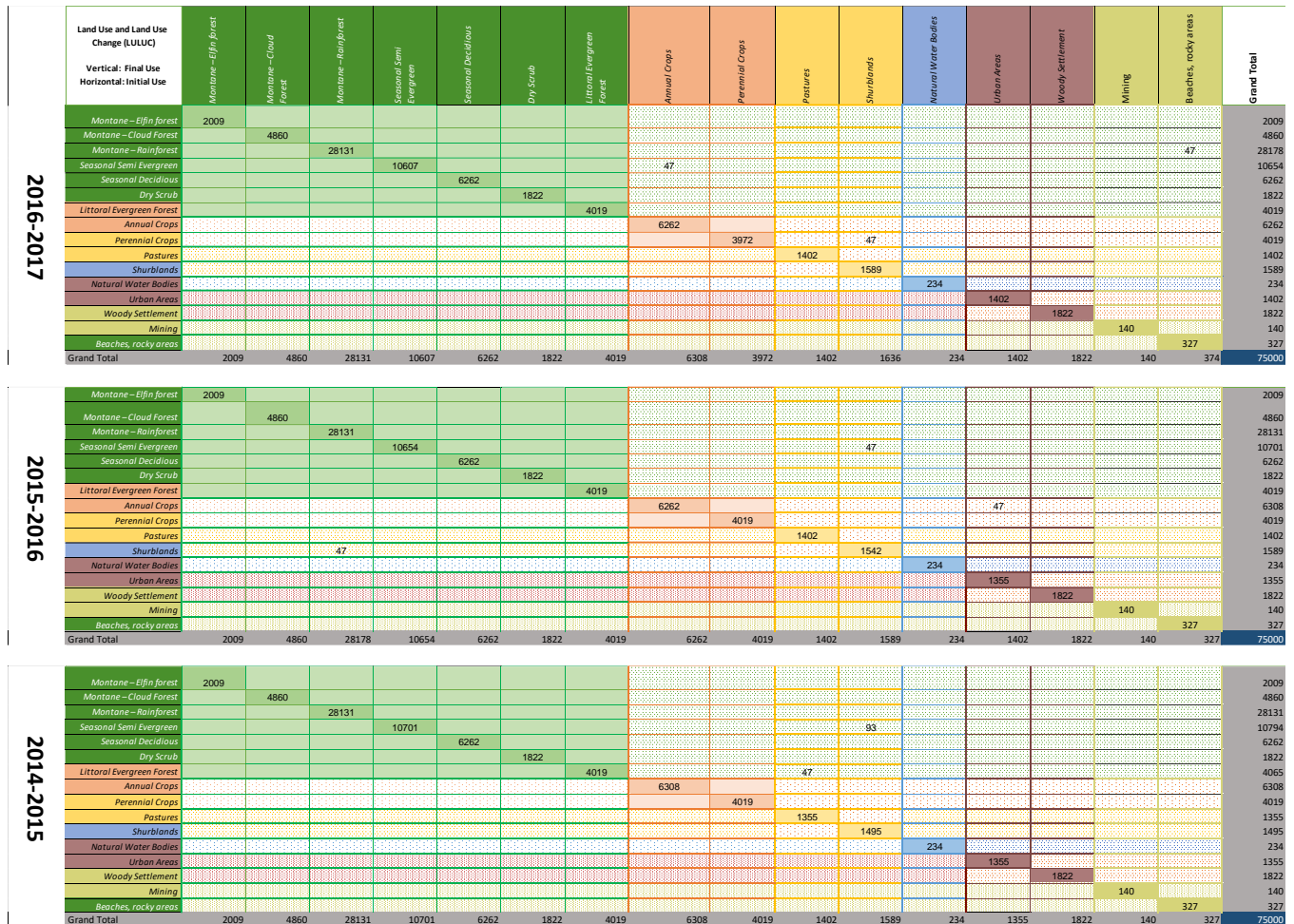


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FS/FEVER>SWSET_2012/_	1	46.7
FS/FRAIN>SWSET_2006/_	1	46.7
FS/FRAIN>SWSET_2012/_	1	46.7
GF/GGRASS>FRAIN_2016/Hurricane_2017	1	46.7
GG/GGRASS	26	1215.0
GG/GWGRASS	29	1355.1
OO/IMIN	2	93.5
OO/OOTHER	7	327.1
SS/SSET	27	1261.7
SS/SWSET	34	1588.8
WW/WWET	5	233.6
Sum	1605.0	75000.0

For facilitating the understanding of the data, the information of the pivot table was reorganized in land use and land use change matrices and disturbance matrices (figure 67).

Figure 66. Land use change matrices (area in ha)





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	Land Use and Land Use Change (LULUC)	Montane-Effin forest	Montane-Cloud Forest	Montane-Rainforest	Seasonal Semi Evergreen	Seasonal Deciduous	Dry Scrub	Littoral Evergreen Forest	Annual Crops	Perennial Crops	Pastures	Shrublands	Natural Water Bodies	Urban Areas	Woody Settlement	Mining	Beaches, rocky areas	Grand Total	
	Vertical: Final Use Horizontal: Initial Use																		
2013-2014	Montane-Effin forest	2009																2009	
	Montane-Cloud Forest		4860															4860	
	Montane-Rainforest			28131														28131	
	Seasonal Semi Evergreen				10794													10794	
	Seasonal Deciduous					6262												6262	
	Dry Scrub						1822											1822	
	Littoral Evergreen Forest							4065										4065	
	Annual Crops								6308										6308
	Perennial Crops									4019									4019
	Pastures										47								47
	Shrublands											1495							1495
	Natural Water Bodies												234						234
	Urban Areas													1308					1308
	Woody Settlement														1776				1776
	Mining															93			93
	Beaches, rocky areas																327		327
Grand Total		2009	4860	28131	10794	6262	1822	4065	6308	4019	1355	1495	234	1355	1822	140	327	75000	
2012-2013	Montane-Effin forest	2009																2009	
	Montane-Cloud Forest		4860															4860	
	Montane-Rainforest			28131														28131	
	Seasonal Semi Evergreen				10794													10794	
	Seasonal Deciduous					6262												6262	
	Dry Scrub						1916											1916	
	Littoral Evergreen Forest							4065										4065	
	Annual Crops								6308										6308
	Perennial Crops									4112									4112
	Pastures										1215								1215
	Shrublands											1495							1495
	Natural Water Bodies												234						234
	Urban Areas													1308					1308
	Woody Settlement														1776				1776
	Mining															93			93
	Beaches, rocky areas																327		327
Grand Total		2009	4860	28178	10794	6262	1916	4065	6355	4112	1215	1495	234	1308	1776	93	327	75000	
2011-2012	Montane-Effin forest	2009																2009	
	Montane-Cloud Forest		4860															4860	
	Montane-Rainforest			28178														28178	
	Seasonal Semi Evergreen				10794													10794	
	Seasonal Deciduous					6262												6262	
	Dry Scrub						1916											1916	
	Littoral Evergreen Forest							4065										4065	
	Annual Crops								6355										6355
	Perennial Crops									4112									4112
	Pastures										1215								1215
	Shrublands											1449							1449
	Natural Water Bodies												234						234
	Urban Areas													1308					1308
	Woody Settlement														1682				1682
	Mining															93			93
	Beaches, rocky areas																327		327
Grand Total		2009	4860	28178	10794	6262	1916	4065	6355	4112	1215	1495	234	1308	1776	93	327	75000	
2010-2011	Montane-Effin forest	2009																2009	
	Montane-Cloud Forest		4860															4860	
	Montane-Rainforest			28224														28224	
	Seasonal Semi Evergreen				10841													10841	
	Seasonal Deciduous					6308												6308	
	Dry Scrub						1916											1916	
	Littoral Evergreen Forest							4065										4065	
	Annual Crops								6262										6262
	Perennial Crops									4112									4112
	Pastures										1215								1215
	Shrublands											1449							1449
	Natural Water Bodies												234						234
	Urban Areas													1262					1262
	Woody Settlement														1682				1682
	Mining															93			93
	Beaches, rocky areas																327		327
Grand Total		2009	4860	28224	10841	6308	1916	4065	6355	4112	1215	1449	234	1308	1682	93	327	75000	
2009-2010	Montane-Effin forest	2009																2009	
	Montane-Cloud Forest		4907															4907	
	Montane-Rainforest			28224														28224	
	Seasonal Semi Evergreen				10841													10841	
	Seasonal Deciduous					6308												6308	
	Dry Scrub						2009											2009	
	Littoral Evergreen Forest							4065										4065	
	Annual Crops								6262										6262
	Perennial Crops									4112									4112
	Pastures										1215								1215
	Shrublands											1449							1449
	Natural Water Bodies												234						234
	Urban Areas													1262					1262
	Woody Settlement														1682				1682
	Mining															93			93
	Beaches, rocky areas																327		327
Grand Total		2009	4907	28224	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1682	93	327	75000	



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	Land Use and Land Use Change (LULUC)																Grand Total			
	Vertical: Final Use	Horizontal: Initial Use	Montane-Ellin forest	Montane-Cloud Forest	Montane-Rainforest	Seasonal Semi Evergreen	Seasonal Deciduous	Dry Scrub	Littoral Evergreen Forest	Annual Crops	Perennial Crops	Pastures	Shrublands	Natural Water Bodies	Urban Areas	Woody Settlement		Mining	Beaches, rocky areas	
2008-2009	Montane-Ellin forest	2009																		
	Montane-Cloud Forest		4907																	
	Montane-Rainforest			28224																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6308														
	Dry Scrub						2009													
	Littoral Evergreen Forest							4065												
	Annual Crops								6262											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1449								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1682					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28224	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1682	93	327		75000	
2007-2008	Montane-Ellin forest	2009																		
	Montane-Cloud Forest		4907																	
	Montane-Rainforest			28224																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6308														
	Dry Scrub						2009													
	Littoral Evergreen Forest							4065												
	Annual Crops								6262											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1449								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1682					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28224	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1682	93	327		75000	
2006-2007	Montane-Ellin forest	2009																		
	Montane-Cloud Forest		4907																	
	Montane-Rainforest			28224																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6308														
	Dry Scrub						2009													
	Littoral Evergreen Forest							4065												
	Annual Crops								6262											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1449								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1682					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28224	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1682	93	327		75000	
2005-2006	Montane-Ellin forest	2009																		
	Montane-Cloud Forest		4907																	
	Montane-Rainforest			28224																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6308														
	Dry Scrub						2009													
	Littoral Evergreen Forest							4065												
	Annual Crops								6262											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1449								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1636					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28224	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1682	93	327		75000	
2004-2005	Montane-Ellin forest	2009																		
	Montane-Cloud Forest		4907																	
	Montane-Rainforest			28271																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6308														
	Dry Scrub						2009													
	Littoral Evergreen Forest							4065												
	Annual Crops								6215											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1402								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1589					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28271	10841	6308	2009	4065	6262	4112	1215	1449	234	1262	1636	93	327		75000	



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	Land Use and Land Use Change (LULUC)																Grand Total			
	Vertical: Final Use	Horizontal: Initial Use	Montane – Elfin forest	Montane – Cloud Forest	Montane – Rainforest	Seasonal Semi Evergreen	Seasonal Deciduous	Dry Scrub	Littoral Evergreen Forest	Annual Crops	Perennial Crops	Pastures	Shrublands	Natural Water Bodies	Urban Areas	Woody Settlement		Mining	Beaches, rocky areas	
2003-2004	Montane – Elfin forest	2009																		
	Montane – Cloud Forest		4907																	
	Montane – Rainforest			28271																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6355														
	Dry Scrub						2103													
	Littoral Evergreen Forest							4065												
	Annual Crops								6215											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1402								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1589					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28271	10841	6355	2103	4065	6215	4112	1215	1402	234	1262	1589	93	327	75000		
2002-2003	Montane – Elfin forest	2009																		
	Montane – Cloud Forest		4907																	
	Montane – Rainforest			28271																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6355														
	Dry Scrub						2103													
	Littoral Evergreen Forest							4065												
	Annual Crops								6215											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1402								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1589					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28271	10841	6355	2103	4065	6215	4112	1215	1402	234	1262	1589	93	327	75000		
2001-2002	Montane – Cloud Forest		4907																	
	Montane – Rainforest			28271																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6355														
	Dry Scrub						2103													
	Littoral Evergreen Forest							4065												
	Annual Crops								6215											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1402								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1589					
	Mining															93				
Beaches, rocky areas																327				
Grand Total		2009	4907	28271	10841	6355	2103	4065	6215	4112	1215	1402	234	1262	1589	93	327	75000		
2000-2001	Montane – Elfin forest	2009																		
	Montane – Cloud Forest		4907																	
	Montane – Rainforest			28271																
	Seasonal Semi Evergreen				10841															
	Seasonal Deciduous					6355														
	Dry Scrub						2103													
	Littoral Evergreen Forest							4065												
	Annual Crops								6215											
	Perennial Crops									4112										
	Pastures										1215									
	Shrublands											1402								
	Natural Water Bodies												234							
	Urban Areas													1262						
	Woody Settlement														1589					
Mining															93					
Beaches, rocky areas																327				
Grand Total		2009	4907	28271	10841	6355	2103	4065	6215	4112	1215	1402	234	1262	1589	93	327	75000		

7.2 Emission Factors

The information on Emission Factors (EFs) was obtained from default values of the 2006 IPCC Guidelines, 2019 Refinement to the 2006 IPCC Guidelines, and from the National Forest Inventory from Saint Lucia (2009), as both islands share the same forest types, and no recent Forest inventory has taken place in Dominica.

For forest land,



- Dominica used the default values from the 2006 IPCC Guidelines for the carbon fraction of wood for all forest classes.
- The default values from the 2019 Refinement to the 2006 IPCC Guidelines for the average annual above-ground biomass growth, ratio of below-ground to above-ground biomass, litter and deadwood stocks for all forest classes, and CH₄ and N₂O EFs
- Regional values estimated from Chave et al. (2014) and data from the Saint Lucia's NFI for the above-ground biomass of all forest classes
- Local expert judgment for the fraction of biomass loss due to disturbance for all forest classes.

For cropland,

- Dominica used the default EFs from the 2006 IPCC Guidelines for the carbon fraction, biomass accumulation rate, above-ground biomass, litter and deadwood stocks for all cropland classes; and the default values from the 2019 Refinement to the 2006 IPCC Guidelines for the ratio of below-ground to above-ground biomass for perennial cropland.

For grassland,

- Dominica used the EFs from the 2006 IPCC Guidelines for all carbon pools covered by the FRL/FREL.

For settlements,

- Dominica used the default EFs from the 2006 IPCC Guidelines for the carbon fraction of woody settlements; and the default values from the 2019 Refinement to the 2006 IPCC Guidelines were used for the ratio of below-ground to above-ground biomass for woody settlements.

Dominica has decided to use emission and removal factor from different IPCC guidelines, selecting the most updated values available and considered most appropriate to the national circumstances.

National Forest Inventory [from Saint Lucia] (Tier 2)

In 2009, two hundred plots were surveyed, each 20 meters in radius, covering a wide range of elevations in all parts of the country. Both floristic and biophysical data were recorded within every plot (table 12). To guide the selection of field sites, a simple starter map was produced, dividing Saint Lucia into 24 cells and showing approximate elevational zones and known areas of botanical interest (Graveson, 2009).⁷⁶ The floristic data were analyzed using Two-way Indicator Species Analysis (TWINSpan), supported with a manual floristic analysis, to assign the plots to distinct vegetation classes. Each vegetation class is described and illustrated in some detail in the report.

A simple method to sample quite rapidly the vegetation, the physiognomy and the habitats throughout the cells and vegetation zones on the starting map was developed. A standardized method that could be applied to all types of forest was required, from secondary xeric woodland with small tightly packed trees, to rainforest where some tree trunks are extremely wide. After preliminary trials in contrasting xeric and wet forest types, a 20-metre radius

⁷⁶ Graveson (2009). National Forest Demarcation and Bio-Physical Resource Inventory Project Caribbean – Saint Lucia: The Classification Of The Vegetation Of Saint Lucia. FCG International Ltd in association with AFC Consultants International GmbH



circular plot with a 7m radius subplot in the center was chosen. The prime focus of the standardized survey was the 7m subplot.

Table 12 The biophysical and floristic information recorded from every plot

Plot measurements	Description
Plot	Plot number.
Date	Date of survey.
Location	Name of area plot is located in.
Team	Initials of surveyors present on this plot survey.
Description	Simple habitat type: e.g. river valley, degraded dry woodland, rainforest.
GPS N	Northing (UTM) of plot center point as read from GPS.
GPS E	Easting (UTM) of plot center point as read from GPS.
Rockiness	1=1-10% of ground covered by rocks; 2=10-30% of ground covered by rocks; 3=>30% of ground covered by rocks
Canopy (m)	Measured using a clinometer.
Canopy (%)	Estimated visually, using a mirror to reflect the canopy.
Number of stumps ≥5cm	0=no stumps of ≥5cm diameter found in plot; 1=1-4 stumps of ≥5cm diameter found in plot; 2=more than 4 stumps of ≥5cm diameter in plot.
Number of logs ≥5cm	0=no logs of ≥5cm diameter on ground; 1=1-4 logs ≥5cm diameter on ground; 2=more than 4 logs of ≥5cm diameter on ground.
Wind	Assessment based on canopy wind noise and sculpturing of vegetation. 0=no wind noise; 1=slight wind noise; 2=moderate wind noise; 3=full exposure - sculptured vegetation.
Slope (%)	Measured using a clinometer.
Direction (°)	Slope aspect. Measured using a compass.
Elevation (m)	As read from GPS, occasionally with later corrections from map. 1=1-30% of trees in plot have vines; 2=31-70% of trees in plot have vines; 3>70% of trees in plot have vines.
Epiphytes, including ferns	1=1-30% of tree have epiphytes; 2=31-70% of tree have epiphytes; 3>70% of trees have epiphytes.
Herbs (%)	% ground cover, visually estimated to nearest 5%
Ferns terrestrial (%)	% ground cover of non-arborescent ferns, visually estimated to nearest 5%.
Mosses/filmy ferns	0 = absent from trees; 1=surface cover present on most trees; 2=cover with depth on some trees; 3=surface cover with depth on most trees; 4=depths of 2cm present.
DBH1 (cm)	Measurement of the diameter at breast height of the widest trunk in the 7m subplot.
DBH2 (cm)	Measurement of the diameter at breast height of the second widest trunk in the 7m subplot.
Notes	Notes possibly useful for analysis, including details if the plot survey was not standard.



Species names of all trees DBH \geq 5cm	Genus and species name for woody species with stem DBH \geq 5cm.
Number of trees	Number of individuals of every species with stem DBH \geq 5 cm (including arborescent herbs with trunks \geq 5cm).
Species names of all saplings, herbs, vines and terrestrial ferns	Genus and species names.
Species names of all epiphytes	Genus and species names (dry forest areas only).
Other tree species	Additional tree species in the area, within the 20m plot radius.

All of the plot measurements shown in [Table 11](#) were made in the 7m subplot, with the exception of the “other tree species”, which were recorded throughout the 20m plot.

A stratified sampling approach was selected to decide where to conduct the plots, guided by the zones shown on the starter map to ensure not to miss any rare vegetation types. Plots were not chosen randomly but selected to illustrate the variety within each destination. Thus, in rainforest area, a steep slope, a gentle slope, a ridge top, a gully, exposed positions, and/or sheltered positions might be chosen.

For major forest classes analysis Stehle’s (1945) method was followed. For example, some species are typically found in the Deciduous Seasonal Forest where the upper canopy tends to lose its leaves in the dry season; these species were assigned a value of 1. Other species are typically found in moister environments, e.g. by rivers, and the trees lose some leaves during the dry season in proportion to the severity of the drought; these Semi-evergreen Seasonal Forest species were assigned a value of 2. Some species are typically found in the forest reserve and rarely outside, and do not have a seasonal leaf fall; these Lower Montane Rainforest trees were assigned a value of 3. Plants typically only found in Cloud Montane Rainforest were assigned a value of 4. Thus, following this method every plot was placed in a specific vegetation class ([table 12](#)).

Table 13 Attributed recorded by Forest Class

Attribute (Average by Forest Class)	Cloud Montane Rainforest (n=4)	Lower Montane and Montane Rainforest (rainforest) (n=75)	Semi-evergreen Seasonal Forest (n=22)	Deciduous Seasonal Forest (n=72)
Mean Forest Class Average (FCV)	3.5	2.9	1.9	1.1
Mean Number of Trees DBH \geq 5cm	25.0	30.0	17.0	19.0
Mean Rocks Score (0-3)	0.3	0.5	1.3	1.3
Mean Canopy Height (m)	5.3	27.6	22.8	11.2
Mean Canopy (%)	72.0	63.5	64.3	46.5
Mean Stumps Score (0-2)	0.3	1.1	1.1	0.8
Mean Logs Score (0-2)	1.0	1.4	1.5	1.0
Mean Wind Score (0-3)	2.0	1.2	0.6	1.2
Mean Slope (%)	28.0	26.0	20.0	16.0



Mean Elevation (m)	851	445	155	103
Highest Elevation (m)	869	680	390	413
Lowest Elevation (m)	824	102	15	4
Mean Vines Score (0-3)	1.3	1.4	1.0	0.8
Mean Epiphytes Score (0-3)	3.0	0.9	0.2	0.4
Mean Herbaceous (non-fern) ground cover (%)	10.0	4.1	5.9	13.4
Mean Ferns Ground Cover (%)	22.0	15.9	0.6	0.0
Mean Moss Score (0-4)	4.0	0.8	0.1	0.0
Mean DBH 1 and 2 (cm)	17.0	38.3	31.3	21.1

7.3 IPCC Methodologies applied

Following paragraphs 10⁷⁷ and 21⁷⁸ of annex to decision 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.

For the estimation of GHG emissions and removals for the Forest and Land Use Change Sector, Dominica 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, below-ground biomass, dead organic matter). It includes the analysis for Land remaining in a land-use category and lands converted to a new land-use category. The Dominica’s 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). IPCC methodology tiers 1, and 2 were applied. All definitions, methods and assumptions are described.

The equations were applied to each of the land use dynamics included in the pivot table (figure 68)

⁷⁷ 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.

⁷⁸ 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.

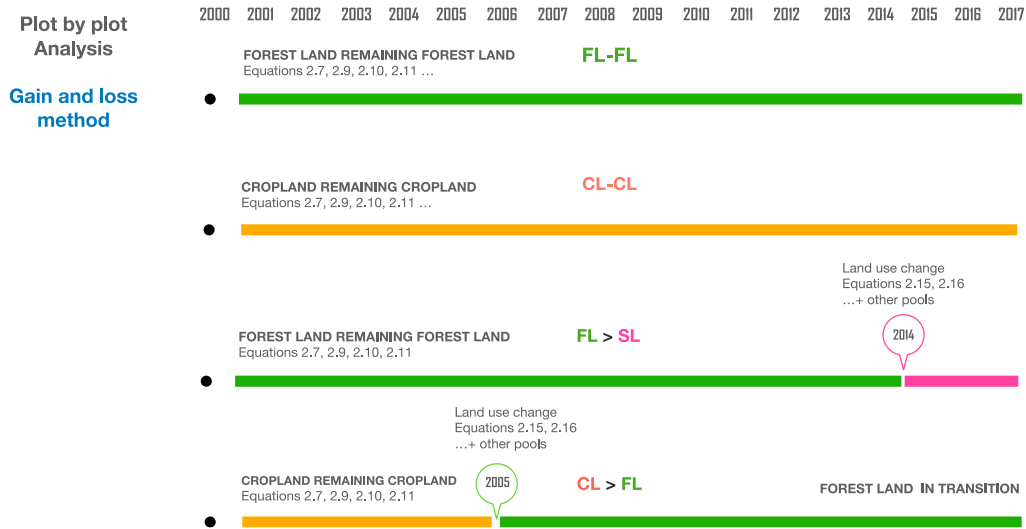


Figure 67 Diagram explaining how IPCC equations for the Gain and Loss method were applied to the land use dynamics.

7.3.1 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:

ΔC_{LUi} = 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
- SOC** = soils
- HWP** = harvested wood products

Table 14. Carbon pools included

	Included
ΔC_{AB}	Yes
ΔC_{BB}	Yes
ΔC_{DOM_LI}	Yes
ΔC_{SOC}	Yes
ΔC_{HWP}	No

Clarification Notes



Data on HWP is not available as yet.

7.3.2 Change in biomass carbon stocks (above-ground biomass and below-ground biomass) in forest lands remaining in the same category

Annual change in carbon stocks in biomass in forest land remaining in the same category (gain-loss method) (Equation 2.7, Ch2, V4)

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

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 forest land remaining in the same land-use category (Equation 2.9, Ch2, V4)

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

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 15. Sources of activity data for land remaining

A: area of land remaining in the same land-use category



LU	Sub-Category	Source	Notes
F	Forest lands	Forestry Division	Collect earth assessment - Annual time series 2000-2017
C	Croplands	Forestry Division	Collect earth assessment - Annual time series 2000-2017
G	Grasslands	Forestry Division	Collect earth assessment - Annual time series 2000-2017
W	Wetlands	Forestry Division	Collect earth assessment - Annual time series 2000-2017
S	Settlements	Forestry Division	Collect earth assessment - Annual time series 2000-2017
O	Other lands	Forestry Division	Collect earth assessment - Annual time series 2000-2017

Clarification Notes

Forest land remaining Forest land was separated in 2 main scenarios based on damage degree. Through multiple discussions with country experts, it was estimated that 75% was highly impacted and 25% was slightly impacted by the hurricane:

- 1) Scenario 1 is the area of forest slightly affected [25%]. Thus, from the total area of Forest land remaining Forest land, 25% was allocated to this section, which is the “No significant damage”, which are patches of forest that because of their location and characteristic where not significantly affected by the hurricane.
- 2) Scenario 2 is the area of forest highly affected [75%]. Thus, from the total area of Forest land remaining Forest land, 75% was allocated to this section. This section had 3 further subdivisions:
 - a. Damage I: the stem remained standing but has broken branches or heavy defoliation [60%],
 - b. Damage II: the steam and branches are broken, heavy defoliation, and tree was not uprooted [25%].
 - c. Damage III: trees are uprooted [15%].

For each section, from the areas initially estimated at [75%], the 3 further subdivisions were estimated by multiplying the allocated percentage.

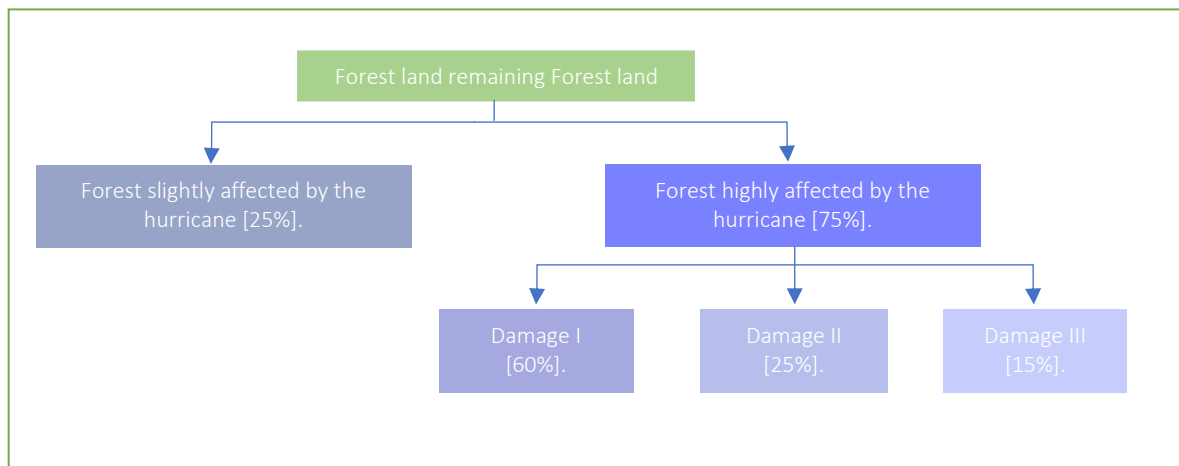


Figure 68 Area distribution in Forest lands remaining forest lands, depending on affectation degree by hurricane Maria (2017)



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Table 16. Carbon fraction values

CF: Carbon Fraction t C (t d.m.) ⁻¹						
LU	Category	Value	Default Value (tier 1)	Error o range reported	Source	Comments and assumptions
F	Elfin and Cloud forest	0.47	X	(0.44 - 0.49)	2006 IPCC, Vol 4, Ch4, Table 4.3. Carbon fraction of aboveground forest biomass	Tropical/Subtropical forest.
	Montane Forest	0.47	X	(0.44 - 0.49)	2006 IPCC, Vol 4, Ch4, Table 4.3. Carbon fraction of aboveground forest biomass	Tropical/Subtropical forest
	Semi-evergreen Forest	0.47	X	(0.44 - 0.49)	2006 IPCC, Vol 4, Ch4, Table 4.3. Carbon fraction of aboveground forest biomass	Tropical/Subtropical forest
	Deciduous - Coastal Forest	0.47	X	(0.44 - 0.49)	2006 IPCC, Vol 4, Ch4, Table 4.3. Carbon fraction of aboveground forest biomass	Tropical/Subtropical forest
C	Annual Crops	0	X		Assumption	
	Perennial Crops	0.5	X		IPCC 2006, V4, Ch5, p.5.11 (Step 4)	
G	Grasslands	0.47	X		IPCC 2006, V4, Ch6, page 6.29. Step 5 - herbaceous	
	Woody Grasslands	0.5	X		IPCC 2006, V4, Ch6, page 6.29. Step 5 - woody biomass	
W	Wetlands	0	X		Assumption	
S	Non-Woody Settlements	0	X		Assumption	
	Woody Settlements	0.47	X	(0.44 - 0.49)	2006 IPCC, Vol 4, Ch4, Table 4.3. Carbon fraction of aboveground forest biomass	Tropical/Subtropical forest
O	Mining and Other Lands	0	X		Assumption	

Clarification Notes

IPCC 2006/2019 Default values are used as to date not country-specific research has been carried out. Agreed on May 21st 2020 with Forest Division Team.

Table 17. Values of ratio of below to above ground biomass

R: Ratio of below ground biomass to above ground biomass							
LU	Category	Type	Value	Default Value (tier 1)	Error o range reported	Source	Comments and assumptions



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F	Elfin and Cloud forest	Natural	0.221	X	SD: 0.036	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical Rainforest, South America, secondary >20yr
	Montane Forest	Natural	0.221	X	SD:0.036	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical Rainforest, South America, secondary >20yr
	Semi-evergreen Forest	Natural	0.284	X	SD:0.061	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical moist deciduous forest, South America, Secondary >20yr
	Deciduous - Coastal Forest	Natural	0.379	X	SD:0.04	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical dry forest, South America, Secondary >20yr
C	Annual Crops		0	X		Assumption	
	Perennial Crops		0.284	X	SD:0.061	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical moist deciduous forest, South America, Secondary >20yr
G	Grasslands (Dry)		2.8	X		IPCC 2006, V4, Ch6, Table 6.4	
	Grassland (Moist)		1.6	X		IPCC 2006, V4, Ch6, Table 6.4	
	Woody Grassland		2.8	X		IPCC 2006, V4, Ch6, Table 6.4	
W	Wetlands		0			Assumption	
S	Non-Woody Settlements		0			Assumption	
	Woody Settlements		0.284	X	SD:0.061	2019 IPCC RF, Vol 4, Ch4, Table 4.4	Tropical moist deciduous forest, South America, Secondary >20yr
O	Mining and Other Lands		0			Assumption	

Average annual increment in biomass [Tier 1] (Equation 2.10, Ch2, V4)

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

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



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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 18. Values for Net biomass growth tonnes d. m. ha-1 yr-1

GW: Net biomass growth tonnes d. m. ha-1 yr-1							
LU	Category	Type	Value	Default Value (tier 1)	Error o range reported	Source	Comments and assumptions
F	Elfin and Cloud forest	Undisturbed	0.00			Assumption	Expert Judgement, Forestry Division. Gw is 0 as it is considered stable forest.
		Disturbed (Hurricane, fire, logging, Shift.Cult)	4.40	X	SD:1.6	2019 IPCC RF, Vol 4, Ch4, Table 4.9	
	Montane Forest	Undisturbed	0.00	X		Assumption	Expert Judgement, Forestry Division. Gw is 0 as it is considered stable forest.
		Disturbed (Hurricane, fire, logging, Shift.Cult)	5.90	X	SD: 2.3	2019 IPCC RF, Vol 4, Ch4, Table 4.9	Tropical Rainforest, South America, secondary <20yr
	Semi-evergreen Forest	Undisturbed	2.70	X	SD: 1.1	2019 IPCC RF, Vol 4, Ch4, Table 4.9	Tropical moist deciduous forest, South America, Secondary >20yr
		Disturbed (Hurricane, fire, logging, Shift.Cult)	5.20	X	SD: 2.3	2019 IPCC RF, Vol 4, Ch4, Table 4.9	Tropical moist deciduous forest, South America, Secondary <20yr
	Deciduous - Coastal Forest	Undisturbed	1.60	X	SD: 1.1	2019 IPCC RF, Vol 4, Ch4, Table 4.9	Tropical dry forest, South America, Secondary >20yr
		Disturbed (Hurricane, fire, logging, Shift.Cult)	3.90	X	SD: 2.4	2019 IPCC RF, Vol 4, Ch4, Table 4.9	Tropical dry forest, South America, Secondary <20yr
	Croplands	Annual	0	X		Assumption	Assumed to be 0 for Annual Croplands remaining Annual Croplands following Tier 1 approach and for lands converted to annual croplands.
		Perennial (Moist)	5.2	X		IPCC 2006, V4, Ch5, Table 5.1	Assumed to be 0 for Perennial Croplands remaining Perennial Croplands following Tier 1 approach and for lands converted to Perennial croplands the value is equal to 5.2 t.d.m ha-1 yr-1. For Tropical moist (Value 2.6 C ha-1 yr-1, this value is divided for the CF=0.5, to obtain de t.d.m)



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		Perennial (Dry)	3.6	X		IPCC 2006, V4, Ch5, Table 5.1	Assumed to be 0 for Perennial Croplands remaining Perennial Croplands following Tier 1 approach and for lands converted to Perennial croplands the value is equal to 3.6 d.m ha-1 yr-1. For Tropical dry (Value 1.8 C ha-1 yr-1, this value is divided for the CF=0.5, to obtain de t.d.m)
	Grasslands	Dry	2.3	X		IPCC 2006, V4, Ch6, Table 6.4	Assumed to be 0 for Grasslands remaining Grasslands, following Tier 1 approach.
		Moist	6.2	X		IPCC 2006, V4, Ch6, Table 6.4	
		Woody	1.5	X			Estimated as the AGB divided by 10 years, which was the time indicated by the Dominica team to have woody components in grasslands.
	Wetlands		0	X		Assumption	Assumed to be 0 for Wetlands remaining Wetlands following Tier 1 approach and lands converted to Wetlands
	Settlements	Settlements	0	X		Assumption	Assumed to be 0 for Settlements remaining Settlements following Tier 1 approach and lands converted to Settlements
		Woody Setement	1.27	X			Assumed to be 0 for Woody Settlements remaining Woody Settlements following Tier 1 approach and for lands converted to Woody Settlements, Gw is equal to 70% is the same value as settlements, 10% is same value a Perennial Crops, 10% is same value as Semi-Evergreen Forest, 10% is same value as Deciduous Forest. These was decided based on expert knowledge on the composition of the woody component in settlements.
	Mining and Other Lands		0	X			Assumed to be 0 for Other Lands remaining Other Lands following Tier 1 approach and lands converted to Other Lands

Clarification Notes

These values were agreed to on June 4th, 2020 Forestry Division team. [For the application of the equation, the growth rates were applied based on the condition of the forest: stable/mature, regenerating or after conversion.](#)

[In forest land remaining forest lands, the growth rates were applied based on the damage class as follows:](#)



- a. For the “No Significant Damage” class, the undisturbed growth rate by forest type was applied from 2000 to 2017.
- b. For the “Damage I class”, the undisturbed growth rate by forest type was applied from 2000 to 2017. For the years after the hurricane, after the literature review and local expert consultation, it was assumed that of the total weight of a tree, 65% corresponds to trunk, 30% to the branches and 5% to the leaves. Because in this class the stem remained standing but has broken branches or heavy defoliation, the Gw was only applied to the 35% affected, and assumed to be recovered in 5 years; thus, the estimated value is $Gw \text{ [branches and leaves]} = AGB * 35\% / 5 \text{ years}$
- c. For the Damage II and Damage III classes, the undisturbed growth rate by forest type was applied from 2000 to 2017. For the years after the hurricane, the Gw of Disturbance was used. It is assumed that, even if trees were not uprooted, the recovery growth rate is applied to the whole tree for early successional (pioneer) species established and new recruits in open gaps formed after hurricane disturbances, growing rapidly in the high light environment.

For all classes, a maximum stock value was used, meaning that the Gw was applied annually until that maximum stock was reached. Time [years] was estimated by dividing ABG/Gw .

Table 19. Values for time to reaching max stock

Forestland	Time to reach max stock [years]
Elfin and Cloud forest (FLOUD)	4.4
Montane Forest (FRIN)	47.4
Semi-evergreen Forest (FEVER)	43.8
Deciduous - Coastal Forest (FDEC, FLIT, FDRYS)	10.6
Croplands	
Perennial (CPER) (Moist)	8.1
Perennial (CPER) (Dry)	5.0
Grassland	
Grassland (GGRASS)(Dry)	1
Grassland (GGRASS)(Moist)	1
Grassland Woody (GWGRASS)	10
Settlement	
Woody Settlement (SWOOD)	22.6

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

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

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

$L_{\text{wood-removals}}$ = 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)

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

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

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

Where:

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

H = annual wood removals, roundwood, m³ 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

$BCEFR$ = biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark), tonnes biomass removal (m³ of removals)⁻¹

Table 20. Annual wood removals values

H: Annual wood removals, roundwood, m ³ yr ⁻¹				
LU	Year	Hardwood -m3	Fuelwood -m3	Source
F		IE		

Clarification Notes

Detailed national statistics on wood removals is not available as yet. However, losses due to wood removals were estimated as an area of cover loss, through the Collect Earth assessment, and allocated as “Logging Disturbance”, where a fraction (fd) was determined and then used in eq. 2.14

Table 21. BCEFR values

BCEFR: biomass conversion and expansion factor, t biomass removal (m ³ of removals) ⁻¹				
LU	Sub-Category	Value	Range/Error	source
F		NE		



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

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

Where:

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

FG_{trees} = annual volume of fuelwood removal of whole trees, m³ yr⁻¹

FG_{part} = annual volume of fuelwood removal as tree parts, m³ 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 (m³ of removals)⁻¹

Table 22. *FG_{trees}* and *FG_{part}* values

FG _{trees} = annual volume of fuelwood removal of whole trees				
LU	Sub-Category	Source	years	Notes
F	NE	NE		
FG _{part} = annual volume of fuelwood removal as tree parts				
LU	Sub-Category	Sources		Notes
F	NE	NE		

Clarification Notes

Detailed national statistics on fuelwood removals is not available as yet

Table 23. *Wood density values*

D: wood density, g / cm ³				
LU	Sub-Category	Value	Range/Error	Source
F	Cloud Montane Rainforest	0.598	0.290 – 0.990	Graveson (2009), Reyes <i>et al</i> (1992) and Chave <i>et al</i> (2007).
	Lower Montane and Montane Rainforest	0.672	0.360 – 0.820	
	Semi-evergreen Seasonal Forest	0.601	0.470 – 0.871	
	Deciduous Seasonal Forest	0.655	0.482 -0.700	

**Clarification Note**

Graveson (2009), in Appendix 3, added a table of species identified per Forest Class Values (FCV). Therefore, wood density was assigned to these species based on Specie, Genus or Family. Wood Density values were assigned based on Reyes *et al* (1992)⁷⁹ and Chave *et al.* (2007)⁸⁰ (See Annex III. Wood Density by FCV in the Excel GHG calculation tool).

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

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

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

A_{disturbance}: area affected by disturbances, ha yr⁻¹

Figure 69. Land use matrices for disturbances

⁷⁹ Reyes, G., Brown, S., Chapman, J., Lugo, Ariel E. 1992. Wood densities of tropical tree species, Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 1992, 15p.

⁸⁰ Chave, Jérôme & Muller-Landau, Helene & Baker, Timothy & Easdale, Tomás & ter Steege, Hans & Webb, Campbell. (2007). Regional and phylogenetic variation of wood density across 2456 Neotropical tree species. Ecological applications : a publication of the Ecological Society of America. 16. 2356-67. 10.1890/1051-0761(2006)016[2356:RAPVOW]2.0.CO;2.



DISTURBANCES						
	Land Use and Land Use Change (LULUC) Vertical: Inicial Use Horizontal: Final Use	Affected by Fire	Affected by Hurricane	Affected by Logging	Affected by Shifting Cultivation	TOTAL
Montane Rainforest		28271			28,271	
Semi-evergreen Forest		10187			10,187	
Deciduous Forest		6916			6,916	
Dry Scrub Forest		1636			1,636	
Litoral Forest		3551			3,551	
Croplands, Annual Crops					0	
Croplands, Perennial Crops					0	
Grasslands (Pastures)					0	
Wetland					0	
Settlement					0	
Woody Settlement					0	
Other Lands					0	
Mining					0	
TOTAL					57,570	
2015-2016	Elfin and Cloud forest					0
	Montane Rainforest					0
	Semi-evergreen Forest					0
	Deciduous Forest		47		47	93
	Dry Scrub Forest					0
	Litoral Forest					0
	Croplands, Annual Crops					0
	Croplands, Perennial Crops					0
	Grasslands (Pastures)					0
	Wetland					0
	Settlement					0
	Woody Settlement					0
	Other Lands					0
	Mining					0
	TOTAL					93

Table 24. Average above ground biomass t.d.m ha-1

B _w = average above-ground biomass of land areas affected by disturbances							
LU	Category	Value	Regional value (tier 2)	Default Value (tier 1)	Error o range reported	Source	Comments and assumptions
F	Elfin and Cloud forest	19.2	X			Estimated using equation by Chave (2014) using NFI data and Forest Classes	$ABG=0.0673*(WD*D^2*H)^{0.976}$, where D is in cm, H is in m, and WD is in g/cm-3
	Montane Forest	279.6	X			Estimated using equation by Chave (2014) using NFI data and Forest Classes	$ABG=0.0673*(WD*D^2*H)^{0.976}$, where D is in cm, H is in m, and WD is in g/cm-3
	Semi-evergreen Forest	227.6	X			Estimated using equation by Chave (2014) using NFI data and Forest Classes	$ABG=0.0673*(WD*D^2*H)^{0.976}$, where D is in cm, H is in m, and WD is in g/cm-3



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	Deciduous - Coastal Forest	41.5	X			Estimated using equation by Chave (2014) using NFI data and Forest Classes	$ABG=0.0673*(WD*D^2*H)^{0.976}$, where D is in cm, H is in m, and WD is in g/cm-3
C	Annual Crops	0		X			Assumed to be 0 following Tier 1 approach
	Perennial Crops (Moist)	42		X	75%	IPCC 2006, V4, Ch5, Table 5.1	For Tropical moist (Value 21 of C, this value is divided for the CF=0.5, to obtain de t.d.m). Assumed to be 0 for Croplands remaining Croplands, following Tier 1 approach
	Perennial Crops (Dry)	18		X	75%	IPCC 2006, V4, Ch5, Table 5.1	For Tropical dry (Value 9 of C, this value is divided for the CF=0.5, to obtain de t.d.m). This value is used only for conversions from Dry Forest (ex. FDEC,FDRYS, FLIT) to Croplands
G	Grasslands (Dry)	2.3		X		IPCC 2006, V4, Ch6, Table 6.4	Assumed to be 0 for Grasslands remaining Grasslands, following Tier 1 approach
	Grasslands (Moist)	6.2		X		IPCC 2006, V4, Ch6, Table 6.4	Assumed to be 0 for Grasslands remaining Grasslands, following Tier 1 approach
	Woody Grassland	15					Values allocated by expert judgement. The value was selected using as reference the AGB for FEVER and FDEC/FSCRY and Perennial Croplands
W	Wetlands	0		X			Assumed to be 0
S	Non-Woody Settlements	0		X			Assumed to be 0
	Woody Settlements	28.7		X		Estimates as: $=(0*0.7)+(0.1*227.6)+(0.1*41.5)+(0.1*18)$	70% is the same value as settlements, 10% is same value a Perennial Crops, 10% is same value as Semi-Evergreen Forest, 10% is same value as Deciduous Forest. These was decided based on expert knowledge on the composition of the woody component in settlements.
O	Mining and Other Lands	0		X			Assumed to be 0

**Clarification Notes**

Chave et al (2014)⁸¹ pantropical biomass allometric equation was selected to estimate biomass in Saint Lucia, and the same approach was considered applicable to Dominica. Tree AGB (kg) was regressed against the product $\rho * D^2 * H$. The best-fit pantropical model identified was:

$$AGB_{est}: 0.0673 * (\rho * D^2 * H)^{0.976}$$

$$(\sigma = 357; AIC = 3130; df = 4002)$$

where D is in cm, H is in m, and ρ is in g cm³. This model performed well across forest types and bioclimatic conditions. The destructive harvest dataset assembled for the study was distributed across the tropics and across vegetation types. They compiled tree harvest studies that had been carried out in old-growth or secondary woody vegetation, excluding plantations and agroforestry systems. Sites included harvest experiments reported from the Afro-tropical realm (n=1429, including Madagascar), data from Latin America (n=1794), and from Southeast Asia and Australia (n=781). It is acknowledged that forest dynamics in Caribbean islands are different compared to continental lands, especially because of the constant influence of Hurricanes and storms, which tend to lead to shorter trees.

Table 25. Fraction of biomass loss due to disturbances

Fd: Fraction of biomass loss due to disturbances				
Forest Type	Disturbance	Fd	Tier 2	Notes
Elfin and Cloud forest	Affected by hurricane	0.6, 0.25, 0.15	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Fire	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Logging	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Shifting Cultivation	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
Montane Forest	Affected by hurricane	0.6, 0.25, 0.15	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Fire	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Logging	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Shifting Cultivation	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement

⁸¹ Chave, Jérôme & Réjou-Méchain, Maxime & Burquez, Alberto & Chidumayo, Emmanuel & Colgan, Matthew & Delitti, Wellington & Duque, Alvaro & Eid, Tron & Fearnside, Philip & Goodman, Rosa & Henry, Matieu & Martinez-Yrizar, Angelina & Mugasha, Wilson & Muller-Landau, Helene & Mencuccini, Maurizio & Nelson, Bruce & Ngomanda, Alfred & Nogueira, Euler & Ortiz, Edgar & Vieilledent, Ghislain. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*. 20. 3177-3190. 10.1111/gcb.12629.



Semi-evergreen Forest	Affected by hurricane	0.6, 0.25, 0.15	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Fire	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Logging	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Shifting Cultivation	0.60	x	Forestry Division, Collect Earth Assessment and Expert Judgement
Deciduous - Coastal Forest	Affected by hurricane	0.6, 0.25, 0.15	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Fire	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Logging	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Shifting Cultivation	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Fire	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Logging	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement
	Affected by Shifting Cultivation	NO	x	Forestry Division, Collect Earth Assessment and Expert Judgement

Clarification Notes

Fd values were selected based on expert judgment of the interpreters who did the Collect Earth, estimated as an average of the lost seen in the images, caused the by the indicated disturbance.

In forest land remaining forest lands, the fd were applied based on the damage class as follows:

- For the “No Significant Damage” class, a fd was applied to the disturbances before hurricane Maria. For example, shifting cultivation in 2015.
- For the “Damage I class”, after local expert consultation and based on what was observed during and right after the Hurricane Maria (2017), assumptions include that 5% of the canopy flew away and the other 95% remained on the forest floor. Therefore, the 5% loss of leaves is only applied to 5% of the total tree biomass per ha. Therefore, $L_{disturbance} = \{A_{disturbance} [ha] \bullet BW \cdot 0.05 [t.d.m/ha] \bullet CF \cdot 0.05$
- For the Damage II and Damage III classes, after local expert consultation and based on what was observed during and right after the Hurricane Maria (2017), assumptions include that 10 % was extracted and used for logs, charcoal, firewood and 15% was lost in the waterways. Therefore, a 25% loss is applied to the total tree biomass per ha. Therefore, $L_{disturbance} = \{A_{disturbance} [ha] \bullet BW [t.d.m/ha] \bullet CF \cdot 0.25$



7.3.3 Change in dead organic matter carbon stock in forest land remaining in the same category

As previously indicated, it was observed that the majority leaf litter ended up on the forest floor after the hurricane Maria, which was evident during forest access route restoration immediately after. Approximately 75% of canopy leaves blown off became forest litter. The remaining 25% is considered to be lost through heavy flooding and blown out of the forest structure. Some dead wood was also lost due to land erosion, although some remained trapped because of the nature of the destruction. Some rivers changed their courses due to the volume of water or damming along the streams due to landslides. Mainly dead wood on steep slopes was lost to waterways rather than areas of flat land. Approximately 10-20% of dead wood may have reached the ocean. From the remaining 80-90%, about 10% was used for lumber, charcoal, fuelwood and composting, with some sinking in the ocean and returned as driftwood. The rest remained in the forest floor and river sides.

In order to capture this dynamic, Dominica team intended to use the Tier 2 approach for calculating DOM in forest lands remaining in the same category. For this estimation, the equations 2.17 and 2.19 were applied.

ANNUAL CHANGE IN CARBON STOCKS IN DEAD ORGANIC MATTER (Equation 2.197, Ch2, V4)

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{LT}$$

C_{DOM} = annual change in carbon stocks in dead organic matter (includes dead wood and litter), tonnes

$C \text{ yr}^{-1}$

ΔC_{DW} = change in carbon stocks in dead wood, tonnes $C \text{ yr}^{-1}$

ΔC_{LT} = change in carbon stocks in litter, tonnes $C \text{ yr}^{-1}$

ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD OR LITTER (STOCK-DIFFERENCE METHOD) (Equation 2.19, Ch2, V4)

$$\Delta C_{DOM} = [A \cdot (DOM_{t2} - DOM_{t1}) / T] \cdot CF$$

ΔC_{DOM} = annual change in carbon stocks in the dead wood/litter pool, tonnes $C \text{ yr}^{-1}$

A = area of managed land, ha

DOM_{t1} = dead wood/litter stock at time t1 for managed land, tonnes d.m. ha^{-1}

DOM_{t2} = dead wood/litter stock at time t2 for managed land, tonnes d.m. ha^{-1}

T = (t2 – t1) = time period between time of the second stock estimate and the first stock estimate, yr

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

For DOM in t1, the C stock value was used and multiplied by the area of each forest type. For DOM in t2, the DOM value was estimated as the transfer of biomass carbon loss resulting from disturbances to DOM, tonnes $C \text{ yr}^{-1}$.



Dominica team searched for literature on decomposition rates after disturbances in the region, but information was very scarce.

Kaarik (1974)⁸² indicates that decomposition of wood is generally a slow process that involves biological, chemical, and physical processes and that the sequence that these processes act on dead wood varies over time due to changes in physical climate and the chemical and physical makeup of the wood over its decay life. It is also mentioned that each piece of dead wood has a unique chemical and physical makeup and that the difference in chemical and physical composition starts with differences in live trees. Harmon et al. (1986)⁸³ and Martius (1997)⁸⁴, indicate that differences among trees depend on tree species (wood characteristics), nutrient composition of soil, climate, tree health (including infections by insects, microbes, and fungus), and how the tree died. Nogueira et al. (2005)⁸⁵ points out that differences within trees may also be important due to internal variation in wood density.

A study on decomposition and carbon cycling of dead trees in tropical forests of the central Amazon (Chambers et al., 2000)⁸⁶ indicates that the measured rate varied by between 0.015 to 0.67 year⁻¹, averaging 0.19 year⁻¹ with predicted error of 0.026 year; and that a tree of average biomass was predicted to decompose at 0.17 year⁻¹. Another study by Powers et al. (2009)⁸⁷ about decomposition in tropical forests along a rainfall gradient, indicates that decay rates ranged from 0.47 year⁻¹ for raffia decomposing above ground without mesofauna in a dry forest in Thailand (HKK) to 15.10 year⁻¹ for bay leaves decomposing above ground with mesofauna in a wet forest in Papua New Guinea (PNG). Palace et al. (2008)⁸⁸ estimated that decomposition rates for all pieces of wood was 0.17 year⁻¹ for large (>10 cm diameter), 0.21 year⁻¹ for medium (5-10 cm diameter), and year⁻¹ for small size (2-5 cm diameter) class necromass. Other tropical forest necromass decomposition rates range from 0.03 year⁻¹ (Delaney et al. 1998)⁸⁹ to 0.51 year⁻¹ (Collins, 1981)⁹⁰.

⁸² Kaarik, AA. 1974. Decomposition of wood. In Dickinson, C.H., Pugh, G.J.F., 1974. *Biology of Plant Litter Decomposition*. Academic Press, NYC, pp. 129–174

⁸³ Harmon, M.E., Franklin, J.F., Swanson, F.J., Sollins, P., Gregory, S.V., Lattin, J.D., Anderson, N.H., Cline, S.P., Aumen, N.G., Sedell, J.R., Lienkaemper, G.W., Cromack, K., Cummins, K.W., 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15, 133-302.

⁸⁴ Martius, C., 1997. Decomposition of wood. In Junk, Wolfgang J., 1997. *Ecological Studies* 126. The Central Amazon Floodplain. Ecology of a Pulsing System. Springer, NYC, 267-276

⁸⁵ Nogueira, E.M., Nelson, B.W., Fearnside, P.M., 2005. Wood density in dense forest in central Amazonia, Brazil. *Forest Ecology and Management* 208, 261–286.

⁸⁶ Chambers, J., Higuchi, N., Schimel, J. *et al.* Decomposition and carbon cycling of dead trees in tropical forests of the central Amazon. *Oecologia* **122**, 380–388 (2000). <https://doi.org/10.1007/s004420050044>

⁸⁷ Powers, J.S., Montgomery, R.A., Adair, E.C., Brearley, F.Q., DeWalt, S.J., Castanho, C.T., Chave, J., Deinert, E., Ganzhorn, J.U., Gilbert, M.E., González-Iturbe, J.A., Bunyavejchewin, S., Grau, H.R., Harms, K.E., Hiremath, A., Iriarte-Vivar, S., Manzano, E., De Oliveira, A.A., Poorter, L., Ramanamanjato, J.-B., Salk, C., Varela, A., Weiblen, G.D. and Lerdau, M.T. (2009), Decomposition in tropical forests: a pan-tropical study of the effects of litter type, litter placement and mesofaunal exclusion across a precipitation gradient. *Journal of Ecology*, 97: 801-811. <https://doi.org/10.1111/j.1365-2745.2009.01515.x>

⁸⁸ Palace, M., M. Keller, H. Silva, (2008). Necromass production: studies in undisturbed and logged Amazon forests. *Ecological Applications*: 18, 873–884.

⁸⁹ Delaney, M., Brown, S., Lugo, A.E., Torres-Lezama, A., Quintero, N.B., 1998. The quantity and turnover of dead wood in permanent forest plots in six life zones of Venezuela. *Biotropica* 30(1), 2-11

⁹⁰ Collins, N.M., 1981. The role of termites in the decomposition of wood and leaf litter in the southern Guinea savanna of Nigeria. *Oecologia* 51, 389-399.

For the years after the hurricane Dominica assumes a decomposition rate of 2% annually. Though these estimates of decay are prone to error and hypothetical in nature, they will allow us to attempt estimate the possible dynamics post-hurricane conditions. Based on the natural conditions of Dominica, this decomposition rate is expected to be applied only after 5 years, where it will be assumed that a percentage will be transferred to the soil.



Figure 70 Photo 25 and 26: Forest stump of Prime Forest Tree Species 42 years after Hurricane David, Aug. 1979

7.3.4 Change in soil organic carbon stock in forest land remaining in the same category

Tier 1 Approach was applied from 2000 to 2016. Dominica, using Tier 1 method to estimate SOC pool in Forest land remaining in the same land-use category, reports zero changes in carbon stocks or carbon emissions from this pool.

For 2017, based on the Landslides and floods assessment triggered by Hurricane Maria (2017), about 5.3 Km² or 530 ha of soil was lost in Forest lands, with a desegregation by forest type as follows: Elfin and Cloud: 40% (212 ha), Montane Rainforest: 30% (159 Ha), Semi-evergreen forest: 20% (106 ha), Deciduous-Coastal Forest: 10% (53 ha).

Therefore, for Forest land remaining forest lands, to the total area of each forest type the corresponding percentage was applied and the area affected by landslides was estimated. For the SOC after Hurricane due to landslides a value of 0 was given. Thus, the losses due to landslides was estimated as:

$$\text{Area affected[ha]} = \text{Area per forest type} * \text{fd(landslide)}$$

$$\Delta\text{SOC [tC/yr]} = \text{Area affected} * (\text{SOC after Hurricane} - \text{SOC before hurricane})$$

For the years after the hurricane, an annual recovery of SOC after Hurricane due to landslides was estimated as

$$\Delta\text{SOC [tC/yr]} = \text{SOC before Hurricane} / 20 \text{ years}$$

Using a Tier 1 approach, it is estimated that it will take 20 years to the soil to recover, either through natural and/or assisted restoration or rehabilitation.



7.3.5 Change in biomass carbon stocks (above-ground biomass and below-ground biomass) in land converted to a new land-use category

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

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

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}

$\Delta C_{\text{CONVERSION}}$ = 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, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C_{yr}^{-1}

Table 26. Sources of area of land converted to a land-use category

A: area of land converted to a land-use category			
LU	Sub-Category	Source	Notes
Non-F>F	Non-Forest Lands > Forest Lands	Forest Division	Collect earth assessment - Annual time series 2000-2017
F>C	Forest lands > Croplands	Forest Division	Collect earth assessment - Annual time series 2000-2017
F>G	Forest lands > Grasslands	Forest Division	Collect earth assessment - Annual time series 2000-2017
F>W	Forest lands > Wetlands	Forest Division	Collect earth assessment - Annual time series 2000-2017
F>S	Forest lands > Settlements	Forest Division	Collect earth assessment - Annual time series 2000-2017
F>O	Forest lands > Other lands	Forest Division	Collect earth assessment - Annual time series 2000-2017

Annual increase in biomass carbon stocks on land converted to other land-use category (tier 2) (Equation 2.9, Ch2, V4)

Annual increase in carbon stocks in biomass due to land converted to another land-use category was estimated using the same approach as in forest lands remaining forest lands.



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

$$\Delta C_{\text{CONVERSION}} = \sum_i \{ (B_{\text{AFTER}_i} - B_{\text{BEFORE}_i}) \cdot \Delta A_{\text{TO_OTHERS}_i} \} \cdot C$$

Where:

$\Delta C_{\text{CONVERSION}}$ = 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

$\Delta A_{\text{TO_OTHERS}_i}$ = 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

Note: 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 forest lands remaining in the same category.

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

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

7.3.6 Change in dead organic matter in Carbon stock in land converted to a new land category

Land converted to another land-use category (Equation 2.23, Ch2, V4)

$$\Delta C_{\text{DOM}} = \frac{(C_n - C_o) * A_{on}}{Ton}$$

Where:

ΔC_{DOM} = annual change in carbon stocks in dead wood or litter, tonnes C yr⁻¹

C_o = dead wood/litter stock, under the old land-use category, tonnes C ha⁻¹



C_n = dead wood/litter stock, under the new land-use category, tonnes C ha⁻¹

A_{on} = area undergoing conversion from old to new land-use category, ha

T_{on} = time period of the transition from old to new land-use category, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses.

Table 27. Dead wood/litter stock values

Dead wood/litter stock tonnes C ha ⁻¹ (For conversion only)						
Pool	Land Use	Value	Tier 1	Error	Source	Note
Litter	Elfin and Cloud forest	NO			n.a	
	Montane Forest	4.8	x	Range: 2.1-16.4	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical rainforest
	Semi-evergreen Forest	5.9	x	Range: 1.9-14.8	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical moist
	Deciduous - Coastal Forest	2.4	x	Range: 2.1-2.7	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical dry
DOM	Elfin and Cloud forest	3.3		n.a	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical mountain System
	Montane Forest	14.8	x	Range: 0.6 - 218.9	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical rainforest
	Semi-evergreen Forest	8.0	x	Range: 1.9-14.8	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical moist
	Deciduous - Coastal Forest	9.0	x	Range:1.3-17.3	2019 IPCC RF, Vol 4, Ch2, Table 2.2	Tropical dry
Litter	Annual	0	x		IPCC 2006, V4, Ch5, page 5.13. Tier 1	
	Perennial	0	x		IPCC 2006, V4, Ch5, page 5.13. Tier 1	
DOM	Annual	0	x		IPCC 2006, V4, Ch5, page 5.13. Tier 1	
	Perennial	0	x		IPCC 2006, V4, Ch5, page 5.13. Tier 1	
Litter	Grassland	0	X		IPCC 2006, V4, Ch6, page 6.31. Tier 1	
DOM	Grassland	0	X		IPCC 2006, V4, Ch6, page 5.31. Tier 1	
Litter	Wetlands	NO				
DOM	Wetlands	NO				
Litter	Settlement	NO				
	Woody Settlement	NO				
DOM	Settlement	NO				
	Woody Settlement	NO				
Litter	Other Lands	NO				



DOM	Other Lands	NO				
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Clarification Note

For lands converted to Forest lands, T=20, until Forest lands is considered stable (F>F), then changed to DOM=0. For other conversions, T=1, meaning the loss on DOM happens the year of conversion.

7.3.7 Change in Carbon stock in soils in land converted to a new land category

Annual change in carbon stocks in mineral soils, tonnes C yr⁻¹ (Equation 2.25, Ch2, V4)

$$\Delta C_{\text{Mineral}} = \frac{(SOC_0 - SOC_{0-t})}{D}$$

$$\Delta SOC = \sum_{c,s,i} \{ (SOC_{REF} * F_{LU} * F_{MG} * F_I * A$$

Where,

$\Delta C_{\text{Mineral}}$ = annual change in carbon stocks in mineral soils, tonnes C yr⁻¹

SOC_0 = soil organic carbon stock in the last year of an inventory time period, tonnes C

$SOC(0-T)$ = soil organic carbon stock at the beginning of the inventory time period, tonnes C

T = number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr.

c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country.

SOC_{REF} = the reference carbon stock, tonnes C ha⁻¹

FLU = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

FMG = stock change factor for management regime, dimensionless

FI = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha.

Soil information was obtained from the Global Soil Organic Carbon Map -GSOCmap-, from FAO (2019) (figure 71). The web address of the portal is <http://54.229.242.119/GSOCmap/>. The country was selected, and information was downloaded through the “crop & Download” function. The result of the process is a TIFF file. The TIFF image processing was done in QGIS Desktop version 3.1.6. The TIFF had to undergo a correction for adequate georeferencing, which was done by selecting 4 sampling points and the coordinates were reassigned.



As a result, a CVS file is generated containing the SOC ref values for each sampling point. Information was saved as CSV file. Then, information is organized by land use and sub-category and an average value is estimated.



Figure 71 Dominica - Global Soil Organic Carbon Map -GSOCmap-, from FAO (2019).

Dominica has information on land uses obtained through Collect earth assessment described in the activity data section. Thus, the objective is to link the SOC information for each of the plots (figure 72), which then allows allocating the SOC ref value by land use and sub-categories of land use (Table 28). The TIFF image was processed using the Samples Raster Values tool for the process of linking the Collect Earth plots with the SOC shapefile.

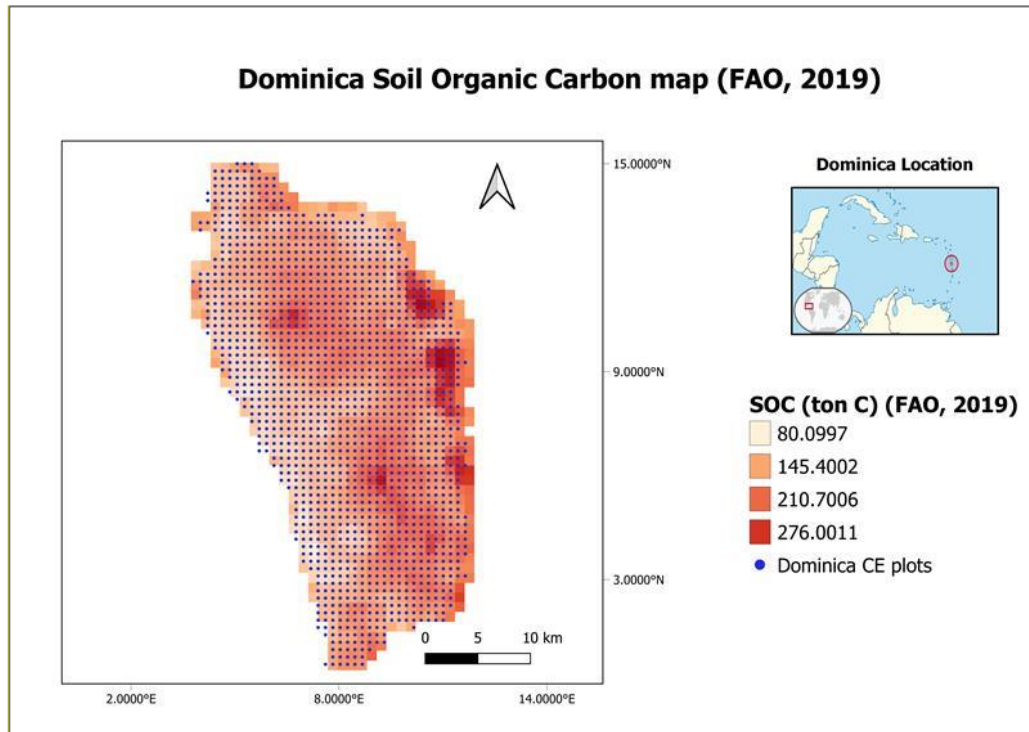


Figure 72 Overlapping FAO SOC map vs Collect Earth sampling grid

Table 28 Soil organic carbon by land use sub-category [tC ha]

Sub-category of land use	Number of plots	Average t C ha	Maximum t C ha	Minimum t C ha	StdDev t C ha
CANNUAL	131	155.4	307.0	93.5	46.6
CPER	87	148.8	292.5	97.4	37.9
FCLLOUD	109	187.7	286.0	117.4	28.7
FELF	42	216.8	310.0	150.3	33.8
FCLOD and FELF	151	195.8	310.0	117.4	32.8
FDEC	149	152.6	334.3	88.3	44.4
FDSCRUB	35	125.1	167.6	80.1	20.3
FLIT	77	168.4	295.8	113.6	39.9
FDEC, FDSCRUB, FLIT	261	153.6	334.3	80.1	42.6
FEVER	225	156.9	317.8	98.3	38.2
FRAIN	608	164.8	341.3	101.5	33.2
GGRASS	26	158.7	275.4	103.4	35.1
GWGRASS	30	112.2	167.6	93.5	15.0
OMIN	2	101.8	103.1	100.6	1.8
OOTHER	7	180.2	310.0	121.4	62.4
SSET	25	134.9	259.7	87.6	50.0
SWSET	34	144.8	259.3	80.1	49.8



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WWET	4	181.0	250.7	115.4	60.9
Grand Total	1591	161.2	341.3	80.1	40.3

Table 29. FLU, FMG and FI Values for values by Land use and sub-categories of land use

Notation	FLU	FMG	FI	Tier 1	Source
Parameter	Factor for land use systems	Factor for management regime	Factor for input of organic matter		
Units	Dimensionless	Dimensionless	Dimensionless		
Forestland					
Elfin and Cloud forest (FLOUD)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Montane Forest (FRAIN)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Semi-evergreen Forest (FEVER)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Deciduous - Coastal Forest (FDEC)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Deciduous - Coastal Forest (FLIT)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Deciduous - Coastal Forest (FDCRUB)	1.00	1.00	1.00	X	IPCC 2006, Vol 4, Ch 4, pg 4.40
Croplands					
Annual (CANNUALC)	0.48	1.00	0.92	X	IPCC 2006, V4, Ch.5, table 5.5 dry, Moist wet, Long-term Cultivated / Full tillage / Low, tropical, moist wet
Perennial (CPER) (Moist)	1.00	1.15	0.92	X	IPCC 2006, V4, Ch5, Table 5.5 Perennial / Reduce tillage, moist wet, tropical / Low, tropical, moist wet
Perennial (CPER) (Dry)	1.00	1.15	0.92	X	IPCC 2006, V4, Ch5, Table 5.5 Perennial / Reduce tillage, moist wet, tropical / Low, tropical, moist wet
Grassland					
Grassland (GGRASS)(Dry)	1.00	1.00	1.00	X	
Grassland (GGRASS)(Moist)	1.00	1.00	1.00	X	
Settlement					
Settlement (SSET)	0.00	0.00	0.00	x	
Woody Settlement (SWOOD)	1.00	1.00	1.00	x	

Clarification Note

For lands converted to Forest lands, D=20, until Forest lands is considered stable (F>F), then changed to SOC=0. For Forest lands converted to other lands, D=20, until indicating a transitional change of SOC to the new SOC values depending on the conversion.

7.3.8 Non-CO2 Emissions

Estimation of Greenhouse Gas Emissions from s (Equation 2.27, Ch2, V4)

$$L_{\text{fire}} = A \cdot MB \cdot Cf \cdot Gef \cdot 10^{-3}$$

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG (CH₄, N₂O).

A = area burnt, ha

MB = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless

G_{ef} = emission factor, g kg⁻¹ dry matter burnt

Table 30. MB, C_f, GefCH₄, GefN₂O values

		MB	C _f	G _{ef} CH ₄	G _{ef} N ₂ O
LU	Sub-Category	Mass of fuel available for combustion	Combustion factor	Emission factor- CH ₄	Emission factor- N ₂ O
		tonnes ha ⁻¹	Dimensionless	g kg ⁻¹ dry matter burnt	g kg ⁻¹ dry matter burnt
F	Deciduous-Coastal Forest	36.2	1	6,8	0,2

A summary of the level of the methods used for activity data and emission factors is included in [table 30](#)

Table 31. Methods and EF used for the FRL

Category	CO ₂		N ₂ O		CH ₄	
	AD	EF	AD	EF	AD	EF
5. LULUCF						
A. Forest Lands	CS	T1, T2	CS	T1	CS	T1
B. Croplands	CS	T1	NO	NA	NO	NA
C. Grasslands	CS	T1	NO	NA	NO	NA
D. Wetlands	CS	T1	NO	NA	NO	NA
E. Settlements	CS	T1	NO	NA	NO	NA

T1 – Tier 1, T2 – Tier 2, T3 – Tier 3, CS – Country specific, D – IPCC default, IE – Included Elsewhere; NA – Not Applicable; NE – Not Estimates; NO – Not Occurring



7. Results of GHG emissions and Removals

Historical GHG emissions of CO₂, CH₄ and N₂O for the period 2001–2017 associated with deforestation and forest degradation and net removals of CO₂ associated with conservation of forest carbon stocks and enhancement of forest carbon stocks were calculated as part of the analysis. However, due to country specific circumstances, the national FRL/FREL proposed by Dominica is the expected net balance of emissions and removals post-disturbance (Hurricane Maria 2017) due to forest regrowth as natural regeneration starting in 2018, along with the expected C removals of lands converted to forest lands calculated and emissions due to deforestation (figure 73).

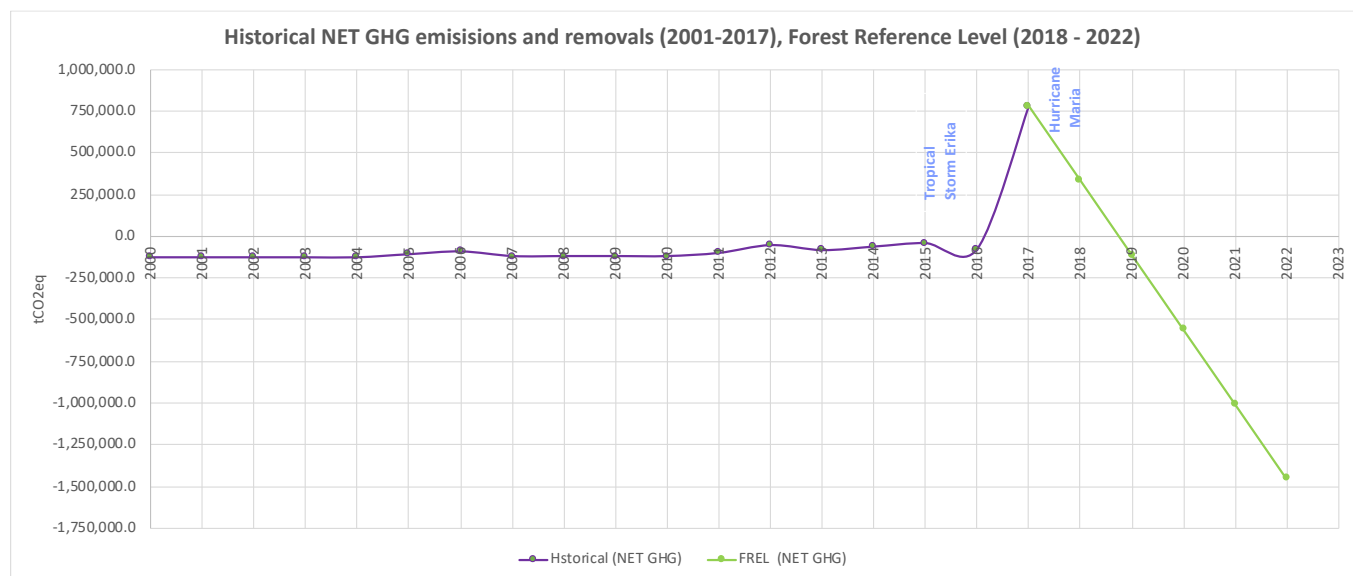


Figure 73 Historical C Stocks in Forest lands (2000 - 2017) and Forest Reference Level (2018 -2025) [tC]

The proposed FRL/FREL was constructed using the gain–loss method from the 2006 IPCC Guidelines. All lands were considered as managed. The forest above-ground biomass values were obtained from Saint Lucia’s Nation Forest

⁹¹Photo:<https://www.semanticscholar.org/paper/Perceptions-of-nature-in-the-Caribbean-island-of-Yarde/cf1497bde9823974f51b8ccf73cbe93eb8cf8787>



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Inventory carried out in 2009, as they share same forest conditions. The FAO GSOCmap and IPCC default values from the 2006 IPCC Guidelines, and the 2019 Refinement to the 2006 IPCC Guidelines were also used. Dominica used global warming potential values from the IPCC Second Assessment Report based on the effects of GHGs over a 100-year time-horizon to convert CH₄ and N₂O emissions into tons of CO₂e emissions. The analysis includes the pools above-ground biomass, below-ground biomass, dead organic matter and soil organic carbon. Harvested wood products were excluded due to lack of data.

For the estimations of annual GHG emissions and removals, Dominica applied the land representation approach 3, using the sampling method combined with a plot-by-plot annual analysis using 1605 plots of 1ha distributed in a systematic grid 750 m × 750 m that were analyzed annually from 2000 to 2017 to determine land use, land use changes, year of land use change, disturbance and year of disturbance using the Collect Earth software, which contains a combination of high and medium spatial resolution imagery (i.e. 15 m resolution Landsat imagery, 2.5 m resolution SPOT imagery and high-resolution imagery from several other sources) accessible through the Google Earth, Bing Maps and Google Earth Engine platforms. Dominica used the Collect Earth tool to synchronize the view of each sampling point on the three platforms and incorporate the land-use condition for each year of the time series 2001–2017. Forest land was stratified by forest type (Elfin Forest, Cloud Forest, Montane rainforest, Semi-evergreen forest, Deciduous Forest; Littoral Forest and Dry Scrub). Cropland was classified as either annual or perennial cropland, settlements were classified as woody and non-woody. Other land was divided into other land and mining. Grasslands and Wetlands did not have a further subclassification.

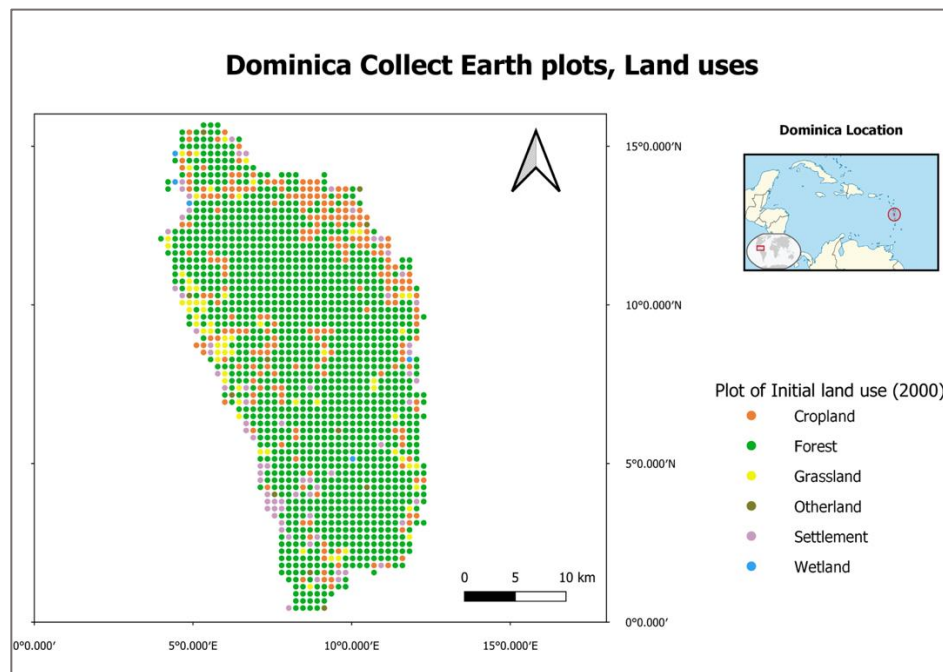


Figure 74 Dominica initial land use in 2000, represented in the sampling plots



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The sampling approach combined with an annual plot by plot analysis allowed capturing multiple land use changes for a plot; however, these were not registered; therefore, only the initial Land Use (figure 74) and the Final land use was captured, and only when that second land use reached the definition. Specifically, in conversion to forest, only when the forest reached the definition that conversion would be registered; otherwise, it remained in the initial land use. Also, the survey allowed to capture multiple disturbances; however, only the primary one was accounted.

The land use and land use change analysis indicated that total area of forest lands in 2000 was 58,551 Ha compared to 57,710 Ha in 2017 (figure 75), resulting in a forest loss of 888 Ha in 17 years of about 52Ha per year, locating Dominica in a high forest cover low, deforestation country. However, all forest were severely affected in 2017 by Hurricane Maria, which was a hurricane category 5, removing most of the canopy cover and in some cases uprooting trees, causing also floods and landslides.

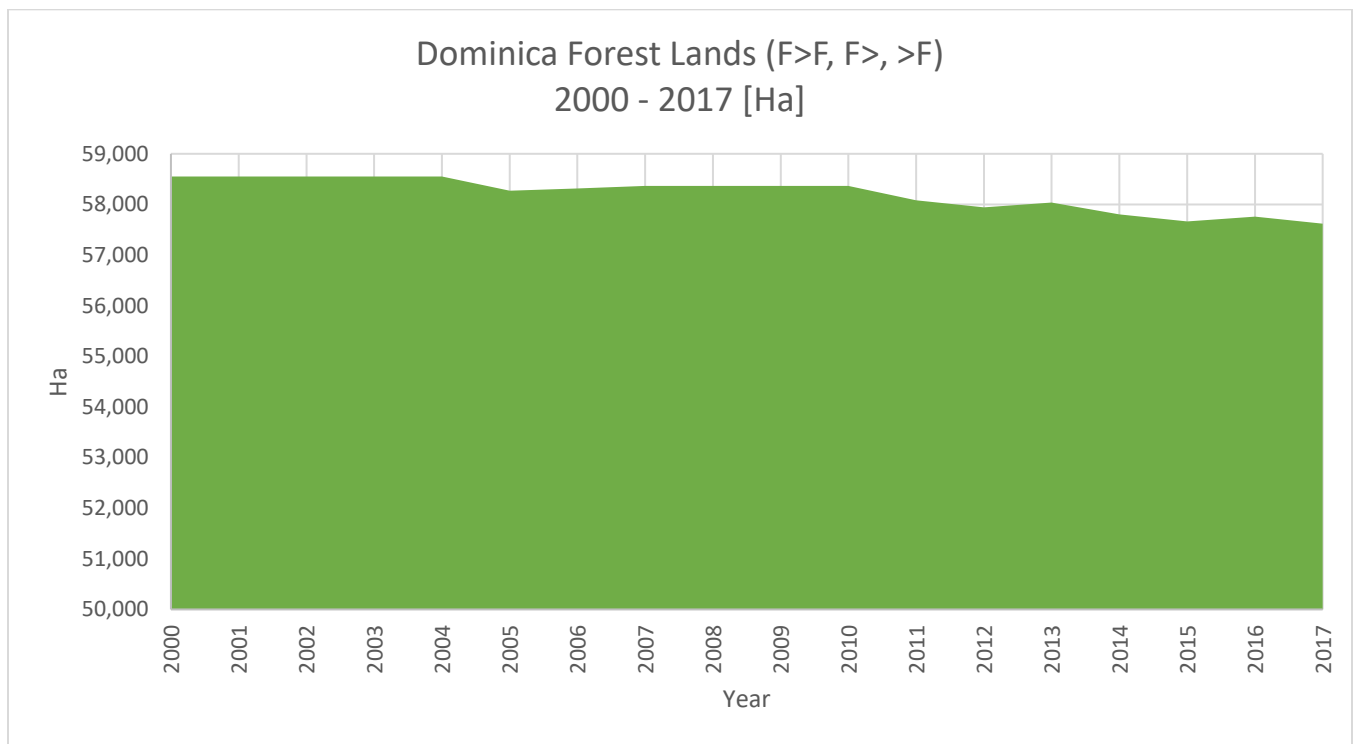


Figure 75 Net balance of forest lands in Dominica (Forest lands remaining and Forest lands converted to and from other land uses) [Ha]

In the period 2000-2017, 280 Ha of forest were converted to croplands, 327 Ha converted to Grasslands, 280 Ha converted to Settlements and 94 Ha converted to Other lands (figure 76).

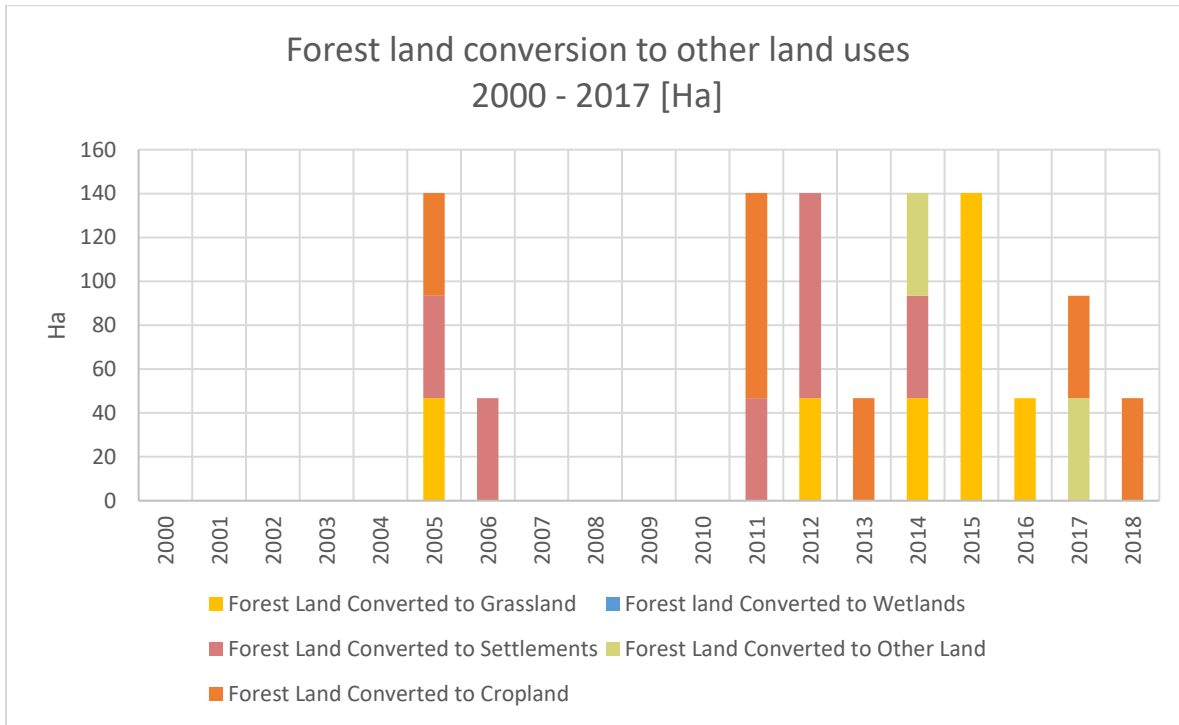


Figure 76 Forest land conversion to other land uses 2001 to 2017 [Ha]

Historical net GHG emissions and removals average -100,610 tCO₂e from 2001 to 2016 including all carbon pools (AGB, BGB, DOM, SOC), and for CO₂ and non-CO₂ gases (CH₄, N₂O). Average net balance of emissions and removals in Forest lands remaining Forest Lands for the period 2001 to 2016 were -122,852 tCO₂e, excluding the year of the Hurricane. Emissions due to the hurricane Maria (2017) were estimated as 730,654 tCO₂e for the AGB_BGB pool and 339,080 for the SOC pool; these emissions are associated to the losses due to wood extraction for logging, charcoal, fuelwood, and biomass lost due to flooding, landslides, heavy rains and strong winds. However, most of losses in the AGB_BGB pool were transferred to the DOM pool, estimated as -14,646,458 millions tCO₂e, increasing drastically the C stocks in the DOM pool. Average removals from lands converted to Forest lands for the period 2001 to 2016 were estimated as -1,147 tCO₂e and emissions from Forest lands converted to other lands were estimates as 26.685 tCO₂e.

The expected annual removals for the period 2018 to 2025 is -22,188 tCO₂e in the forest that had no significant damage, and -430,318 tCO₂e due to natural regeneration and forest recovery. Additional -1,147 removals are expected due to the conversion of other lands to forest. These removals are estimated including the four C pools (table 32).

Some emissions of about 6,671 tCO₂ might be expected due to deforestation. Forest conversion and degradation have a compounding factor which is that small farmers tend to be resource-poor, with low capacity to invest in soil and water conservation measures. In cases where lands are converted to housing and other forms of urban development, land degradation is driven by similar factors particularly where settlements are unplanned and



developed without infrastructure to control pollution, runoff, erosion and landslides. In Dominica, land and water resources degradation has been historically driven mainly by clearing of forests in environmentally fragile areas (steep slopes underlain by erodible soils within high rainfall zones) and subsequent replacement by intensive agricultural cultivation. Installation of poorly constructed farm access roads in these areas in many instances contributes to land degradation. Other activities such as poorly managed mining and quarrying operations and expansion of settlement areas in erosion-prone and landslide-prone areas compounds the country's vulnerability to impacts from climate change. However, because of the fallen branches, twigs and tree stumps after the hurricane which initially hindered any major movement of persons into the forested areas, few months after the hurricane access to forest areas became more complicated due to an exposed undergrowth. Those, changes in behavioral patterns are expected to change, which will be monitored in future land use and land use change assessments.

Dominica is one of the few carbon-neutral countries in the world, largely due to carbon sequestration. It is important to note that the forest disturbance regime is driven by storms. Wind damage to forests is not unusual, and the forest types in Dominica developed in the face of intermittent storms. Not the storms as such, but the increased frequency and intensity of storms constitute an unusual threat for Dominica's forests. Forests have been seriously disturbed by Hurricane Maria, but their recovery capacity is naturally high. Agriculturally driven deforestation is no longer a threat. There are no alarming degradation phenomena, no pressing unmet needs for wood, and no indications that forestry problems are closely linked to widespread poverty.

Forest resources management should therefore aim at increasing the resilience of forests to climate change. Specifically, forest adaptation should focus mainly on natural regeneration, while plantations may help increase the value of abandoned agricultural land.

Table 32 NET Historical GHG Emissions [CO2, N2O, CH4] [tCO2eq]

REDD+ Activity	Sub-category	Carbon Pool	Gas	Units	Equation	2000	2001	2002	2003	2004	2005	2006	2007	2008	
	Forest lands remaining Forest Lands (Undisturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e / yr			-126,904	-126,904	-126,904	-126,904	-126,904	-126,202	-124,626	-124,626	-124,626
Conservation and Sustainable Forest Management	Forest remaining Forest lands (Undisturbed) [Net Balance ABG_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.7	-126,904	-126,904	-126,904	-126,904	-126,904	-126,202	-124,626	-124,626	-124,626	
	F >F (Undisturbed) [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	
	F>F before conversion to C [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-4,718	-4,718	-4,718	-4,718	-4,718	-4,484	-4,484	-4,484	-4,484	
	F>F before conversion to G [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-6,126	-6,126	-6,126	-6,126	-6,126	-5,892	-5,892	-5,892	-5,892	
	F>F before conversion to W [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0	
	F>F before conversion to S [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-5,136	-5,136	-5,136	-5,136	-5,136	-4,902	-3,326	-3,326	-3,326	
	F>F before conversion to O [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-1,810	-1,810	-1,810	-1,810	-1,810	-1,810	-1,810	-1,810	-1,810	-1,810
	F >F (Undisturbed) [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0	0



REDD+ Activity	Sub-category	Carbon Pool	Gas	Units	Equation	2009	2010	2011	2012	2013	2014	2015	2016	2017
	Forest lands remaining Forest Lands (Undisturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	CO ₂ , CH ₄ , N ₂ O	t CO ₂ e / yr			-124,626	-124,626	-124,050	-120,958	-119,382	-117,338	-113,710	-113,256
Conservation	Forest remaining Forest lands (Undisturbed) [Net Balance ABG_BGB]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.7	-124,626	-124,626	-124,050	-120,958	-119,382	-117,338	-113,710	-113,256	-28,904
	F >F (Undisturbed) [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-109,114	-27,621
	F>F before conversion to C [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	-4,484	-4,484	-4,142	-4,142	-2,566	-2,566	-2,566	-2,566	-1,283
	F>F before conversion to G [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	-5,892	-5,892	-5,892	-5,658	-5,658	-4,082	-1,283	0	0
	F>F before conversion to W [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
	F>F before conversion to S [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	-3,326	-3,326	-3,093	-234	-234	0	0	0	0
	F>F before conversion to O [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	-1,810	-1,810	-1,810	-1,810	-1,810	-1,576	-1,576	-1,576	0
	F >F (Undisturbed) [Losses]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.11	0	0	0	0	0	0	-828	0	0
	F >F (Undisturbed) [DOM]	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [SOC]	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0



REDD+ Activity	Sub-category	Carbon Pool	Units	Equation	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SFM	Forest remaining Forest lands (Disturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	t CO2e / yr		0	0	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [Net balance AGB_BGB]	Biomass (AGB+BGB)	t CO2e / yr	Equation 2.7	0	0	0	0	0	0	0	0	0	0
	F >F (Disturbance) [Gains]	Biomass (AGB+BGB)	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0	0
	F >F (Disturbance) Losses	Biomass (AGB+BGB)	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [DOM]	DOM	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [SOC]	SOC	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [CH4]	Non-CO2 emissions due to biomass burning (CH4)	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [N2O]	Non-CO2 emissions due to biomass burning (N2O)	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0	0



REDD+ Activity	Sub-category	Carbon Pool	Gas	Units	Equation	2010	2011	2012	2013	2014	2015	2016	2017
Forest degradation	Forest remaining Forest lands (Disturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e / yr		0	0	0	0	0	0	17,744	730,654
	Forest remaining Forest lands (Disturbance, before conversion) [Net balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.7	0	0	0	0	0	0	17,744	15,034,032
	F >F (Disturbance) [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	-289	-442,048
	F >F (Disturbance) Losses	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	18,033	15,476,079
	Forest remaining Forest lands (Disturbance, before conversion) [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	-14,642,458
	Forest remaining Forest lands (Disturbance, before conversion) [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	339,080
	Forest remaining Forest lands (Disturbance, before conversion) [CH4]	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [N2O]	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0



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REDD+ Activity	Sub-category	Carbon Pool	Gas	Units	Equation	2000	2001	2002	2003	2004	2005	2006	2007	2008
Enhancement of Carbon Stocks	Land Converted to Forest	AGB, BGB, DOM, SOC	CO ₂ , CH ₄ , N ₂ O	t CO ₂ e / yr		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	DOM	CO ₂	t CO ₂ e / yr	Equation 2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	SOC	CO ₂	t CO ₂ e / yr	Equation 2.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Non-CO ₂ emissions due to biomass burning (CH ₄)	CH ₄	t CO ₂ e / yr	Equation 2.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Non-CO ₂ emissions due to biomass burning (N ₂ O)	N ₂ O	t CO ₂ e / yr	Equation 2.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cropland converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
	C>F [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
	C>F [Losses]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
	C>F [Conversion]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
	Cropland converted to Forest lands [DOM]	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
	Cropland converted to Forest lands [SOC]	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0



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Grasslands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
G>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
G>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
G>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Grasslands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Grasslands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
W>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
W>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
W>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
S>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0



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S>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
S>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
O>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
O>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
O>F[Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Lands converted to Forest lands [CH4]	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0
Lands converted to Forest lands [N2O]	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0



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REDD+ Activity	Sub-category	Carbon Pool	Gas	Units	Equation	2009	2010	2011	2012	2013	2014	2015	2016	2017
Enhancement of Carbon Stocks	Land Converted to Forest	AGB, BGB, DOM, SOC	CO ₂ , CH ₄ , N ₂ O	t CO ₂ e / yr		0.0	0.0	0.0	0.0	-6751.7	-580.1	-580.1	-5404.2	1276.3
	Land Converted to Forest	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.7	0.0	0.0	0.0	0.0	-167.9	-167.9	-167.9	-335.8	-335.8
	Land Converted to Forest	DOM	CO ₂	t CO ₂ e / yr	Equation 2.9	0.0	0.0	0.0	0.0	-792.7	-792.7	-792.7	-1955.5	-1955.5
	Land Converted to Forest	SOC	CO ₂	t CO ₂ e / yr	Equation 2.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Non-CO ₂ emissions due to biomass burning (CH ₄)	CH ₄	t CO ₂ e / yr	Equation 2.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Non-CO ₂ emissions due to biomass burning (N ₂ O)	N ₂ O	t CO ₂ e / yr	Equation 2.24	0.0	0.0	0.0	0.0	-6751.7	-580.1	-580.1	-5404.2	1276.3
	Cropland converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.15	0	-6,752	-580	-580	-580	1,160	-6,752	-580	-580
	C>F [Gains]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.9	0	-580	-580	-580	-580	-580	-580	-580	-580
	C>F [Losses]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.11	0	0	0	0	0	1,740	0	0	0
	C>F [Conversion]	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	-6,172	0	0	0	0	-6,172	0	0
	Cropland converted to Forest lands [DOM]	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	-168	-168	-168	-168	-168	-168	-168	-168
	Cropland converted to Forest lands [SOC]	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0	-793	-793	-793	-793	-793	-793	-793	-793



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Grasslands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	-26,143	464
G>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	-580	-580
G>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0	1,044
G>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	-25,563	0
Grasslands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	-168	-168
Grasslands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	-1,163	-1,163
Wetlands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0	0
W>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0	0
W>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0	0
W>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0	0
S>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0	0



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S>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
S>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0	0
O>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0	0
O>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	0	0	0	0	0	0	0	0	0
O>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0
Lands converted to Forest lands [CH4]	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0
Lands converted to Forest lands [N2O]	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0	0



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REDD +	Sub-category	Carbon Pool	Gas	Units	Equation	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Deforestation	Forest converted to other land uses	AGB, BGB, DOM, SOC	CO ₂ , CH ₄ , N ₂ O	t CO ₂ e / yr		0	0	0	0	0	17,858	32,370	4,490	4,490	
	Forest converted to other land uses	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr		0.0	0	0	0	0	8,921	24,522	0	0	
	Forest converted to other land uses	DOM	CO ₂	t CO ₂ e / yr		0.0	0	0	0	0	5,860	3,358	0	0	
	Forest converted to other land uses	SOC	CO ₂	t CO ₂ e / yr		0.0	0	0	0	0	3,078	4,490	4,490	4,490	
	Forest converted to other land uses	Non-CO ₂ emissions due to biomass burning (CH ₄)	CH ₄	t CO ₂ e / yr		0.0	0	0	0	0	0	0	0	0	0
	Forest converted to other land uses	Non-CO ₂ emissions due to biomass burning (N ₂ O)	N ₂ O	t CO ₂ e / yr		0.0	0	0	0	0	0	0	0	0	0
	Forest converted to Cropland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0.00	0	0	0	0	4,605	0	0	0	0
	Forest converted to Cropland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0.00	0	0	0	0	1,953	0	0	0	0
	Forest converted to Cropland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0.00	0	0	0	0	696	696	696	696	696
	Forest converted to Grassland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0.00	0	0	0	0	2,678	0	0	0	0
	Forest converted to Grassland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0.00	0	0	0	0	1,953	0	0	0	0
	Forest converted to Grassland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0.00	0	0	0	0	1,066	1,066	1,066	1,066	1,066
	Forest converted to Wetland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0.00	0	0	0	0	0	0	0	0	0
	Forest converted to Wetland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0.00	0	0	0	0	0	0	0	0	0
	Forest converted to Wetland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0.00	0	0	0	0	0	0	0	0	0
	Forest converted to Settlement	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0.00	0	0	0	0	1,637	24,522	0	0	0
	Forest converted to Settlement	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0.00	0	0	0	0	1,953	3,358	0	0	0
	Forest converted to Settlement	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0.00	0	0	0	0	1,315	2,728	2,728	2,728	2,728
	Forest converted to Other land	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0.00	0	0	0	0	0	0	0	0	0
	Forest converted to Other land	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0.00	0	0	0	0	0	0	0	0	0
Forest converted to Other land	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	



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RED D+	Sub-category	Carbon Pool	Gas	Units	Equation	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Deforestation	Forest converted to other land uses	AGB, BGB, DOM, SOC	CO ₂ , CH ₄ , N ₂ O	t CO ₂ e / yr		4,490	4,490	23,134	66,837	43,022	55,702	73,117	44,369	79,281	
	Forest converted to other land uses	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr		0	0	11,103	47,763	27,490	32,437	47,112	21,603	51,021	
	Forest converted to other land uses	DOM	CO ₂	t CO ₂ e / yr		0	0	4,472	7,693	3,358	7,265	6,717	2,382	5,740	
	Forest converted to other land uses	SOC	CO ₂	t CO ₂ e / yr		4,490	4,490	7,559	11,381	12,174	16,001	19,289	20,384	22,520	
	Forest converted to other land uses	Non-CO ₂ emissions due to biomass burning (CH ₄)	CH ₄	t CO ₂ e / yr		0	0	0	0	0	0	0	0	0	0
	Forest converted to other land uses	Non-CO ₂ emissions due to biomass burning (N ₂ O)	N ₂ O	t CO ₂ e / yr		0	0	0	0	0	0	0	0	0	0
	Forest converted to Cropland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	6,497	0	27,490	0	0	0	0	23,531
	Forest converted to Cropland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	2,519	0	3,358	0	0	0	0	2,382
	Forest converted to Cropland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	696	696	2,450	2,450	3,242	3,242	3,242	3,242	3,242	3,967
	Forest converted to Grassland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	0	2,678	0	26,194	47,112	21,603	0	0
	Forest converted to Grassland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	0	1,953	0	3,358	6,717	2,382	0	0
	Forest converted to Grassland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	1,066	1,066	1,066	2,132	2,132	3,328	6,617	7,712	7,712	7,712
	Forest converted to Wetland	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	0	0	0	0	0	0	0	0
	Forest converted to Wetland	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	0	0	0	0	0	0	0	0
	Forest converted to Wetland	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0	0	0	0	0	0	0	0	0	0
	Forest converted to Settlement	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	4,605	45,085	0	1,637	0	0	0	0
	Forest converted to Settlement	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	1,953	5,740	0	1,953	0	0	0	0
	Forest converted to Settlement	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	2,728	2,728	4,043	6,799	6,799	8,115	8,115	8,115	8,115	8,115
	Forest converted to Other land	Biomass (AGB+BGB)	CO ₂	t CO ₂ e / yr	Equation 2.16	0	0	0	0	0	4,605	0	0	0	27,490
	Forest converted to Other land	DOM	CO ₂	t CO ₂ e / yr	Equation 2.23	0	0	0	0	0	1,953	0	0	0	3,358
Forest converted to Other land	SOC	CO ₂	t CO ₂ e / yr	Equation 2.24	0	0	0	0	0	1,315	1,315	1,315	1,315	2,728	

For the projection period, the following are the estimates:

FREL/FRL (Projection) ---> Subject to MRV													
REDD+ Activities	Sub-category	Carbon Pool	Gas	Units	Equation	2018	2019	2020	2021	2022	2023	2024	2025
CONSERVATION AND SFM (Assisted Forest Management)	Forest lands remaining Forest Lands (Undisturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e /yr		-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188
	Forest remaining Forest lands (Undisturbed) [Net Balance ABG_BGB]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.7	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188
	F >F (Undisturbed) [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188	-22,188
	F>F before conversion to C [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
	F>F before conversion to G [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
	F>F before conversion to W [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
	F>F before conversion to S [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
	F>F before conversion to O [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [Losses]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.11	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [DOM]	DOM	CO2	t CO2e /yr	Equation 2.19	0	0	0	0	0	0	0	0
	F >F (Undisturbed) [SOC]	SOC	CO2	t CO2e /yr	Equation 2.24	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbed) [NET BALANCE ALL]	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e /yr		-430,318	-430,318	-430,318	-430,318	-430,318	-430,318	-430,318	-430,318
	Forest remaining Forest lands (Disturbance, before conversion) [Net balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.7	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755
	F >F (Disturbance) [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755	-416,755
	F >F (Disturbance) Losses	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.11	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [DOM]	DOM	CO2	t CO2e /yr	Equation 2.19	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [SOC]	SOC	CO2	t CO2e /yr	Equation 2.24	-13,563	-13,563	-13,563	-13,563	-13,563	-13,563	-13,563	-13,563



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	Forest remaining Forest lands (Disturbance, before conversion) [CH4]	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0
	Forest remaining Forest lands (Disturbance, before conversion) [N2O]	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr	Equation 2.27	0	0	0	0	0	0	0	0
ENHANCEMENT OF CARBON STOCKS	Land Converted to Forest	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e / yr		-1147.3	-1147.3	-1147.3	-1147.3	-1147.3	-1147.3	-1147.3	-1147.3
	Land Converted to Forest	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	-668.9	-668.9	-668.9	-668.9	-668.9	-668.9	-668.9	-668.9
	Land Converted to Forest	DOM	CO2	t CO2e / yr	Equation 2.23	-65.3	-65.3	-65.3	-65.3	-65.3	-65.3	-65.3	-65.3
	Land Converted to Forest	SOC	CO2	t CO2e / yr	Equation 2.24	-349.4	-349.4	-349.4	-349.4	-349.4	-349.4	-349.4	-349.4
	Land Converted to Forest	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e / yr	Equation 2.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Land Converted to Forest	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr	Equation 2.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cropland converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	-407	-407	-407	-407	-407	-407	-407	-407
	C>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-161	-161	-161	-161	-161	-161	-161	-161
	C>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	97	97	97	97	97	97	97	97
	C>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	-343	-343	-343	-343	-343	-343	-343	-343
	Cropland converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	-47	-47	-47	-47	-47	-47	-47	-47
	Cropland converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	-220	-220	-220	-220	-220	-220	-220	-220
	Grasslands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	-262	-262	-262	-262	-262	-262	-262	-262
	G>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	-64	-64	-64	-64	-64	-64	-64	-64
	G>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.11	39	39	39	39	39	39	39	39
	G>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	-236	-236	-236	-236	-236	-236	-236	-236
	Grasslands converted to Forest lands [DOM]	DOM	CO2	t CO2e / yr	Equation 2.23	-19	-19	-19	-19	-19	-19	-19	-19
	Grasslands converted to Forest lands [SOC]	SOC	CO2	t CO2e / yr	Equation 2.24	-129	-129	-129	-129	-129	-129	-129	-129
	Wetlands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.15	0	0	0	0	0	0	0	0
	W>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.9	0	0	0	0	0	0	0	0



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W>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.11	0	0	0	0	0	0	0	0
W>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.16	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [DOM]	DOM	CO2	t CO2e /yr	Equation 2.23	0	0	0	0	0	0	0	0
Wetlands converted to Forest lands [SOC]	SOC	CO2	t CO2e /yr	Equation 2.24	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.15	0	0	0	0	0	0	0	0
S>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
S>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.11	0	0	0	0	0	0	0	0
S>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.16	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [DOM]	DOM	CO2	t CO2e /yr	Equation 2.23	0	0	0	0	0	0	0	0
Settlements converted to Forest lands [SOC]	SOC	CO2	t CO2e /yr	Equation 2.24	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [Net Balance AGB_BGB]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.15	0	0	0	0	0	0	0	0
O>F [Gains]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.9	0	0	0	0	0	0	0	0
O>F [Losses]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.11	0	0	0	0	0	0	0	0
O>F [Conversion]	Biomass (AGB+BGB)	CO2	t CO2e /yr	Equation 2.16	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [DOM]	DOM	CO2	t CO2e /yr	Equation 2.23	0	0	0	0	0	0	0	0
Other lands converted to Forest lands [SOC]	SOC	CO2	t CO2e /yr	Equation 2.24	0	0	0	0	0	0	0	0
Lands converted to Forest lands [CH4]	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e /yr	Equation 2.27	0	0	0	0	0	0	0	0
Lands converted to Forest lands [N2O]	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e /yr	Equation 2.27	0	0	0	0	0	0	0	0
Forest converted to other land uses	AGB, BGB, DOM, SOC	CO2, CH4, N2O	t CO2e /yr		6671	6671	6671	6671	6671	6671	6671	6671
Forest converted to other land uses	Biomass (AGB+BGB)	CO2	t CO2e /yr		3999.6	3999.6	3999.6	3999.6	3999.6	3999.6	3999.6	3999.6
Forest converted to other land uses	DOM	CO2	t CO2e /yr		688.9	688.9	688.9	688.9	688.9	688.9	688.9	688.9
Forest converted to other land uses	SOC	CO2	t CO2e /yr		1982.9	1982.9	1982.9	1982.9	1982.9	1982.9	1982.9	1982.9
Forest converted to other land uses	Non-CO2 emissions due to biomass burning (CH4)	CH4	t CO2e /yr		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



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Forest converted to other land uses	Non-CO2 emissions due to biomass burning (N2O)	N2O	t CO2e / yr		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest converted to Cropland	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	913.59	913.59	913.59	913.59	913.59	913.59	913.59	913.59
Forest converted to Cropland	DOM	CO2	t CO2e / yr	Equation 2.23	150.17	150.17	150.17	150.17	150.17	150.17	150.17	150.17
Forest converted to Cropland	SOC	CO2	t CO2e / yr	Equation 2.24	382.51	382.51	382.51	382.51	382.51	382.51	382.51	382.51
Forest converted to Grassland	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	1474.48	1474.48	1474.48	1474.48	1474.48	1474.48	1474.48	1474.48
Forest converted to Grassland	DOM	CO2	t CO2e / yr	Equation 2.23	240.63	240.63	240.63	240.63	240.63	240.63	240.63	240.63
Forest converted to Grassland	SOC	CO2	t CO2e / yr	Equation 2.24	545.54	545.54	545.54	545.54	545.54	545.54	545.54	545.54
Forest converted to Wetland	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest converted to Wetland	DOM	CO2	t CO2e / yr	Equation 2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest converted to Wetland	SOC	CO2	t CO2e / yr	Equation 2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest converted to Settlement	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	1139.52	1139.52	1139.52	1139.52	1139.52	1139.52	1139.52	1139.52
Forest converted to Settlement	DOM	CO2	t CO2e / yr	Equation 2.23	219.97	219.97	219.97	219.97	219.97	219.97	219.97	219.97
Forest converted to Settlement	SOC	CO2	t CO2e / yr	Equation 2.24	956.67	956.67	956.67	956.67	956.67	956.67	956.67	956.67
Forest converted to Other land	Biomass (AGB+BGB)	CO2	t CO2e / yr	Equation 2.16	471.99	471.99	471.99	471.99	471.99	471.99	471.99	471.99
Forest converted to Other land	DOM	CO2	t CO2e / yr	Equation 2.23	78.11	78.11	78.11	78.11	78.11	78.11	78.11	78.11
Forest converted to Other land	SOC	CO2	t CO2e / yr	Equation 2.24	98.15	98.15	98.15	98.15	98.15	98.15	98.15	98.15
					-446,983	-446,983	-446,983	-446,983	-446,983	-446,983	-446,983	-446,983



8. Risk Assessment

Small Island Developing States, in particular those in the Caribbean Region are amongst the most vulnerable to the effects and negative impacts of climate change and other natural hazards. Since the 1950's the Caribbean has had 324 disasters, representing more than 64% of all natural disasters globally. Such disasters bring with them devastating human and economic impacts. Hurricane Maria in 2017, is estimated to have cost Dominica 225 percent of its GDP (Ötker & Srinivasan, 2018)⁹³. [Table 33](#) provides a summary of all natural disasters for Dominica over the years.

After the devastating effects of Hurricane Maria in 2017, the Government of Dominica has commenced its attempts to transform the island into the world's first climate resilient country. In its efforts to do this, the country has developed a National Development Resilient Strategy (NDRS), enacted a new Climate Resilience Act, 2018 and established CREAD- a Climate Resilience Execution Agency of Dominica, to implement Dominica's recovery and resilience plan.

Dominica's Protected Areas (PA) System⁹⁴ plays a critical role in both disaster prevention and recovery by maintaining intact and healthy ecosystems necessary to mitigate natural disasters. Intact habitats and vegetation help stabilize soils, reducing floods, drought, and landslide occurrences as well as sedimentation runoff, and provide a physical barrier for tsunamis and ocean incursion. In addition, PA's provide opportunities for temporary and permeant employment in often rural and marginalized communities, to engage in climate change and mitigation management and education and outreach activities with communities and conserve the many natural resources that are harvested by local and indigenous communities either for commercial or subsistence use. It is not surprising therefore, that the establishment and effective management of the countries protected areas plays a critical role in Enhancing the resilience of ecosystems and sustainable use of natural resources, which is one of seven development objectives in the NDRP.

⁹²Photo: <https://www.dominica-island.info/dominica-land-crab/>

⁹³ Ötker, I and Srinivasan, K. 2018. Bracing for the storm: For the Caribbean, building resilience is a matter of survival", March 2018 . International Monetary Fund. Finance and Development, Volume 55 (1)pp 48-51

⁹⁴ Source: Draft Dominica Protected Areas system Plan 2020

Table 33 Historic Natural Disasters in Dominica (1979-2013)

Date	Event	Impact	Date	Event	Impact
2013 Dec 24	Trough, flash flooding and landslides	Damage to housing and infrastructure	2003	Seismic activity north	
2013 April	Heavy rains, 30+ landslides across the country	Damage to roads and agriculture	2001	Drought	
2013 Sept 5	Landslide Morne Prosper	Roads blocked	1999 April	Landslides in the north 100+	Damage to roads and housing
2011 Jul 29	Landslide Soufriere	Roads blocked	1999	Hurricane Lenny	Coastal Damage
2011 Jul 28	Miracle Lake flooding ayou)	Damage to ecosystem, agriculture, fisheries and road network	1998 to 2000	Seismic activity in the south	
2011	Storm Ophelia	Damage to housing and infrastructure	1997	Landslide Bagatelle	
2010-2011	Severe Drought and extended rainy season of 2010	Loss of income in agricultural sector	1995	Hurricane Luis	Damage to housing, agriculture and infrastructure
2010 May 24	San Sauver Landslide	Disaster Zone	1995	Hurricane Marilyn (Cat 1)	Damage to housing, agriculture and infrastructure
2009 Jul	Flooding	Damage to infrastructure	1995	Hurricane Iris	Damage to housing, agriculture and infrastructure
2008	Hurricane Omar	Damage to coast and fishing industry	1989	Hurricane Hugo	
2007	Hurricane Dean (Cat 2)	Damage to agriculture and housing	1988	Hurricane Gilbert	
2007	Landslide Campbell		1986 Nov 11	Landslide Good Hope	
2007	Landslide		1986 Nov 12	Landslide Castle Bruce	
2007 Nov 29	Earthquake (6.5 Richter Scale)	Housing Infrastructure	1984	Hurricane Klaus	
2004 Nov 21	Earthquake	Damage to churches and housing in the north	1983	Landslide Bellevue Chopin	
2004 Nov	Series of landslides	1980	Hurricanes Frederick & Allen (Cat 1)	Economy Agriculture	
2003	Carholm landslide	Damage to agriculture and Tourism	1979 Aug 29	Hurricane David (Cat 5)	Total devastation
2003	Landslide Bellevue Chopin				

There are three main categories of natural hazards-:

- i) *Geological hazards*: driven by the earths processes i.e. earthquakes, tsunamis and volcanic activity
- ii) *Meteorological & Hydrological hazards*: driven by weather processes i.e extreme temperatures, high winds, cyclones, hurricanes, storms, floods, droughts, landslides
- iii) *Biological hazards*: driven by biological processes i.e disease epidemics and insect/animal plagues

Dominica is particularly prone to geophysical and meteorological hazards. While Dominica’s NPAS are important contributors of Disaster Risk Reduction, PA’s themselves are also at risk from climate change and natural hazards. A risk analysis of climate change and natural hazards to Dominica’s PAS is presented in [table 34](#).

Table 34 A Natural Hazard Risk Assessment for Dominica’s Protected Areas System

		Impact				
		Negligible	Minor	Moderate	Major	Catastrophic
Likelihood	Almost certain				Landslides, Floods	Hurricanes & Storms
	Likely					
	Possible			Phreatic eruption	Earthquakes	
	Unlikely			Sea-level rising, temperature increases		
	Rare		Pandemics		Droughts	Volcano eruption, Tsunami

Risk Level	Low	Moderate	High	Extreme
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9. Uncertainty Assessment

As indicated in the 2006 IPCC guidelines, uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals. This why Dominica has determined the uncertainties of the emission factors, activity data and estimates of emissions and removals from the different categories used to estimate the FRL/FREL; also, identifying significant sources of uncertainty to help prioritize data collection and efforts to improve the GHG inventory and REDD+ reporting.

For the Uncertainty Assessment of the of the whole time series (2000-2017), Dominica applied Approach 1 (Propagation of Error), as described in detail in the 2006 IPCC Guidelines (Volume 1, Chapter 3, section 3.2.3.1).

Using this approach to estimate uncertainty required estimates of the uncertainty for each input, as well as the equation through which all inputs are combined to estimate an output. The simplest equations include statistically independent (uncorrelated) inputs, and this is the assumption made throughout this analysis. For uncorrelated uncertainties, the Guidelines provide two equations: one when the quantities (emission factors, activity data and other estimation parameters) are to be combined by multiplication, reproduced below in equation 3.1 (IPCC 2006 GLs, V. 1, Ch3); and another where the uncertain quantities are to be combined by addition or subtraction, reproduced in equation 3.2 (IPCC 2006 GLs, V. 1, Ch3).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$

Where,

U_{total} = is the percentage uncertainty in the product of the quantities
 U_i = denotes the percentage uncertainties with each of the quantities

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

$$U_{total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \dots + (U_n \cdot x_n)^2}}{|x_1 + x_2 + \dots + x_n|}$$

Where,

U_{total} = is the percentage uncertainty in the sum of the quantities (expressed as a percentage)

U_i = is the percentage uncertainty associated with source/sink i

x_i = is the emission/removal estimate for source/sink i

9.2 Estimation of uncertainties for emission and removal factors

Some of the emission factor estimates of uncertainty ranges were generated by expert judgement, involving country experts who decided on the mean value as well as the uncertainty range. For the values selected by IPCC defaults, the ranges provided were used. AGB values as well as SOC ref values, the standard deviation was calculated using the source data.

The uncertainty of each selected value was estimated using the following equation (*See Excel fille > EF-Values sheet*):

If the range values were provided:

$$U(EF) = \frac{(Upper\ Limit\ (EF) - Lower\ Limit\ (EF))/2}{EF} * 100$$

If the standard deviation was provided:

$$U(EF) = \frac{Z_{\alpha/2} \times SD(EF)}{EF} * 100$$

Where,

- Z:** 1.96
- SD:** Standard deviation of the EF value
- EF:** Emissions Factor value

Table 35 Uncertainty values for selected emission factors

Parameter in the IPCC	Notation	Units according to the IPCC	Category		Value	National Value (tier 2)	Default Value (tier 1)	Error o range reported	Lower CI	Upper CI	SD	Uncertainty (%)	
Wood carbon fraction of dry matter	Cf	[t C (t d.m.) ⁻¹]	Elfin and Cloud forest	FCLLOUD	0.47		X	(0.44 - 0.49)	0.44	0.49		5.3	
			Montane Rainforest	FRAIN	0.47		X	(0.44 - 0.49)	0.44	0.49		5.3	
			Semi-evergreen Forest	FEVER	0.47		X	(0.44 - 0.49)	0.44	0.49		5.3	
			Deciduous - Coastal Forest	FDEC, FDRYS, FLIT	0.47		X	(0.44 - 0.49)	0.44	0.49		5.3	
Average annual ABG growth for a specific woody vegetation type	Gw	[t d.m. ha-1 yr-1]	Elfin and Cloud forest	Undisturbed	0.00		X					0	
				Disturbed (Hurricane, fire, logging, Shift.Cult)	4.40		X	SD:1.6			1.6	71.3	
			Montane Rainforest	Undisturbed	0.00		X						0
				Disturbed (Hurricane, fire, logging, Shift.Cult)	5.90		X	SD: 2.3			2.3	76.4	
			Semi-evergreen Forest	Undisturbed	2.70		X	SD: 1.1			1.1	79.9	
				Disturbed (Hurricane, fire, logging, Shift.Cult)	5.20		X	SD: 2.5			2.5	94.2	
			Deciduous - Coastal Forest	Undisturbed	1.60		X	SD: 1.1			1.1	134.8	
				Disturbed (Hurricane, fire, logging, Shift.Cult)	3.90		X	SD: 2.4			2.4	120.6	
Ratio of below ground biomass to above ground biomass	R		Elfin and Cloud forest	Natural	0.221		X	SD: 0.036			0.036	31.9	
			Montane Rainforest	Natural	0.221		X	SD:0.036			0.036	31.9	
			Semi-evergreen Forest	Natural	0.284		X	SD:0.061			0.061	42.1	
			Deciduous - Coastal Forest	Natural	0.379		X	SD:0.04			0.04	20.7	

Basic Wood Density	D	[t C m ⁻³]	Elfin and Cloud forest		0.598						0.99	324.30
			Montane Rainforest		0.672						0.82	239.00
			Semi-evergreen Forest		0.601						0.87	283.99
			Deciduous - Coastal Forest		0.655						0.70	209.37
Above-ground biomass	AGB - BW, B_BEFORE, B_AFTER	[t d.m. / ha]	Elfin and Cloud forest		19.2	X						45.4
			Montane Rainforest		279.6	X						130.3
			Semi-evergreen Forest		227.6	X						225.5
			Deciduous - Coastal Forest		41.5	X						122.5
Fraction of biomass loss due to disturbances	fd		Elfin and Cloud forest	Affected by hurricane	0.85	x			0.8	0.9		5.9
			Montane Rainforest	Affected by hurricane	0.90	x			0.85	0.95		5.6
			Semi-evergreen Forest	Affected by hurricane	0.90	x			0.85	0.95		5.6
				Affected by Shifting Cultivation	0.60	x			0.55	0.65		8.3
			Deciduous - Coastal Forest	Affected by hurricane	0.85	x			0.8	0.9		5.9
Litter Stocks	Litter	[t C ha ⁻¹]	Elfin and Cloud forest		0.00				0	0		0
			Montane Rainforest		4.80		x	Range: 2.1-16.4	2.1	16.4		149.0
			Semi-evergreen Forest		5.90		x	Range: 1.9-14.8	1.9	14.8		109.3
			Deciduous - Coastal Forest		2.40		x	Range: 2.1-2.7	2.1	2.7		12.5
Dead wood	DW	[t C ha ⁻¹]	Elfin and Cloud forest		3.3				3	3.6		9.1
			Montane Rainforest		14.8		x	Range: 0.6 - 218.9	9.8	19.8		33.8
			Semi-evergreen Forest		8.0		x	Range: 1.9-14.8	1.9	14.8		80.6
			Deciduous - Coastal Forest		9.0		x	Range:1.3-17.3	1.3	17.3		88.9

Soil organic carbon	SOC ref	[t C/ ha]	Elfin and Cloud forest		195.8	x					32.8	32.8
			Montane Rainforest		164.8	x					33.2	39.4
			Semi-evergreen Forest		156.9	x					38.2	47.7
			Deciduous - Coastal Forest		153.6	x					42.6	54.4
Factor for land use	FLU	Dimensionless	Forestland		1.0		x					75
Factor for manage	FMG	Dimensionless	Forestland		1.0		x					75
Factor for input	FI	Dimensionless	Forestland		1.0		x					75

The calculated values were then used in equations 3.1 and 3.2 for the combination of uncertainties with the uncertainties of the activity data.

9.3 Estimation of uncertainties for LULUC activity data

For the uncertainty of the activity data, the IPCC suggest following equation:

$$U(AD) = \frac{Z^* \times s_{ADi}}{ADi} \times 100$$

Where,

$Z = 1,96$ if $n_i > 30$ or $2,365$ if $n_i < 30 * s_{AD}/ADi * 100$

Standard Error (ADi) is equal to:

$$s_{ADi} = \text{Country Total Area} \times \sqrt{\frac{\text{pi} \times (1 - \text{pi})}{(N - 1)}}$$

ni: Number of plots per subcategory of land use

N: Total Number of plots (21991)

pi: n_i/N

Table 36 Example of Uncertainties calculated for Activity Data

LULUC transition	Count of Transition Coding	pi [ni/N]	ADi [pi* total area] ha	SD_ADi [TotalArea*SQRT(pi*(1-pi)/(N-1))] ha	U_ADi [1,96if ni>30 or 2,365 if ni<30*s_AD/ADi*100] %
CC/CANNUAL/_	130.0	0.1	6074.8	510.9	16.5
CC/CPER/_	84.0	0.1	3925.2	417.1	20.8
CF/CANNUAL>FRain_2013/Hurricane_2017	1.0	0.0	46.7	46.7	236.5
CG/CANNUAL>GGRASS_2014/_	1.0	0.0	46.7	46.7	236.5
CG/CPER>GGRASS_2014/_	1.0	0.0	46.7	46.7	236.5
CG/CPER>GGRASS_2018/_	1.0	0.0	46.7	46.7	236.5
CG/CPER>GWGRASS_2017/_	1.0	0.0	46.7	46.7	236.5
CS/CANNUAL>SSET_2016/_	1.0	0.0	46.7	46.7	236.5
CS/CPER>SSET_2014/_	1.0	0.0	46.7	46.7	236.5
FC/FCLoud>CANNUAL_2011/_	1.0	0.0	46.7	46.7	236.5
FC/FDEC>CANNUAL_2005/_	1.0	0.0	46.7	46.7	236.5
FC/FDSCRUB>CANNUAL_2011/_	1.0	0.0	46.7	46.7	236.5
FC/FEVER>CANNUAL_2017/_	1.0	0.0	46.7	46.7	236.5
FC/FEVER>CANNUAL_2018/_	1.0	0.0	46.7	46.7	236.5
FC/FRain>CANNUAL_2013/_	1.0	0.0	46.7	46.7	236.5
FF/FCLoud/Hurricane_2017	108.0	0.1	5046.7	469.1	18.2
FF/FDEC/Hurricane_2015	1.0	0.0	46.7	46.7	236.5
FF/FDEC/Hurricane_2017	148.0	0.1	6915.9	541.8	15.4
FF/FDSCRUB/Hurricane_2017	35.0	0.0	1635.5	273.5	32.8
FF/FELF/Hurricane_2017	42.0	0.0	1962.6	298.9	29.9
FF/FEVER/Hurricane_2017	218.0	0.1	10186.9	641.6	12.3
FF/FEVER/Shifting Cultivation_2015	1.0	0.0	46.7	46.7	236.5
FF/FLIT/Hurricane_2017	76.0	0.0	3551.4	397.7	22.0
FF/FRain/Hurricane_2017	603.0	0.4	28177.6	906.9	6.3
FG/FDEC>GWGRASS_2012/_	1.0	0.0	46.7	46.7	236.5
FG/FDSCRUB>GWGRASS_2005/_	1.0	0.0	46.7	46.7	236.5
FG/FEVER>GWGRASS_2015/_	2.0	0.0	93.5	66.1	167.2
FG/FEVER>GWGRASS_2016/_	1.0	0.0	46.7	46.7	236.5
FG/FLIT>GGRASS_2015/_	1.0	0.0	46.7	46.7	236.5
FG/FRain>GGRASS_2014/_	1.0	0.0	46.7	46.7	236.5
FO/FDSCRUB>OMIN_2014/_	1.0	0.0	46.7	46.7	236.5
FO/FRain>OOTHER_2017/_	1.0	0.0	46.7	46.7	236.5
FS/FDSCRUB>SSET_2011/_	1.0	0.0	46.7	46.7	236.5
FS/FDSCRUB>SWSET_2005/_	1.0	0.0	46.7	46.7	236.5
FS/FDSCRUB>SWSET_2014/_	1.0	0.0	46.7	46.7	236.5
FS/FEVER>SWSET_2012/_	1.0	0.0	46.7	46.7	236.5
FS/FRain>SWSET_2006/_	1.0	0.0	46.7	46.7	236.5
FS/FRain>SWSET_2012/_	1.0	0.0	46.7	46.7	236.5
GF/GWGRASS>FRain_2016/Hurricane_2017	1.0	0.0	46.7	46.7	236.5
GG/GGRASS/_	26.0	0.0	1215.0	236.4	46.0
GG/GWGRASS/_	29.0	0.0	1355.1	249.4	43.5
OO/OMIN/_	2.0	0.0	93.5	66.1	167.2
OO/OOTHER/_	7.0	0.0	327.1	123.4	89.2
SS/SSET/_	27.0	0.0	1261.7	240.8	45.1
SS/SWSET/_	34.0	0.0	1588.8	269.7	33.3
WW/WWET/_	5.0	0.0	233.6	104.4	105.6
Sum					7729.8

However, it is not considered appropriated as it penalizes transitions with low number of plots. This also leads to the misconception that the sample should be intensified to reduce the uncertainty. However, as the sample is not taking static parameters, such as a forest inventory, but is taking samples of transitions that represent dynamics, it

is not possible to intensify a sample in dynamic that does not frequently occur. For instance, fires in cloud forest or conversions of settlements to forest lands.

This is why a new method has been proposed which is based on the interpretation error, rather than the proportions. To estimate the interpretation error, a sub-sample equivalent to 10% for each land use subcategory was taking, for those classes with more than 10 plots. For the classes with less than 10 plots (wetlands and other lands), all samples were reassessed by a GIS expert from the Coalition for Rainforest Nations, evaluating independently a total of 174 samples (Croplands: 22, Forest lands: 124, Grasslands: 5, Wetlands: 5; Settlements: 7, Other lands: 11).

The land use given by Dominica team were compared by the land use given by the GIS expert. The results for each land use category and sub-category are given in the following tables:

		Category	Sub-Category
Total, all land uses	Count	174	174
	Coincidence	169	161
	Percentage of Coincidence	97%	93%
	Interpretation Error [%]	3%	7%

		Category	Sub-Category
Cropland	Count	22	22
	Coincidence	19	17
	Percentage of Coincidence	86%	77%
	Interpretation Error [%]	14%	23%

		Category	Sub-Category
Forest lands	Count	124	124
	Coincidence	124	118
	Percentage of Coincidence	100%	95%
	Interpretation Error [%]	0%	5%

Forest lands, sub-categories	Dry Scrub	Littoral Evergreen Forest	Montane – Cloud Forest	Montane – Elfin forest	Montane – Elfin forest	Seasonal Decidious	Seasonal Semi Evergreen
Count	3.00	8.00	12.00	3.00	63.00	15.00	23.00
Coincidence	2.00	8.00	12.00	0.00	62.00	12.00	22.00
Percentage de Coincidencia	67%	100%	100%	0%	98%	80%	96%
Interpretation Error [%]	33%	0%	0%	100%	2%	20%	4%

		Category	Sub-Category
Grasslands	Count	6	6
	Coincidence	5	4
	Percentage of Coincidence	83%	67%

Interpretation Error [%]	17%	33%
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		Category	Sub-Category
Wetlands	Count	5	5
	Coincidence	5	5
	Percentage of Coincidence	100%	100%
	Interpretation Error [%]	0%	0%

		Category	Sub-Category
Settlements	Count	7	7
	Coincidence	7	7
	Percentage of Coincidence	100%	100%
	Interpretation Error [%]	0%	0%

		Category	Sub-Category
Other Lands	Count	11	11
	Coincidence	10	8
	Percentage of Coincidence	91%	73%
	Interpretation Error [%]	9%	27%

These values of interpretation error were the ones selected for the uncertainty analysis (*The full analysis can be found in the excel file > Annex. Interpretation error*)

9.4 Methodology used for the estimation of uncertainties

The analysis in this submission involves mainly the sum of products of emission factors and activity data. Equations 3.1 and 3.2 were used to combine the uncertainties of individual uncertainties estimated for the emission factors and activity data for each land use sub-category (Forest land, Cropland, Grassland, Wetland, Settlement and Other Lands) as provided in the attached Excel file (*See Excel file > EF-Values sheet*)⁹⁵, and each equation applied for estimating GHG emissions and removals following the methodological guidance from 2006 IPCC GLs, V4, Ch2, as indicated in the above section Chapter 5. Then, the uncertainties associated with the emissions and removals for each land-use category were combined to obtain the uncertainties in the whole categories of Forest land remaining forest land and forest land converted to and from other land-use categories.

In discussions with the technical experts of the Coalition for Rainforest Nations and IPCC, for the propagation of uncertainties some adjustments were also necessary, in order to correctly calculate the uncertainties.

Combination of variables under addition and subtraction

The IPCC Guidelines provide an equation to estimate uncertainties when the quantities are combined under addition and subtraction:

⁹⁵ ADD LINK

$$U_{Total} = \frac{\sqrt{(U_1 \square x_1)^2 + (U_2 \square x_2)^2 + \dots + (U_n \square x_n)^2}}{|x_1 + x_2 + \dots + x_n|} \quad (\text{Equation 3.2, Volume 1, Chapter 3, IPCC 2006})$$

$$U_{Total} = \frac{\sqrt{(U_1 \square x_1)^2 + \dots + (U_i \square x_i)^2 + \dots + (U_n \square x_n)^2}}{|x_1 + \dots + x_i + \dots + x_n|} \quad (\text{Equation 3.2, Volume 1, Chapter 3, IPCC 2019 Refinement})$$

where

- U_{Total} = the percentage uncertainty in the sum of the quantities (half the 95% confidence interval divided by the total (i.e., mean) and expressed as a percentage);
- x_i = quantities to be combined; x_i may be a positive or a negative number;
- U_i = the percentage uncertainties associated with each of the quantities.

Equation 3.2 does not clarify if the same equation has to be applied equally if the quantities are combined under addition and subtraction. This clarification is important specifically for the FOLU sector, as removals are indicated with a negative sign and emissions with a positive sign, especially when the equation 2.15 for conversion to other land uses is applied. Based on different simulations that we run, we concluded that the denominator of the equation should be written according to the way the variables are involved (either under addition or under subtraction) (See [figure 77](#)).

Simulation.

The simulation is based on uncertainty estimates for a subtraction of two variables A and B in three ways, and then the results are compared.

On one hand, the definition of uncertainty is applied:
$$U_{A-B} = \frac{1.96 \times \frac{\sigma_{A-B}}{\sqrt{n}}}{\mu_{A-B}}$$

On the other hand, uncertainties are estimated based on Equation 3.2 with

a negative sign in the denominator
$$U_{Total} = \frac{\sqrt{(U_1 \square x_1)^2 + (U_2 \square x_2)^2}}{|x_1 - x_2|}$$

and then with a positive sign in the denominator
$$U_{Total} = \frac{\sqrt{(U_1 \square x_1)^2 + (U_2 \square x_2)^2}}{|x_1 + x_2|}$$

Under the assumptions that both variables are not correlated, and each variable has a coefficient of variation which is less than 30%, the uncertainty of A-B based on the definition, and the uncertainty of A-B with a negative sign in the denominator converge almost to the same value. This conclusion indicates that Eq. 3.2 should take into account the sign under which each variable is combined.

Sample size: $n = 1000$

$\mu_A = 3, \sigma_A = 0.3$

$\mu_B = 2, \sigma_B = 0.2$

$CV_A = CV_B = 10\%$

Simulation inputs:

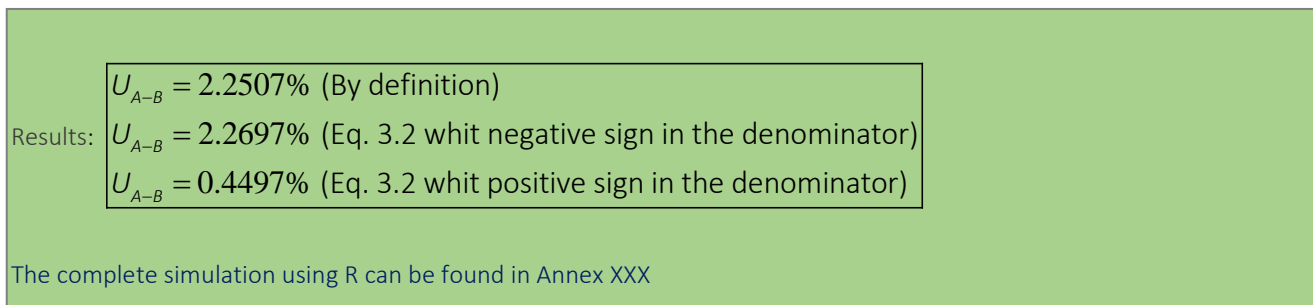


Figure 77 Simulation

Combination of quantities (emissions and removals) under addition

This is a special case for FOLU sector while combining emissions and removals to obtaining the overall inventory. It came to our attention that by applying the Equation 3.2 for addition of quantities with different signs such as emissions and removals, the uncertainty estimate for the overall inventory is overestimated.

$$U_{Total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \dots + (U_n \cdot x_n)^2}}{|\alpha_1 x_1 + \alpha_n x_2 + \dots + \alpha_n x_n|} \quad (\text{Equation 3.2, Volume 1, Chapter 3, IPCC 2006}) \text{ or}$$

$$U_{Total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + \dots + (U_i \cdot x_i)^2 + \dots + (U_n \cdot x_n)^2}}{|\alpha_1 x_1 + \dots + \alpha_i x_i + \dots + \alpha_n x_n|} \quad (\text{Equation 3.2, Volume 1, Chapter 3, IPCC 2019})$$

For example:

	Emissions/ Removals [tCO2e]	Uncertainty [%]
Forest lands	-12,846,072	47.88
Croplands	1,806,550	9.04%
Total	-11,039,522	55.73

When applying this approach, the total uncertainty is even higher than the individual uncertainties. This is why, for the FOLU sector, when the quantities to be combined by addition are of different signs (- and +), understanding the need to capture the difference between emissions and removals, this adjusted equation was applied:

$$U_{Total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + \dots + (U_i \cdot x_i)^2 + \dots + (U_n \cdot x_n)^2}}{|x_1| + \dots + |x_i| + \dots + |x_n|} \quad (\text{Eq.3.2, Adjusted})$$

where

- U_{Total} = the percentage uncertainty in the sum of the quantities (half the 95% confidence interval divided by the total (i.e., mean) and expressed as a percentage);
- x_i = quantities to be combined; x_i may be a positive or a negative number;
- U_i = the percentage uncertainties associated with each of the quantities.

With this approach, using the same individual uncertainties the total is lower and within the maximum values of the individual uncertainties

	Emissions/ Removals [tCO2e]	Uncertainty [%]
Forest lands	-12,846,072	47.88
Croplands	1,806,550	9.04%
Total	-11,039,522	41.99

Properly representing the uncertainties of the estimations for the country is important because of the implications higher or lower uncertainties may represent in terms of decision making, national planning and the carbon market.

For the application of the equations, the process started from the result towards the individual equations.

For this FRL/FRL, the analysis was divided into 4 sections: Forest land remaining forest land (undisturbed), Forest land remaining forest land (disturbed), land converted to forest lands⁹⁶ and forest lands converted to other lands⁹⁷. In each section, the uncertainties for each of the equations (gains, losses, conversions, DOM, SOC), for each scenario of damage (Not Significant damage, Damage I, II and III) and each forest type (Elfin, Cloud, Montane, Semi evergreen, Deciduous, Dry Scrub, Littoral) was estimated (see figure 78).

This is an example of how the uncertainties in the gains for F>F (undisturbed) were estimated:

Gains- No significant Damage	Activity Data		Emission Factor									Removals		U*x*2
	AD	U_AD	Gw[\$B\$]	U_Gw[\$BBS]	R[\$IS]	U_r[\$BIS]	Cf[\$KS]	U_Cf[\$BKS]	EF	U_EF	Removals	U_Removals		
FF/FELF/Hurricane_2017	502	4.84	0.0	0.0	0.22	31.93	0.47	5.32	0.00		0.00			
FF/FCLOUD/Hurricane_2017	1,215	4.84	0.0	0.0	0.22	31.93	0.47	5.32	0.00		0.00			
FF/RAIN/Hurricane_2017	7,009	4.84	0.0	0.0	0.22	31.93	0.47	5.32	0.00		0.00			
FF/FEVER/Hurricane_2017	2,629	4.84	2.7	79.9	0.28	42.10	0.47	5.32	1.63	65.46	-15.70	65.64	1062451	
FF/FEVER/Shifting Cultivation 20	47	4.84	2.7	79.9	0.28	42.10	0.47	5.32	1.63	65.46	-0.28	65.64	336	
FF/FDEC/Hurricane_2017	47	4.84	1.6	134.8	0.38	20.69	0.47	5.32	1.04	104.73	-0.18	104.85	347	
FF/FDSCRUB/Hurricane_2017	1,565	4.84	1.6	134.8	0.38	20.69	0.47	5.32	1.04	104.73	-5.95	104.85	389468	
FF/FLIT/Hurricane_2015	456	4.84	1.6	134.8	0.38	20.69	0.47	5.32	1.04	104.73	-1.73	104.85	32991	
FF/FLIT/Hurricane_2017	993	4.84	1.6	134.8	0.38	20.69	0.47	5.32	1.04	104.73	-3.78	104.85	156711	
											-27.62	46.40	1642303	

This approach was replicated for each of the equations. For the totals, the errors were propagated accordingly.

⁹⁶ File: 3B1a - 2017 Forest Land Nov 2022

⁹⁷ Files: 3B2bi - 2017 Cropland Nov 2022, 3B3bi - 2017 Grassland Nov 2022, 3B5bi - 2017 Settlements Nov 2022, 3B6bi - 2017 Other Lands Nov 2022



Figure 78 Flowchart of uncertainty estimations

The results indicated that forest related emissions and removals have a total uncertainty of 3.76%. The highest uncertainty identified was the one related to forest growth rates, and those were default values from the IPCC. The uncertainty associated to each category can be indicated in the [table 37](#).

Table 37 Total uncertainty of the estimations

Land use	Gas	2017 [tCO ₂ e]	Uncertainty [%]
Forest Land	CO_{2e}	700.62	3.76
Forest Land Remaining Forest Land (undisturbed)	CO ₂	-28.90	44.34
Forest Land Remaining Forest Land (disturbed)	CO ₂	730.65	3.50
Land Converted to Forest Land	CO ₂	-1.13	5.37
Cropland Converted to Forest Land	CO ₂	0.20	7.04
Grassland Converted to Forest Land	CO ₂	-1.33	6.09
Wetlands Converted to Forest Land	CO ₂	0.0	0.0
Settlements Converted to Forest Land	CO ₂	0.0	0.0
Other Land Converted to Forest Land	CO ₂	0.0	0.0
Forest Land Converted to Cropland	CO ₂		11.55
Forest Land Converted to Grassland	CO ₂		8.01
Forest Land Converted to Settlements	CO ₂	7.46	0.0
Forest Land Converted to Other Land	CO ₂		10.20
Aggregate Sources and Non-CO₂ Emissions Sources on Land	CH₄ & N₂O	0	0
Emissions from Biomass Burning	CH ₄	0	0
Emissions from Biomass Burning	N ₂ O	0	0



10. Improvement Plan

The Government of the Commonwealth of Dominica (GoCD) is seeking to improve its capacities in forest resources management by developing a Capacity and Needs Assessment (Phase 1) and subsequently an updated National Forest Inventory (Phase 2), as a critical input to support long-term sustainable forestry management⁹⁸. Phase 1 of this consultancy will focus on enabling Dominica to clearly identify needs and goals as it relates to the Forestry sector, including building capacity within the forestry sector to undertake and maintain the forestry inventory. Phase 2 will consist of the development of an updated National Forest Inventory that includes a high-resolution forest cover GIS database. Both phases are expected to:

1. Inform various forest resource management and conservation planning activities (e.g. development of sustainable forest management plans, a timber and lumber industry, reforestation of degraded/deforested areas, community (Kalinago) forest management projects, among others);
2. Support compliance with reporting responsibilities and other commitments under the various international conventions to which Dominica is a signatory (UNFCCC, UNCBD, UNESCO, UNCCD, etc);
3. Support the advancement of Dominica's resilience and environmental agendas;
4. Collect data necessary to quantify risk associated with impacts of climate change and natural hazards on forests, in order to better plan for budgetary allocations and other risk financing instruments; and
5. Inform future REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiatives in Dominica that can ultimately lead to the establishment of a Payment for Ecosystem Services (PES) scheme.

It is anticipated that the project will be executed in two phases over a total period of 12 months. Phase 1 is expected to last approximately 3 to 4 months and Phase 2 is expected to be carried out in 9 months.

⁹⁸ The estimated funding envelope for this consultancy assignment is approximately USD 350,000. Interested firms should keep this estimate in mind when expressing interest in this consultancy and also when preparing full technical and financial proposals.



11. References

- Arnone, E, Dialynas, Y. G., Noto, L. V. & Bras, R. L. (2015) Accounting for soil parameter uncertainty in a physically based and distributed approach for rainfall-triggered landslides. *Hydrological Processes* 30, 927–944.
- Arnone, E., Noto, L. V., Lepore, C & Bras, R. L. (2011) Physically-based and distributed approach to analyze rainfall-triggered landslides at watershed scale. *Geomorphology* 133, 121–131.
- Błońska, E., Lasota, J., Piaszczyk, W. (2018). The effect of landslide on soil organic carbon stock and biochemical properties of soil. *J Soils Sediments* 18, 2727–2737 <https://doi.org/10.1007/s11368-017-1775-4>.
- Boose, E. R., Serrano, M. I. & Foster, D. R. (2004). Landscape and regional impacts of hurricanes in Puerto Rico. *Ecological Monographs* 74, 335–352
- Chambers, J., Higuchi, N., Schimel, J. (2000). Decomposition and carbon cycling of dead trees in tropical forests of the central Amazon. *Oecologia* 122, 380–388 . <https://doi.org/10.1007/s004420050044>
- Chambers, J. Q., Fisher, J. I., Zeng, H., Chapman, E. L., Baker, D. B. & Hurtt, G. C. (2007). Hurricane Katrina's Carbon Footprint on U.S. Gulf Coast Forests. *Science* 318, 1107
- Chave, Jérôme & Muller-Landau, Helene & Baker, Timothy & Easdale, Tomás & ter Steege, Hans & Webb, Campbell (2007). Regional and phylogenetic variation of wood density across 2456 Neotropical tree species. *Ecological applications: a publication of the Ecological Society of America*. 16. 2356-67. [10.1890/1051-0761\(2006\)016\[2356:RAPVOW\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2006)016[2356:RAPVOW]2.0.CO;2).
- Chave, Jérôme & Muller-Landau, Helene & Baker, Timothy & Easdale, Tomás & ter Steege, Hans & Webb, Campbell.** (2007). Regional and phylogenetic variation of wood density across 2456 Neotropical tree species. *Ecological applications: a publication of the Ecological Society of America*. 16. 2356-67. [10.1890/1051-0761\(2006\)016\[2356:RAPVOW\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2006)016[2356:RAPVOW]2.0.CO;2).
- Chave, Jérôme & Réjou-Méchain, Maxime & Burquez, Alberto & Chidumayo, Emmanuel & Colgan, Matthew & Delitti, Wellington & Duque, Alvaro & Eid, Tron & Fearnside, Philip & Goodman, Rosa & Henry, Matieu & Martinez-Yrizar, Angelina & Mugasha, Wilson & Muller-Landau, Helene & Mencuccini, Maurizio & Nelson,

- Bruce & Ngomanda, Alfred & Nogueira, Euler & Ortiz, Edgar & Vieilledent, Ghislain.** (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*. 20. 3177-3190. 10.1111/gcb.12629.
- Cole, L. E. S., Bhagwat, S. A. & Willis, K. J.** (2014). Recovery and resilience of tropical forests after disturbance. *Nature communications* 5, 3906
- Delaney, M., Brown, S., Lugo, A.E. , Torres-Lezama, A., Quintero, N.B** (1998). The quantity and turnover of dead wood in permanent forest plots in six life zones of Venezuela. *Biotropica* 30(1), 2-11
- Everham, M. E. III & Brokaw, N. V. L.** (1996). Forest damage and recovery from catastrophic wind. *The Botanical Review* 62, 2, 113–185
- Flynn, D. F. B.** (2010). Hurricane disturbance alters secondary forest recovery in Puerto Rico. *Biotropica* 42, 149–157
- Frangi, J. L. & Lugo, A. E.** (1991). Hurricane damage to a flood plain forest in the Luquillo Mountains of Puerto Rico. *Biotropica* 23, 324–335
- Government of Dominica** (2010). National Environmental Summary Commonwealth of Dominica 2010.
- Government of Dominica** (2012). Dominica Low-Carbon Climate-Resilient Development Strategy 2012-2020
- Government of Dominica** (2017) <https://reliefweb.int/report/dominica/fao-agricultural-damage-assessment-mission-dominica-following-hurricane-dean>
- Government of Dominica** (2020). Draft Dominica Protected Areas system Plan 2020
- Graveson** (2009). National Forest Demarcation and Bio-Physical Resource Inventory Project Caribbean – Saint Lucia: The Classification Of The Vegetation Of Saint Lucia. FCG International Ltd in association with AFC Consultants International GmbH
- Hall, J., Muscarella, R., Quebbeman, A., Arellano, G., Thompson, J., Zimmerman, J. K. & Uriarte, M.** (2020). Hurricane-induced rainfall is a stronger predictor of tropical forest damage in Puerto Rico than maximum wind speeds. *Scientific Reports* 10, 4318
- Harmon, M.E., Franklin, J.F., Swanson, F.J., Sollins, P., Gregory, S.V., Lattin, J.D., Anderson, N.H., Cline, S.P., Aumen, N.G., Sedell, J.R., Lienkaemper, G.W., Cromack, K., Cummins, K.W.** (1986). Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15, 133-302.
- Heartsill Scalley, T.** (2017) Insights on forest structure and composition from long-term research in the Luquillo mountains. *Forests* 8, 204

- Heartsill Scalley, T., Scatena, F. N., Lugo, A. E., Moya, S. & Estrada, C. R.** (2010). Changes in structure, composition, and nutrients during 15 years of hurricane-induced succession in a subtropical wet forest in Puerto Rico. *Biotropica* 42, 455–463
- Ilins, N.M.** (1981). The role of termites in the decomposition of wood and leaf litter in the southern Guinea savanna of Nigeria. *Oecologia* 51, 389-399.
- IPCC. 2006.** 2006 IPCC Guidelines for National Greenhouse Gas Inventories. S Eggleston, L Buendia, K Miwa, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl>.
- IPCC. 2019** Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Edited by E Calvo Buendia et al., IPCC, 2019, <https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/>.
- Kaarik, AA.** (1974). Decomposition of wood. In Dickinson, C.H., Pugh, G.J.F., 1974. *Biology of Plant Litter Decomposition*. Academic Press, NYC, pp. 129–174
- Lepore, C., Arnone, E., Noto, L. V., Sivandran, G., & Bras, R. L.** (2013). Physically based modeling of rainfall-triggered landslides: a case study in the Luquillo forest, Puerto Rico. *Hydrology and Earth System Sciences* 17, 3371–3387
- Lepore, C., Kamal, S. A., Shanahan, P. & Bras, R. L.** (2012) Rainfall-induced landslide susceptibility zonation of Puerto Rico. *Environmental Earth Sciences* 66,1667– 1681
- Lindroth, A.** (2009) Storms can cause Europe-wide reduction in forest carbon sink. *Global Change Biology* 15, 346–355
- Lugo, A. E.** (2008) Visible and invisible effects of hurricanes on forest ecosystems: an international review. *Austral Ecology* 33, 368–398
- Martius, C.** (1997). Decomposition of wood. In Junk, Wolfgang J., 1997. *Ecological Studies* 126. The Central Amazon Floodplain. Ecology of a Pulsing System. Springer, NYC, 267-276
- Nogueira, E.M., Nelson, B.W., Fearnside, P.M.** (2005). Wood density in dense forest in central Amazonia, Brazil. *Forest Ecology and Management* 208, 261–286.
- Land Use, Protecting Carbon Sinks, and Enhancing the Resilience of Natural Ecosystems: https://unfccc.int/files/cooperation_support/nama/application/pdf/dominica_low_carbon_climate_resilient_strategy__%28finale%29.pdf
- Negrón-Juárez, R. I.** (2010). Widespread Amazon Forest tree mortality from a single cross-basin squall line event. *Geophysical Research Letters* 37, L16701

- Ötker, I and Srinivasan, K.** (2018). Bracing for the storm: For the Caribbean, building resilience is a matter of survival", March 2018 . International Monetary Fund. Finance and Development, Volume 55 (1)pp 48-51
- Palace, M., M. Keller, H. Silva** (2008). Necromass production: studies in undisturbed and logged Amazon forests. *Ecological Applications*: 18, 873–884.
- Parker, L & Booth, W.** Hurricane Hugo rips through South Carolina. *The Washington Post*. Friday, September 22, 1989.
- Powers, J.S., Montgomery, R.A., Adair, E.C., Brearley, F.Q., DeWalt, S.J., Castanho, C.T., Chave, J., Deinert, E., Ganzhorn, J.U., Gilbert, M.E., González-Iturbe, J.A., Bunyavejchewin, S., Grau, H.R., Harms, K.E., Hiremath, A., Iriarte-Vivar, S., Manzane, E., De Oliveira, A.A., Poorter, L., Ramanamanjato, J.-B., Salk, C., Varela, A., Weiblen, G.D. and Lerda, M.T.** (2009), Decomposition in tropical forests: a pan-tropical study of the effects of litter type, litter placement and mesofaunal exclusion across a precipitation gradient. *Journal of Ecology*, 97: 801-811. <https://doi.org/10.1111/j.1365-2745.2009.01515.x>
- Reyes, G., Brown, S., Chapman, J., Lugo, Ariel E.** (1992). Wood densities of tropical tree species, Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 1992, 15p.
- Scatena, F. N., & Larsen, M. C.** (1991) Physical aspects of hurricane Hugo in Puerto Rico. *Biotropica* 23, 317–323
- Scatena, F. N., Silver, W., Siccama, T., Johnson, A. & Sanchez, M. J.** (1993). Biomass and nutrient content of the Bisley Experimental Watersheds, Luquillo Experimental Forest, Puerto Rico, before and after hurricane Hugo, 1989. *Biotropica* 25, 15–27
- Shiels AB, Walker LR** (2013) Landslides cause spatial and temporal gradients of multiple scales in the Laquillo Mountains of Puerto Rico. *Ecol Bull* 54:211–221
- Shiels AB, Walker LR, Thompson DB** (2006) Organic matter inputs variable resource patches on Puerto Rico landslides. *Plant Ecol* 184:223–236
- Shiels, A. B., Gonzalez, G., Lodge, D. L., Willing, M. R. & Zimmerman, J. K.** (2015). Cascading effects of canopy opening and debris deposition from a large-scale hurricane experiment in a tropical rain forest. *BioScience* 65, 871–881
- Uriarte, M., Thompson, J. & Zimmerman, J. K.** (2019). Hurricane Maria tripled stem breaks and doubled tree mortality relative to other major storms. *Nature Communications* 10, 1362
- Walker, L. R.** (1991). Tree damage and recovery from hurricane Hugo in Luquillo Experimental Forest, Puerto Rico. Part A. special issue: ecosystem, plant, and animal responses to hurricanes in the Caribbean. *Biotropica* 23, 379–385

- Walker, L. R., Voltzow, J., Ackerman, J. D., Fernandez, D. S. & Fetcher, N.** (1992). Immediate impact of hurricane Hugo on a Puerto Rico rain forest. *Ecology* 73, 691–694
- Wang, G. & Eltahir, E. A. B.** (2000). Biosphere-atmosphere interactions over West Africa. II: Multiple climate equilibria. *Quarterly Journal of the Royal Meteorological Society* 126, 1261–1280
- Weaver, P. L.** (1989). Forest changes after hurricanes in Puerto Rico Luquillo Mountains. *Interciencia* 14, 181–192
- Vamdermeer, J. & de la Cerda, I. G.** (2004). Height dynamics of the thinning canopy of a tropical rain forest: 14 years of succession in a post-hurricane forest in Nicaragua. *Forest Ecology and Management* 199, 125–135
- Zhang, J.** (2021). Forest recovery from hurricane disturbances: the influence of changing climate. Georgia Institute of Technology
- Zimmerman, J. K.** (1994). Responses of tree species to hurricane winds in subtropical wet forest in Puerto Rico: Implications for tropical tree life histories. *Journal of Ecology* 82, 911–922



13. ANNEXES

13.1 ANNEX 1. Simulation of uncertainties using R

```
# SUBTRACTION

rm(list=ls())
set.seed(5)

# Simulate
# "n" values from two normal distributions: "A" and "B"

n <- 1000
A <- rnorm(n, mean = 3, sd = 0.3)
B <- rnorm(n, mean = 2, sd = 0.2)

# Correlation(A,B)
Correlation_A_B <- cor(A,B)

# Mean, Variance, Standard deviation
MeanA <- mean(A)
MeanB <- mean(B)

StandardDeviation_A <- sd(A)
StandardDeviation_B <- sd(B)

VarianceA <- var(A)
VarianceB <- var(B)

# Define the random variable "A-B"

SubtractionAB <- (A-B)
Mean_SubtractionAB <- mean(SubtractionAB)
Variance_SubtractionAB <- var(SubtractionAB)
StandardDeviation_SubtractionAB <- sd(SubtractionAB)

#Uncertainty 1: Uncertainty of "A-B" using the Definition

U_SubtractionAB_1 <- ((1.96*StandardDeviation_SubtractionAB/sqrt(n))
```



```

/abs(Mean_SubtractionAB))*100

# Uncertainty 2: Uncertainty of "A-B" using Eq. 3.2 , Vol. 1, Cap. 3 (IPCC 2006, IPCC 2019)
# with negative sign in the denominator

MeanA      <- mean(A)
MeanB      <- mean(B)

StandardDeviation_A <- sd(A)
StandardDeviation_B <- sd(B)

U_A        <- (1.96 * StandardDeviation_A /sqrt(n)/MeanA) * 100
U_B        <- (1.96 * StandardDeviation_B /sqrt(n)/MeanB) * 100

U_SubtractionAB_2      <- sqrt((U_A * MeanA)^2 + (U_B * MeanB)^2)/abs(MeanA - MeanB)

# Uncertainty 3: Uncertainty of "A-B" using Eq. 3.2 , Vol. 1, Cap. 3 (IPCC 2006, IPCC 2019)
# with positive sign in the denominator

MeanA      <- mean(A)
MeanB      <- mean(B)

StandardDeviation_A <- sd(A)
StandardDeviation_B <- sd(B)

U_A        <- (1.96 * StandardDeviation_A /sqrt(n)/MeanA) * 100
U_B        <- (1.96 * StandardDeviation_B /sqrt(n)/MeanB) * 100

U_SubtractionAB_3      <- sqrt((U_A * MeanA)^2 + (U_B * MeanB)^2)/abs(MeanA + MeanB)

# Print the results
options(digits = 5)
print(Correlation_A_B)

## [1] 0.018155
print(MeanA)

## [1] 3.0052
print(MeanB)

## [1] 2.0146
print(VarianceA)

## [1] 0.092176
print(VarianceB)

## [1] 0.039414
print(StandardDeviation_A)

## [1] 0.3036

```

```
    print(StandardDeviation_B)
## [1] 0.19853
    print(Variance_SubtractionAB)
## [1] 0.1294
    print(StandardDeviation_SubtractionAB)
## [1] 0.35972
    print(U_SubtractionAB_1)
## [1] 2.2507
    print(U_SubtractionAB_2)
## [1] 2.2697
    print(U_SubtractionAB_3)
## [1] 0.4479
# END
```