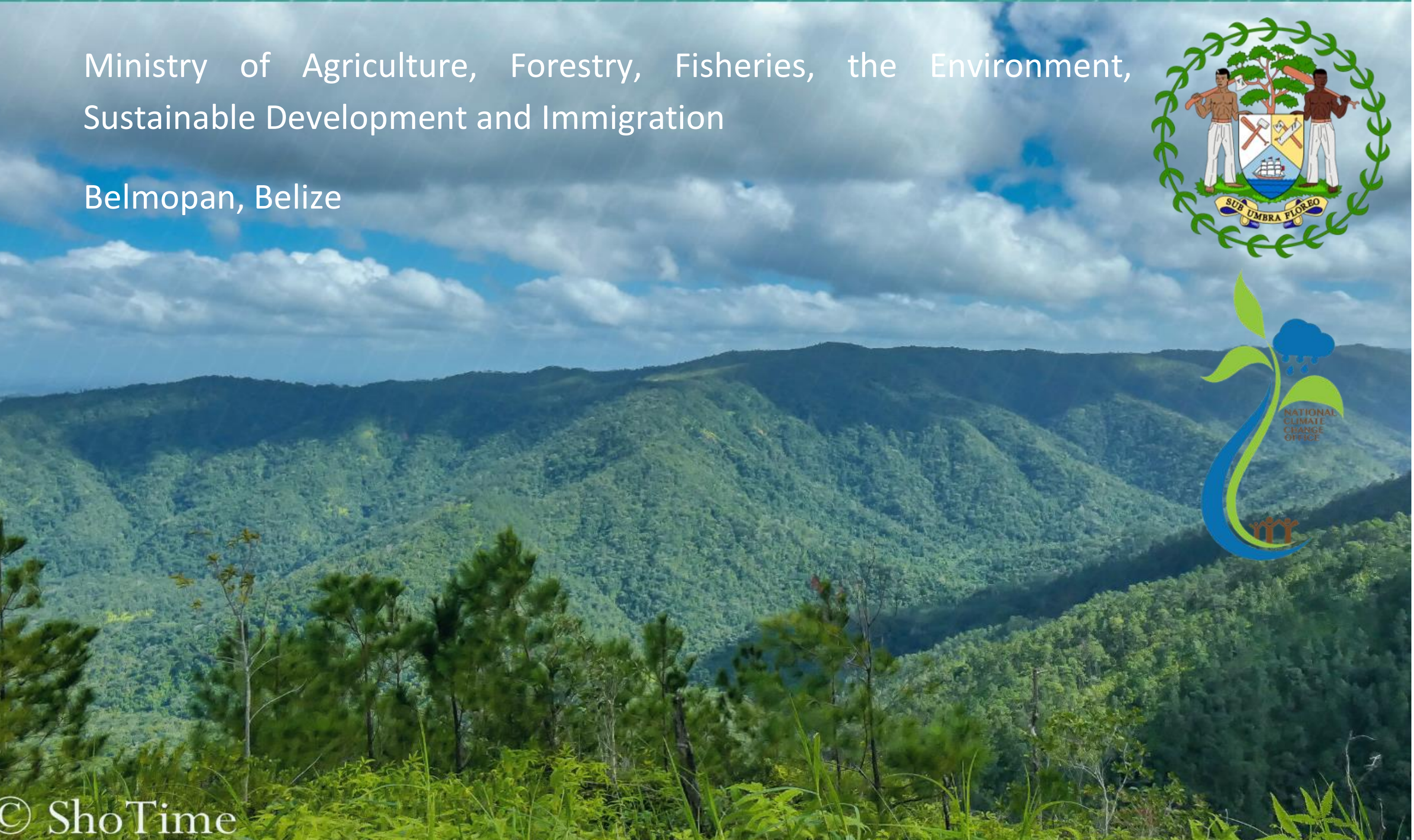
2020

BELIZE'S FOURTH NATIONAL GREENHOUSE GAS INVENTORY REPORT



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Mr. Carlos Fuller, International Liaison Officer of the CCCCC, also provided technical advice during the preparation and review of the report.

LIST OF ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, Forestry, and Other Land Use
API	Annual Production Index
BUR	Biennial Update Report
CaO	Calcium Oxide
CCCCC	Caribbean Community Climate Change Centre
CDM	Clean Development Mechanism
CFE	Comisión Federal de Electricidad
CfRN	Coalition for Rainforest Nations
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
COP	Conference of the Parties
Dm	dry matter
DNA	Designated National Authority
DOE	Department of the Environment
EECA	Energy Efficiency and Conservation Authority
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization (of the United Nations)
FCPF	Forest Carbon Partnership Facility
FD	Forest Department
FP	Focal Point
FNC	Fourth National Communication
FOLU	Forest and Other Land Use
GEF	Global Environment Facility
Gg	Gigagrammes
GHG	Green House Gas
GHGI	Green House Gas Inventory
GJ	Energy Content
GoB	Government of Belize
GPG	Good Practice(s) Guidance
GWP	Global Warming Potential
Ha	hectare
Has	Hectares
INC	Initial National Communication
IPCC	Inter-Government Panel on Climate Change
Kha	kilo hectares (1000 hectares)
Kts	kilotonnes
LIC	Land Information Center
LULUCF	Land Use, Land Use Change and Forestry

M^3	cubic meter
MCF	Methane Conversion Factor
MDGs	Millennium Development Goals
MAFFESDI	Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development, and Immigration
Mt	Metric tons
MNRA	Ministry of Natural Resources and Agriculture
MSW	Municipal Solid Waste
N_2O	Nitrous oxide
NA1	Non-Annex One
NCCC	National Climate Change Committee
NCCO	National Climate Change Office
NEMO	National Emergency Management Organization
NFP	National Focal Point
NIR	National Inventory Report
NMS	National Meteorological Service
NMVOC	Non-Methane Volatile Organic Compound(s)
NO_2	Nitrogen dioxide
NTFP	Non-timber Forest Products
PFC	Perfluorinated Compounds
PMU	Project Management Unit
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDGs	Sustainable Development Goals
SIB	Statistical Institute of Belize
SNC	Second National Communication
SO_2	Sulphur dioxide
SWDS	Solid Waste Disposal Systems
SWMA	Solid Waste Management Authority
TNC	Third National Communication
TOR	Term(s) Of Reference
T-Tonnes	Metric tonnes
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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EXECUTIVE SUMMARY

ES 1. Background information on greenhouse gas inventories

Belize submitted its First National Communication in 2002 followed by the Second National Communication in 2012. The First National Communication presented the greenhouse gas inventory of emissions by sources and removals by sinks for reference year 1994. The Second National Communication presented the greenhouse gas inventory for reference years 1997 and 2000. The emissions of Greenhouse Gases for the 1994 reference year were also re-calculated and reported in the Second National Communication.

In 2016, Belize submitted its Third National Communication. The country reported on its greenhouse gas inventory for reference years 2003, 2006, and 2009. Belize will be submitting its First Biennial Update report, which will include the report on its greenhouse gas inventory report reference years 2012, 2015 and 2017.

In 2012, at the COP 17 in Durban, it was decided that the first Biennial Update Reports from non-Annex I Parties should be submitted by December 2014. However, Least Developed Countries and Small Island Developing States were offered flexibility to submit such reports at their discretion. As a result, Belize in keeping with its commitments, will update the previous national greenhouse gas inventories of emissions and sinks, and conduct GHGI for reference years 2012, 2015 and 2017 which will bring the country up to date and enable Belize to submit its first Biennial Update Report.

The earlier GHG inventories were prepared using the method described by the Intergovernmental Panel on Climate Change (IPCC) 1996 Revised Guidelines, with analysis utilizing the most current updated values provided by the IPCC; the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories; and Good Practice Guidance for Land-use, Land-use Change and Forestry, published in 2003. Attempts will be made to address activity data gaps which contribute to the degree of uncertainty of the estimates. Data gaps are currently related to the data unavailability for regions and activity sectors of the country and inconsistency in reporting/ recording processes.

Following the IPCC Guidelines for National Greenhouse Gas Inventories, the activity sectors surveyed for these inventories include Energy; Industrial Processes and Product Use; Agriculture, Forestry and other Land Uses (AFOLU); and Waste.

The scope of the BUR is to provide an update of the most recently submitted national communication and to provide additional information on mitigation actions taken and their effects as well as proposed mitigation actions the country plans to undertake. The BUR should also include the constraints and related financial, technical and capacity needs, support needed and received and information on domestic Measurement Reporting and Verification.

Belize has been building national capacity through participation in the previous three national communications, and it is expected that the Fourth National Communication will advance that process as it seeks to institutionalize the greenhouse inventory process into the Government of Belize (GOB) through the National Climate Change Office; which will be coordinating with other key Ministries and/or Departments. This will foster continuity and sustainability of future reporting processes.

ES 2. Summary of the national emission and removal related trends

ES 2.1 Greenhouse gas inventory

Through the assessment of Belize's Fourth National Greenhouse Gas Inventory, Belize continues to be a net carbon sink. Notwithstanding this, there was general increase in GHG emissions across almost all subsectors over the study period of this inventory.

The Energy Sector saw increases in emissions in three sub-sectors; transport, electricity generation, and "Other" for residential purposes. Electricity generation and transport emissions were from fossil fuel consumption. "Other" is primarily from residential fuel wood use. Even with much greater availability of butane stoves and ovens, small increase wood for cooking purposes was noted. **The Industrial Processes and Product Use sector** displayed different behavior between the sub-sectors. Carbon dioxide emissions reflected the production level of the mineral (lime and dolomite production) over the period. Production increased between 2012 and 2015 then declined between 2015 and 2017, just the same as the market demand for the material changed. Road paving activities apparently slowed down considerably 2012 and 2015, then increased between 2015 and 2017. The emissions from this activity matched this trend. For the **Agriculture Sector**, there was constant increase in GHG emissions particularly from enteric fermentation (livestock), manure management, soil management, and biomass burning. Only the subcategory of agricultural Liming showed a trend decline over time. This is explained as the result of reduced application of white lime and dolomite to citrus farm soils and reduced utilization by shrimp farms. Both industries had been negatively impacted by diseases during the study period, thus requiring lower levels of application and utilization. The **Forest and Land Use Sector,** and the presence of Belize's natural forests enabled a consistent trend of net carbon sequestration throughout the time series. Noteworthy are the increasing levels of emissions caused throughout the study period caused by natural disturbances (2 major hurricanes), and subsequent increase in emissions from forest land conversion. The major drivers of deforestation were noted to be forest conversion to grassland (pastures), followed by conversion to cropland. National forest cover continues to serve as a carbon sink, although it was noted that this function diminished somewhat over the study period. The Methane and Nitrous emissions of the **Waste Sector** displayed small changes throughout the study period, and noted improved solid waste management through the construction of managed landfill and transfer stations. This has led to a reduction in open burning of waste. Emissions from wastewater and discharge are the highest for this sector, and includes industrial effluent as well. Greenhouse Gas emissions from this sector has been reduced compared to the period between 1997 and 2007 even with the inclusion of wastewater emission

The table below offers a summary of the total net Greenhouse Gas emissions and removals occurring within Belize as were estimated for the period 1994 to 2017.

Table ES 1 Belize's Total Net Greenhouse Gas Emissions and Removals by Sector, 1994-2017 (Gg CO2eq)

Sector	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total National Emissions and Removals *(with AFOLU)*	-6,612.97	-7,193.83	-7,718.26	-11,744.38	-11,202.62	-9,833.79	-7,179.14	-5,260.07	-5,826.79
Total National Emissions and Removals *(without FOLU removals)*	180.96	128.54	158.77	151.77	188.98	255.26	832.19	1,107.46	1,194.71
Energy	NE	NE	NE	NE	NE	NE	538.07	781.81	786.36
Industrial Processes and Product Use	0.67	2.96	6.36	10.57	15.40	22.83	31.43	42.50	43.69
Agriculture, Forestry, and Other Land Use	-6,614.01	-7,197.20	-7,725.07	-11,755.29	-11,218.40	-9,868.83	-7,771.37	-6,104.27	-6,683.66
Waste	0.37	0.41	0.45	0.34	0.37	12.21	22.73	19.89	26.81
International Bunkers	NE	NE	NE	NE	NE	NE	40.37	40.23	71.89

The net GHG emissions and removals for the same period, estimated with and without the AFOLU sector, are presented graphically in the figures below.

Figure ES 1:Trends in National Net Emissions by Sector, 1994-2017 (Gg CO2 eq)

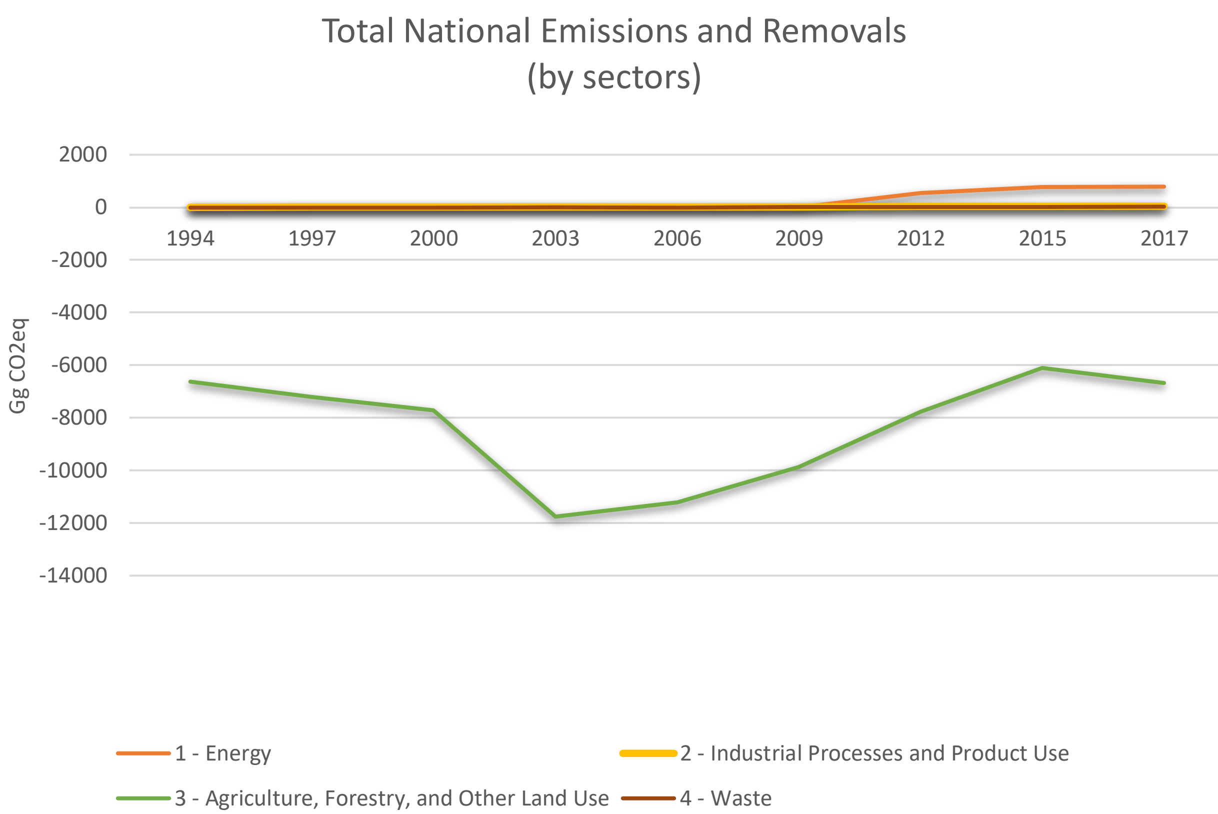
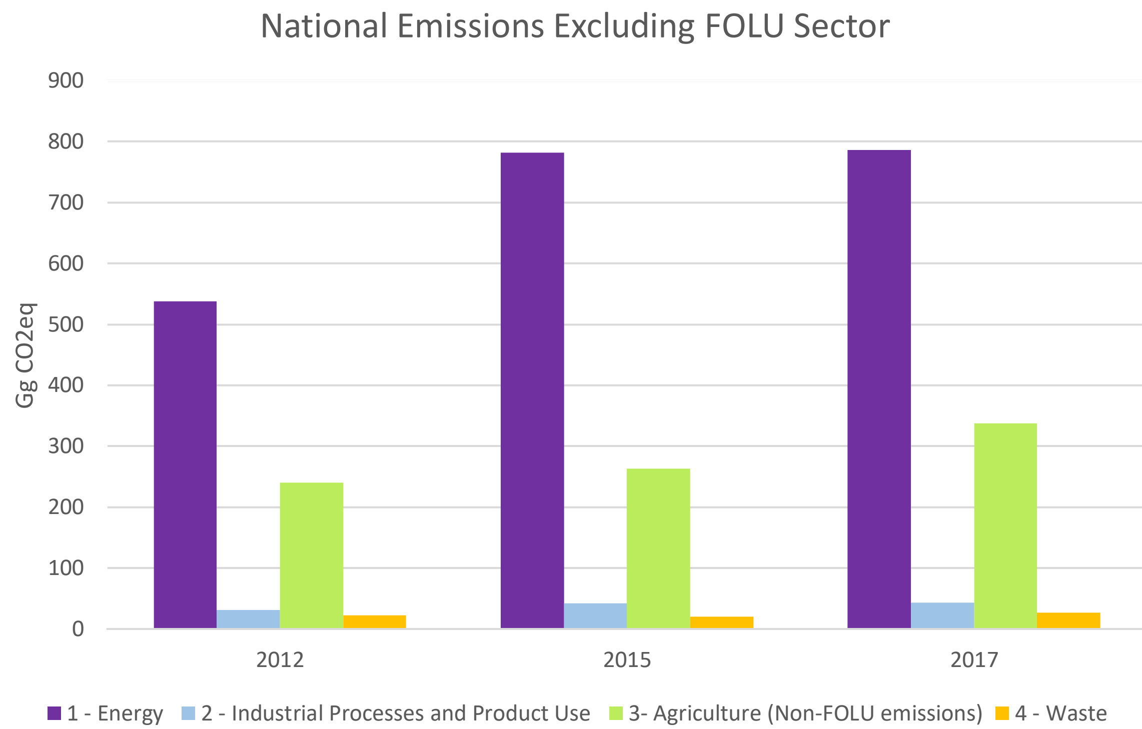


Figure ES 2: National Emissions excluding the Forestry and Other Land Use Sector, 2012, 2015, 2017 (Gg CO2 eq)



The observed increases in the emission trends in the **Energy sector** corresponded to some increases in the imports of petroleum fuels since 2012. This was because of increases in the consumption of petroleum fuels for electricity generation, and in the transport sub-sector. Local aviation has also expanded. Biomass usage for industrial and domestic energy production continued to increase as an alternate to petroleum products. Biomass is primarily used the generation of energy for the national grid and for self-consumption within the sugar industry. There was an increase in the use of this fuel late in the study period due to another company, Santander Sugar Energy Ltd., coming on stream and producing electricity for the national grid. The increase of biomass also increased the greenhouse gases emissions from this source, but this is largely recycled by the additional biomass being cultivated.

The trends displayed by the **IPPU sector** were the decreased production and application of lime, and slow growth in the production of beer, spirits, and bread. Road paving activities using asphalt appeared to fluctuate somewhat which levels of emissions in 2017 being lower that in 2015. Refrigerants use increased with the large number of new buildings constructed.

The most noticeable trend in the **Agriculture, Forest, and Other Land Use sector** is continuing increase by all the gases in all the sub-sectors. While the national forests continued to remove CO_2 resulting in net removals, this function is diminishing as the process of deforestation and forest conversion continued.

The emissions within the **Waste Sector** showed some small changes over the study period, this being due to the fact that some data for wastewater disposal and treatment was accessed and introduced to the estimates. Wastewater treatment and discharge is the greatest contributor to waste emissions, which accounts for industrial effluent as well. This sector also displayed some fluctuations in emissions across the study period with some decline in 2015 but increasing again in 2017.

ES 2.1.1 Major changes in the inventory which have resulted in recalculations

The most significant change which resulted in recalculations is probably the data coming out of the project to establish the Forest Reference level for the REDD+ Readiness preparation. This data was utilized in the calculations for the **AFOLU sector** and revealed that Belize's forest still function as carbon sinks, making Belize a net sink for GHG emissions.

The improved quality (accuracy and inclusiveness) of **Waste sector** data also contributed to significant changes in the emissions as a result of the recalculations. Although methodology was different, better quality of data was obtained from two different surveys conducted to determine waste composition and characterization.

ES.3 Overview of source and sink category emission estimate and trends by sector

ES 3.1 Greenhouse gas inventory

Table ES 2:Total Carbon Dioxide emissions by Sector, 1994-2017 (Gg CO2 eq)

Sectors /sub-sectors	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total CO2 Emissions and Removals	-6,781.92	-7,317.19	-7,871.27	-11,875.58	-11,384.52	-10,074.26	-7,485.37	-5,596.22	-6,249.35
1 - Energy	NE	NE	NE	NE	NE	NE	517.33	755.67	758.97
1.A - Fuel Combustion Activities	NE	NE	NE	NE	NE	NE	517.33	755.67	758.97
2 Industrial Processes and Product Use	NE	NE	NE	NE	NE	NE	1.52	1.65	0.49
2.A - Mineral Industry	NE	NE	NE	NE	NE	NE	1.52	1.65	0.49
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NE	NE	NE	NE	NE	NO	9.29E-08	9.16E-08
2.H - Other	NE	NE	NE	NE	NE	NE	3.75E-12	1.12E-06	6.52E-07
3 - Agriculture, Forestry, and Other Land Use	-6,782.01	-7,317.29	-7,871.38	-11,875.67	-11,384.61	-10,074.31	-8,004.28	-6,353.59	-7,008.87
3.B - Land	-6,777.53	-7,307.69	-7,837.85	-11,885.21	-11,391.36	-10,089.05	-8,011.33	-6,344.00	-6,987.00
3.C - Aggregate Sources and non-CO2 emissions sources on land - *Agriculture*	11.92	5.08	5.65	20.49	6.99	8.54	5.41	13.93	12.63
3.D - Other	-16.40	-14.68	-39.18	-10.94	-0.24	6.20	1.64	-23.52	-34.50
4 - Waste	0.10	0.10	0.11	0.08	0.09	0.05	0.05	0.06	0.07
4.C - Incineration and Open Burning of Waste	0.10	0.10	0.11	0.08	0.09	0.05	0.05	0.06	0.07
International Bunkers	NE	NE	NE	NE	NE	NE	40.01	39.87	71.25
1.A.3.a.i - International Aviation (International Bunkers)	NE	NE	NE	NE	NE	NE	40.01	39.87	71.25

Table ES 3: Total Methane emissions by Sector, 1994-2017 (Gg CO2 eq)

Sectors	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total CH4 Emissions	109.43	87.58	108.12	93.79	124.02	158.91	189.49	199.40	254.77
1 - Energy	NE	NE	NE	NE	NE	NE	7.53	8.83	9.50
1.A - Fuel Combustion Activities	NE	NE	NE	NE	NE	NE	7.53	8.83	9.50
3 - Agriculture, Forestry, and Other Land Use	109.21	87.34	107.87	93.60	123.81	155.47	165.62	177.61	228.29
3.A - Livestock	73.54	50.25	71.26	75.18	98.06	121.28	129.90	136.88	174.32
3.C - Aggregate Sources and non-CO2 emissions sources on land - *FOLU*	34.77	34.77	33.14	12.14	21.85	23.12	24.47	24.29	34.77
3.C - Aggregate Sources and non-CO2 emissions sources on land - *Agriculture*	0.90	2.33	3.47	6.28	3.89	11.07	11.26	16.44	19.20
4 - Waste	0.22	0.23	0.25	0.19	0.21	3.44	16.34	12.97	16.97
4.B - Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	2.87	0.00	0.00	2.87
4.C - Incineration and Open Burning of Waste	0.22	0.23	0.25	0.19	0.21	0.11	0.12	0.13	0.13
4.D - Wastewater Treatment and Discharge	NE	NE	NE	NE	NE	0.46	16.22	12.84	13.97
International Bunkers	NE	NE	NE	NE	NE	NE	0.01	0.01	0.01
1.A.3.a.i - International Aviation (International Bunkers)	NE	NE	NE	NE	NE	NE	0.01	0.01	0.01

Table ES 4: Total Nitrous Oxide emissions by Sector, 1994-2017 (Gg CO2 eq)

Sectors	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total N2O Emissions	58.85	32.81	38.52	26.83	42.46	58.72	86.81	95.85	124.53
1 - Energy		NE	NE	NE	NE	NE	13.212	17.315	17.895
1.A - Fuel Combustion Activities	NE	NE	NE	NE	NE	NE	13.212	17.315	17.895
3 - Agriculture, Forestry, and Other Land Use	58.79	32.75	38.44	26.78	42.40	50.01	67.28	71.71	96.92
3.A - Livestock	0.971	0.084	1.105	0.153	0.327	0.349	1.753	1.975	2.944
3.C - Aggregate Sources and non-CO2 emissions sources on land - *FOLU*	13.266	13.266	9.983	3.399	6.083	6.436	6.811	6.888	9.678
3.C - Aggregate Sources and non-CO2 emissions sources on land - *Agriculture*	44.554	19.398	27.356	23.223	35.993	43.229	58.720	62.848	84.299
4 - Waste	0.061	0.066	0.072	0.053	0.059	8.707	6.310	6.818	9.718
4.B - Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	2.540	0.000	0.000	2.540
4.C - Incineration and Open Burning of Waste	0.061	0.066	0.072	0.053	0.059	0.031	0.035	0.036	0.036
4.D - Wastewater Treatment and Discharge	NE	NE	NE	NE	NE	6.136	6.275	6.782	7.142

Table ES 5:Total Hydrofluorocarbon emissions by Sector, 1994-2017 (Gg CO2 eq)

Sectors	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total HFC Emissions	0.67	2.96	6.36	10.57	15.40	22.83	29.90	40.86	43.20
2 - Industrial Processes and Product Use									
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0.67	2.96	6.36	10.57	15.40	22.83	29.90	40.86	43.20

ES 3.1.1 Energy Sector

The estimates for the Energy Sector were affected by increased imports of petroleum fuels since 2012. The electricity generation sub-sector saw a slightly increase in the use of petroleum fuels. The increasing use of renewable energy sources combined with the importation of electricity from Mexico helped to mitigate GHG emissions for electricity generation. The largest increase in use of petroleum fuel during this study period was in the transport sub-sector which contributed to increasing the greenhouse gases emissions. The increase in petroleum fuel consumption was in the three sub-sectors; land, sea and air. However, there was a decrease in petroleum products usage and emissions for the transport sub-sector in 2017. Fuel consumption for national aviation has now become significant compared to the period of the last national report which had categorized it as insignificant. At the same time, there was a large increase in consumption of aviation fuel used by international flights arriving in Belize. The greenhouse gas emissions for international aviation were reported under the caption of international bunkers.

Biomass usage for industrial and domestic energy production continued to increase as an alternate to petroleum products. Biomass is primarily used in the generation of energy for the sugar industry. There was an increase in the use of this fuel over the past two years due to Santander Sugar Energy Ltd. coming on stream and producing electricity for the national grid. According to the Belize Electricity Limited Annual Reports the share of biomass source in electricity generation mix increased from 12% in 2012, to 14% in 2015, and to 50.1% in 2017. SSEL began cultivation of sugarcane on 20,000 acres of land, and entered into a Power Purchase Agreement with BEL for the supply of up to 8 MWh of electricity. The increase of biomass also increased the greenhouse gases emissions from this source. However, the sugarcane plants that are the source of the biomass capture contribute to the recycling of some volumes of CO_2 through photosynthesis, thus mitigating the negative impact of the additional generation of this gas.

Belize has made some advances in the utilization of alternative energy sources such as biomass and hydro power for electricity generation, but petroleum fuels are still in considerable use within other subsectors. The utilization of petroleum fuels for electricity generation has been reduced somewhat as a result of the continual use of hydro power, biomass and the importation of electricity from neighbouring Mexico. The growing economy, especially evident in the tourism sector, has caused the transport sub-sector to increase the use of petroleum fuels such as gasoline (premium, regular, and aviation), diesel and kerosene. The local aviation transport sector, once considered insignificant in relation to greenhouse gas emissions reporting, has started to show an increase in petroleum fuel usage. During the last few years, there has been an increase in the number of international airlines providing service to Belize. The fuel usage by international airlines is described under the international bunkers section.

ES 3.1.2 Industrial Processes and other Product Use Sectors

Industrialization is Belize advancing at a slow pace being somewhat limited by energy and labour costs. Activities which release greenhouse gas emissions within the Industrial Processes and other Product Use Sectors occur within a narrow range. There are very few of the sub-sectors displaying any reasonable level of activity to be estimated, these being lime production and road paving with asphalt in the Mineral Products sub-sector; and the production of beer, wine, and spirits, production of meat, fish, poultry, production of bread, and production of animal feed in the Food and Drink production sub-sector.

The fourth national greenhouse gas inventory shows that emissions from the IPPU sector continue to be released from the same sources as those for the previous inventories. Carbon dioxide Emissions from lime and dolomite production increased slightly between 2012 and 2015, then declined sharply between 2015 and 2017. The reduced emissions in the latter part of the study period is probably attributed to decreased application in the agriculture industries such as citrus and shrimp farming. The calculations show that CO_2 emissions from road paving also increased between 2012 and 2015, but decreased somewhat between 2015 and 2017. This trend suggests that road paving activities continued as expected with the expansion of the network between 2012 and 2015, but then slowed between 2015 and 2017. Emissions from refrigerants showed a steady increase between 2012 and 2017. This trend is expected with the continuing erection of new buildings with air-conditioning, and maintenance of existing structures similarly equipped.

ES 3.1.3 Agricultural, Forestry, and Other Land Use Sector

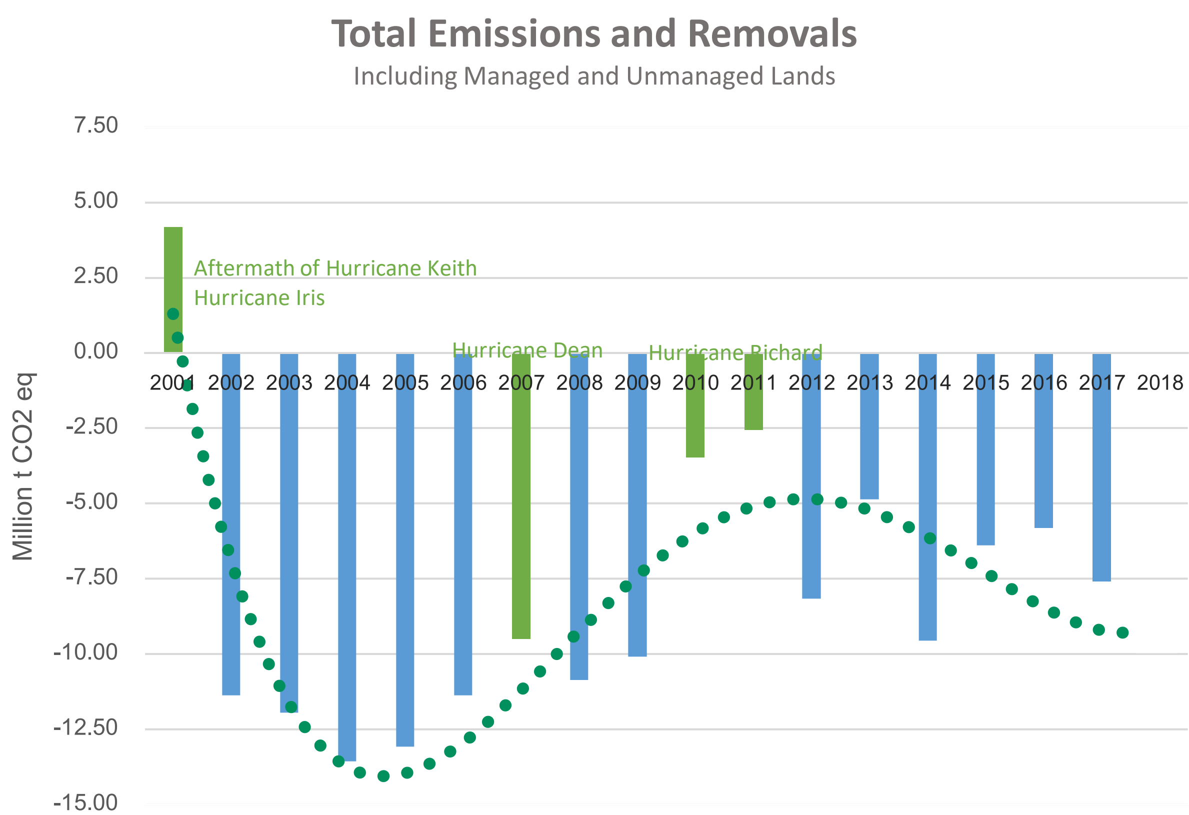
For the Agriculture activities, the main emissions accounted for in this GHG inventory were those from enteric fermentation and manure management. In terms of cropping systems, the methane emitted from rice cultivation as well as the N_2O emissions from managed soils and burning crop residues are also included in this report.

For the FOLU activities, the GHG inventory proposed by Belize is the net of Greenhouse gas (GHG) emissions and removals for all Intergovernmental Panel on Climate Change (IPCC) categories and subcategories at national level, which includes land remaining in same category and conversions to other land uses. It includes the pools above-ground biomass, below-ground biomass. Belize's National GHG Inventory includes a distinction between of managed and unmanaged lands, following the 2006 IPCC guidelines and the managed lands proxy (MLP). Therefore, the GHGI excludes the effect of recurrent hurricanes and pests, which have historically dominated emissions and removals in the country (see Figure ES 3).

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

10, of decision 12/CP.17 enabling the gradual improvement of their data and methods, including additional pools as appropriate.

Figure ES 3:Total emissions and removals in Belize, 1994-2017 (including Managed and Unmanaged Lands)



The cyclic behavior displayed in Figure ES 3 is largely due to recurring hurricanes. Important hurricane events are highlighted in the graph. Usually in the year of a large-scale hurricane, emissions increase, followed by a period of recovery (increased removals).

ES 3.1.4 Waste

The Methane and Nitrous emissions of the **Waste Sector** displayed small changes throughout the study period, and noted improved solid waste management through the construction of managed landfill and transfer stations. This has led to a reduction in open burning of waste. Emissions from wastewater and discharge are the highest for this sector, and includes industrial effluent as well. Greenhouse Gas emissions from this sector has been reduced compared to the period between 1997 and 2007 even with the inclusion of wastewater emission

ES 4 Overview of source and sink emissions by gases

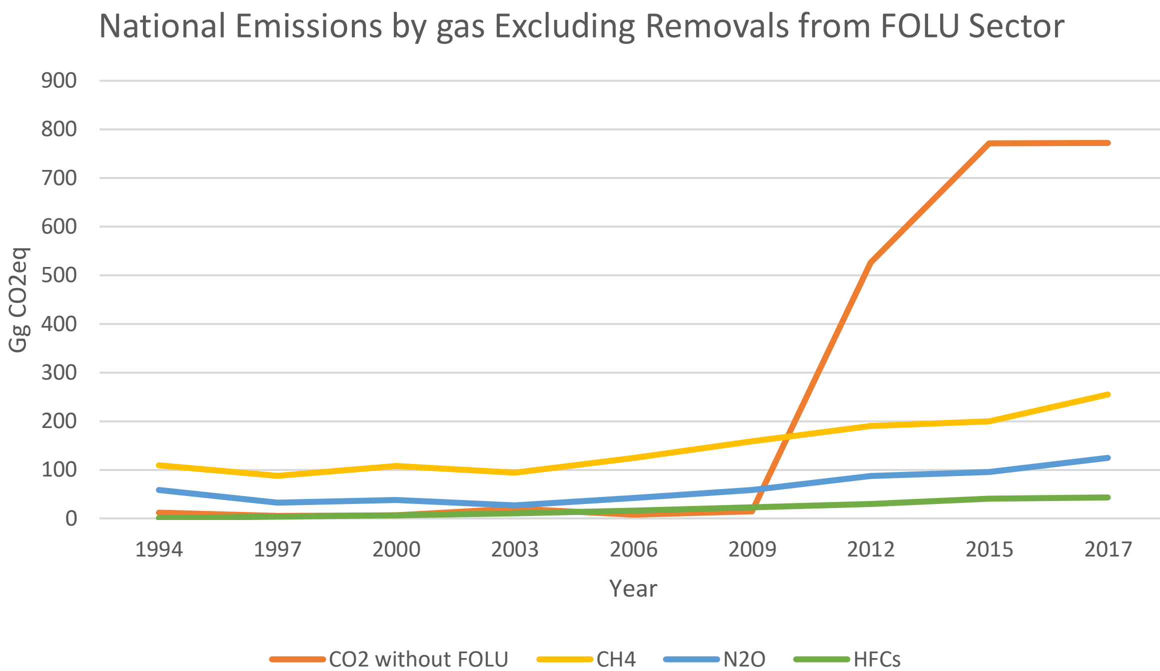
Table ES 6: Summary of GHG emissions and removals by gasTable ES 6 below shows the net Greenhouse Gas emissions and removals for the period from 1994 to 2017.

Table ES 6: Summary of GHG emissions and removals by gas, 1994-2017 (Gg CO2eq)

Gas	1994	1997	2000	2003	2006	2009	2012	2015	2017
CO2	-6,781.918	-7,317.188	-7,871.267	-11,875.585	-11,384.516	-10,074.262	-7485.365	-5596.216	-6249.345
CH4	109.427	87.584	108.133	93.802	124.032	158.927	189.51	199.4	254.819
N2O	58.852	32.815	38.515	26.829	42.461	58.720	86.806	95.845	124.535
HFCs	0.669	2.960	6.363	10.572	15.399	22.825	29.904	40.855	43.199

Figure ES 4: National Emissions by gas Excluding Removals from FOLU Sector, 1994-2017 (Gg CO2eq)Figure ES 4 below shows emission trends by gas, excluded CO2 removals from the FOLU sector to. CO2 emissions reflected predominantly reflect energy sector emissions.

Figure ES 4: National Emissions by gas Excluding Removals from FOLU Sector, 1994-2017 (Gg CO2eq)



1. Background information of Belize greenhouse gas inventory

The production of the Fourth National Greenhouse Gas Inventory of Emissions and Removals Report is the result of collecting activity data related to each of four sectors; namely **Energy, Industrial Processes and Product Use, Agriculture, Forestry and Other Land Use, and the Waste Sector**. It is another step in the process of institutionalizing the GHG inventory within the appropriate Government Departments coordinated and lead by the National Climate Change Office in the Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration. It was conducted as a part of the transition from the practice of hiring national consultants, to a stage where public officers are actively engaged in the collection and archiving of data. This methodology fosters a better understanding of the process and the assumption of ownership. It also assists the development of capacity to systematically and routinely conduct such exercises as Belize continues to meet its obligations as a Party to UNFCCC. This report is complementary to those produced for each of the activity sectors.

1.1 Context of the GHG inventory report

As is the standard practice with all the parties to the Convention, Belize's first and second GHG inventories covered the following sectors: Energy; Industrial Processes (and Solvents); Agriculture, Land Use Land Use Change and Forestry; and Waste. The Industrial Solvents sector was grouped with the Industry Sector since this sector is relatively undeveloped in Belize. Estimates of emissions and removals of GHGs were determined for the base year 1994 for the Initial National Communication and greenhouse gas inventory, followed-up by the Second National Communication which reported on the estimates of emissions and sinks for reference years 1997 and 2000 for that particular inventory. The emission factors utilized were the default factors provided by IPCC 2006 Revised Guidelines, with analysis utilizing the most current updated values provided by the IPCC. The Peer Review of earlier Greenhouse Gas inventories had helped to identify activity data gaps, so greater additional effort was made to find relevant data in order to improve the completeness and quality of the current exercise.

The third national GHG inventory was expected to capture new sources of emissions and sinks that might have arisen as a result of development activities within the sectors. The Third National Greenhouse Gas Inventory was originally planned to estimate emissions of and sinks for greenhouse gases for reference years 2003 and 2006. During the inception workshop, the participating national counterparts recommended that reference year 2009 be included since the inventory was beginning in 2012 and data for reference year 2009 should be available.

Belize had been building national capacity through participation in the previous two national communications and greenhouse gas inventories, and it was expected that the Third National Communication would further that process as it sought to institutionalize the greenhouse inventory process (data collection, analysis, and report preparation) within the Government of Belize Departments.

Previous GHG inventories and National Communications were prepared and submitted under the aegis of the National Meteorological Service (NMS). For the INC, the NMS was housed within the Ministry of Energy, and Transportation, but had been transferred to the Ministry of Natural Resources and the Environment by the time of preparation of the SNC. This Department was also previously responsible for housing the UNFCCC National Focal Point for Belize. Since 2012, the responsibility for the preparation of the NC has become the responsibility of the Belize National Climate Change Committee (BNCCC). Support to this process is provided by the National Climate Change Office which serves as the secretariat of the BNCCC, and is housed in the Ministry of Forestry, Fisheries, and Sustainable Development. The Ministry has continued to evolve into the Ministry of Agriculture, Fisheries, Forestry, Sustainable Development, the Environment and Immigration. However, it is still the umbrella ministry of the National Climate Change Office, which also continues to lead the process for the preparation of the National Communication, greenhouse gas inventory, and now the Biennial Update Reports. While the process is underway to institutionalize the greenhouse inventory into government departments, data collection and report preparation is assisted by the Caribbean Community Climate Change Centre, and local/national consultants with experience in this exercise.

The Caribbean Community Climate Change Centre is also a repository for the national communications since they are entered to the Clearinghouse database.

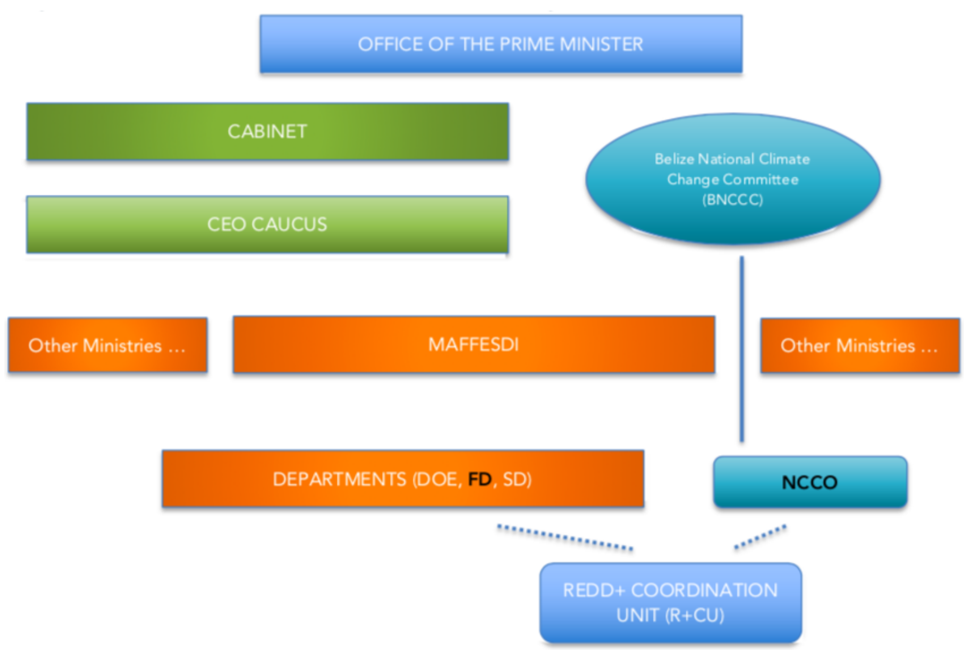
1.2 Institutional Arrangements

Following paragraph 13, annex to 17/CP.8, a brief description of procedures and arrangements undertaken to collect and archive data for the preparation of the national GHG inventories is included, as well as efforts to make this a continuous process, including information on the role of the institutions involved.

1.3 Procedures and arrangements for the preparation of the GHG inventory

To respond to the set of international reporting requirements inscribed in the UNFCCC and in the Paris Agreement, Belize is fully committed to establish a coherent, overarching governance structure to coordinate climate change management initiatives at the national level. The institutional framework critical for the implementation of climate change commitments and opportunities, including REDD+ is provided by Figure 1.1 below.

Figure 1.1: Belize institutional framework for the preparation of the GHG AFOLU inventory



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

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

United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD).

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

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

The Department of Agriculture's aim is to provide an environment that is conducive to increase production and productivity, promoting investment, and encouraging private sector involvement in agribusiness enterprises in a manner that ensures competitiveness, quality production, trade and sustainability[1].

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

The Department of the Environment (DOE), also currently housed in the MAFFESDI, was established in September 1989 to protect the nation's environment. The passage of the Environmental Protection Act (EPA) in November 1992 conferred broad statutory powers on the DOE concerning a wide range of environmental issues. Objectives of the DOE include identifying the major environmental problems confronting Belize and working towards the solution of these problems; assisting and working in close partnership with project proponents to ensure that their projects are both environmentally and technically sound through the implementation of Government's Environmental Impact Assessment

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

requirements; To develop and promulgate new regulations and standards for the prevention and control of pollution aimed at ensuring a greater and healthier quality of life for all Belizeans, among others.

In addition to its other responsibilities, the DOE has the new task of data collection and management for the IPPU sector for GHG inventory purposes.

The Belize Solid Waste Management Authority (BSWaMA) was formally established through the enactment of the Solid Waste Management Authority Act, 1991, Chapter 224 of the laws of Belize Revised Edition 2000. The Authority was established to ensure that solid waste generated in the country is managed in an environmentally sound manner. The BSWaMA works in conjunction with Local Government bodies and other stakeholders, to ensure the safe and environmentally sound management of solid waste in Belize. It applies the concept of Integrated Sustainable Solid Waste Management to improve on and contribute to the protection of human health/safety and the environment, the conservation of natural resources, and the promotion of the occupational health/safety of workers in the waste sector.

With the financial support of loans from IFCs the SWaMA is leading the transition from waste disposal (and burning) in open dumps to disposal in a managed landfill designed to protect ground and surface water from contamination, minimize the accumulation of toxic landfill gases and allow for green use of the landfill after it has reached the end of its useful life. The Authority is also now the lead in data collection and management for the waste sector.

The Energy Unit, and the Ministry of Energy, Science & Technology, and Public Utilities were founded in 2012. The Energy Unit has responsibility for governance of the energy sector in Belize. Its mission is to plan, promote and effectively manage the production, delivery and use of energy through Energy Efficiency, Renewable Energy, and Cleaner Production interventions for the sustainable development of Belize. Key activities performed by the Energy Unit include data collection for the purpose of planning Belize's future energy supplies and calculating greenhouse gas emissions, public awareness on topics such as energy efficiency, as well as regulation and market reforms that promote a sustainable future for Belize. Under the current structure for the preparation of GHG inventories in Belize, this Unit takes the lead in data collection and management in this sector.

1.4 Inventory Process

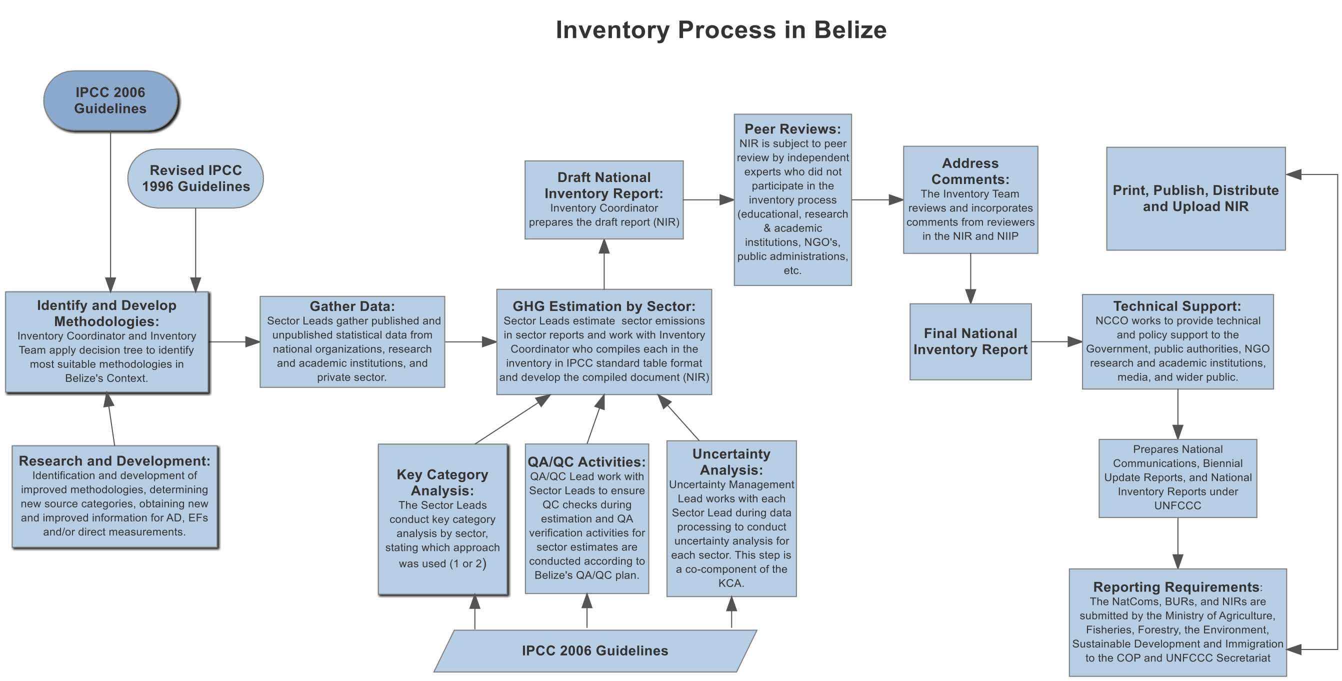
The Belize Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration (MAFFESDI) through the National Climate Change Office (NCCO), is entrusted with the role of leading the country's national and international agenda on climate change. Belize has been a party to the UNFCCC since 1992. The NCCO, in its capacity as Focal Point to the UNFCCC, is also the coordinating body for all reporting obligations to the Secretariat, including National Communications, Biennial Update Reports, and National Greenhouse Gas Inventory Reports.

In this context, the chart below details the processes that contribute to the GHG Inventory preparation and reporting cycle. Belize's national GHG Inventory team is comprised of an Inventory Coordinator who synchronizes all sector and crosscutting activities/reports, and ensures functionality of GHG Inventory Management System; Sector Leads who take the executive roles in coordinating data collection, estimating, and reporting GHG emissions and sinks for their sectors, and Crosscutting roles such as Quality Assurance/Quality Control; and Uncertainty Management Leads who facilitate report quality indicators. Each of the Inventory Team members' and other important entities' (independent experts) specific roles and responsibilities are described in

Table 1.1. These Institutional Arrangements for inventory development will guarantee its perpetuity and integrity, promote institutionalization of the inventory process, and enable prioritization of future developments.

Belize's Inventory Process intends to elucidate the roles and responsibilities of all GHG Inventory Teams and Stakeholders into an understandable process flow from role establishment, to inventory preparation to dissemination to the wider public. Figure 1.2 below outlines the various processes considered during the preparatory process of a National Inventory Report (NIR). Preparing a comprehensive inventory requires the identification and documentation of all relevant contributors to the National Inventory. Reviewing the status of existing methods, data sources, and emissions factors play a vital role in emissions estimation, and ultimately report writing. These portions of the inventory process require various quality inputs such as uncertainty analysis, key category analysis and QA/QC checks to ensure that country estimations are reported according to IPCC Good Practice Guidelines and follow the TACCC Principles (Transparency, Accuracy, Completeness, Comparability, and Consistency). At the final stages of the process, where the draft NIR is reviewed to produce the final NIR, publication and dissemination to policy makers as well as the wider public ensure that transparency efforts are covered, and that informed national decisions and policy mainstreaming is facilitated. The Inventory Process that Belize adopts is not a fixed model, but rather a model based on continuous improvement that benefits the country at large with opportunity for development.

Figure 1.2: Inventory Process in Belize



Source: National Climate Change Office

A Greenhouse Gas Inventory team was formally assembled by the NCCO to provide support to the process. Members were selected from various departments and institutions depending on what contributions they could make. Some of the members of the team have benefited from capacity building training sessions facilitated by the NCCO and local, regional, or international partners. The table below provides details.

Table 1.1: Belize Greenhouse Gas Inventory Team

No.	Name	Designation	Role
1	Dr. Percival Cho	Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration (MAFFESDI); National Climate Change Office	Designated National Entity
2	Dr. Lennox Gladden	National Climate Change Office	UNFCCC Focal Point/ Chief Climate Change Officer
3	Ms. Brittany Meighan	National Climate Change Office	National Inventory Coordinator Compiler & Generalist QA/QC Lead
4	Mr. Geon Hanson	Energy Unit, Ministry of Labour, Local Government, Rural Development, Public Service, Energy & Public Utilities	Lead, Energy Sector
5	Ms. Kayla Gabourel	Energy Unit, Ministry of Labour, Local Government, Rural Development, Public Service, Energy & Public Utilities	Alternate Lead, Energy Sector
6	Ms. Omaira Avila	Caribbean Agriculture Research Development Institute	Lead, Agriculture Sector
7	Mr. Hector Reyes	Caribbean Agriculture Research Development Institute	Alternate Lead, Agriculture Sector
8	Dr. Victoriano Pascual	Agriculture Department, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Expert, Agriculture Sector
9	Mr. Edgar Ek	Department of the Environment, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Lead, IPPU Sector
10	Mr. Erwin Jimenez	Department of the Environment, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Alternate Lead, IPPU Sector
11	Mr. Emerson Garcia	Solid Waste Management Authority, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Lead, Waste Sector
12	Mr. German Lopez	Forest Department, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Lead, Land Use & Land Use Change Sector
13	Mr. Edgar Correa	Forest Department, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	REDD+ Lead, Land Use & Land Use Change Sector Lead.
14	Ms. Florencia Guerra	Forest Department, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration	Forest carbon stock Technical Lead

Source: National Climate Change Office

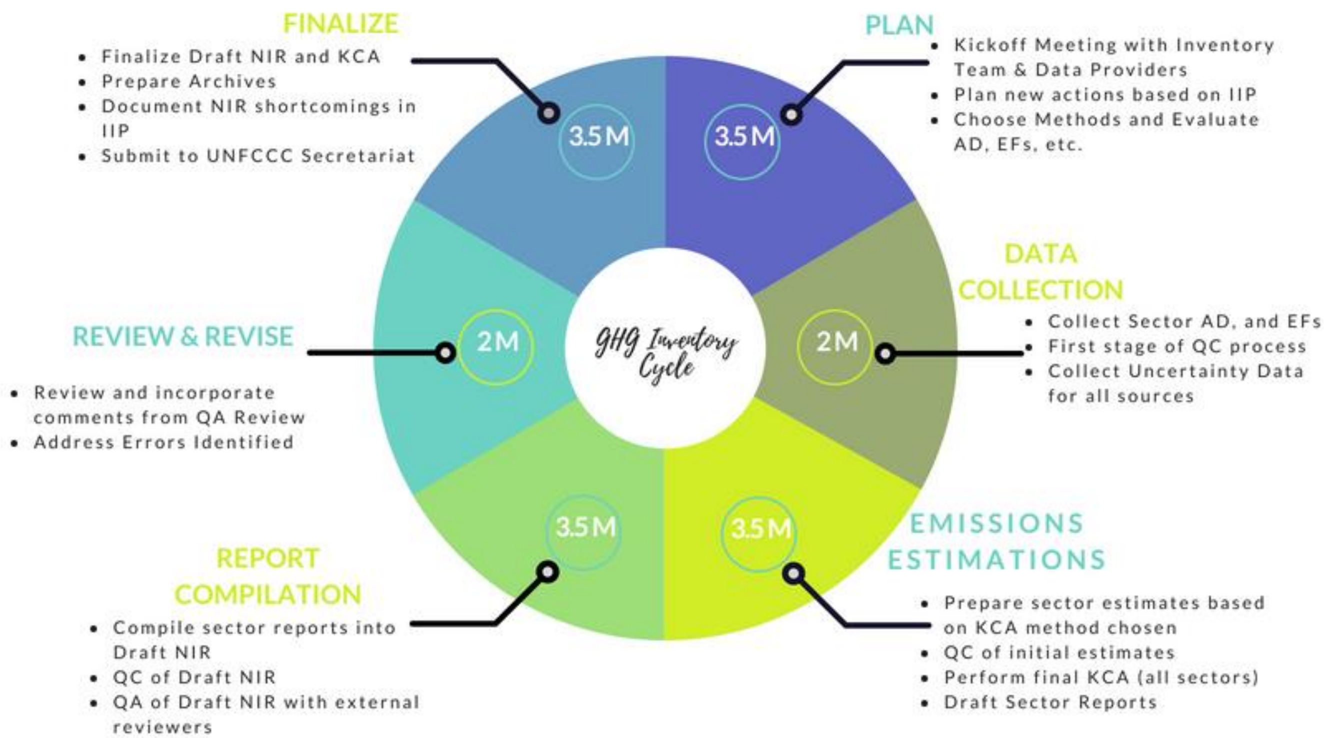
1.5 Greenhouse Gas Inventory Cycle

Belize's GHG Inventory Cycle is segregated into six phases based on the 2006 IPCC guidelines and the CGE Handbook on Building Sustainable National Greenhouse Gas Inventory Management Systems. The cycle is consistent with the Biennial Update Report (BUR) preparation, through which countries submit their updated GHG Inventory Reports as technical annexes to the BUR. It is a continuous cycle spanning an 18-month period from planning to submission of the report. Each phase, Planning, Data Collection, Emissions Estimation, Report Compilation, Review & Revision, and Finalize focuses on delivering the specific outcomes of each stage as illustrated in Figure 1.3 below. The 18-month timeframe selected was chosen based on its suitability for an Institutionalized GHG Inventory Team whose members have professional objectives apart from inventory preparation activities. This cycle permits for interim relief of duties for the GHG Inventory Team between submission dates every 24 months.

The first half of the cycle encompasses meeting and planning the way forward with the Inventory Team, incorporating necessary improvements identified from the previous cycle, drafting and signing legal agreements, data collection, and sector emissions estimations and collation. In the second half of the cycle, report compilation and verification activities are introduced, followed by revision of the final inventory report for submission to the UNFCCC Secretariat and presentation at COP. The final stage of the cycle also includes identification and documentation of further improvements to include in the Inventory Improvement Plan (IIP), which is the basis of the planning stage in the new cycle. During the review stage, all feedback from the preceding inventory are collated and evaluated as input into the planning of the new inventory.

Throughout all phases of the cycle, crosscutting activities are implemented as necessary, such as QA/QC activities as outlined in Belize's GHG Inventory QA/QC Plan, as well as data archiving. These activities, however, are more relevant from Data Collection through Report Compilation.

Figure 1.3: Belize's GHG Inventory Cycle



Source: NCCO-Belize's GHGI Institutional Arrangements

1.6 Data acquisition and data management

The GHG Inventory exercise is now executed by an inventory team lead by the Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration (MAFFESDI) and comprised as described below in the table. This structure was designed and intended to encourage buy-in to the process and eventual assumption of ownership by the relevant government authorities.

The involvement of the government officers was achieved through their preliminary work to obtain/access and share source data, via participation in data validation sessions, in review of draft reports produced by the consultants, as well as through participation in the validation of the reports. Occasionally these government officers were themselves the sources of data and information.

The National Climate Change Office functioned as the liaison between the sources of data and information and the CCCCC. However, the Data Collectors/Consultants sub-contracted by the Centre were also able to engage in direct contact with data sources to obtain data. Additional details of the GHG Inventory Team are described in

Table 1.1 above.

The National Climate Change Office has taken the initiative to establish a structure to assist with the preparation of the national greenhouse gas inventories as a part of the institutionalization of the process. The Sector Teams were constructed to include personnel from Departments with direct responsibility for or participation in the relevant sector. For example, the “Forest and Other Land Use (FOLU)” sector was headed by a Forest Department representative; while the Energy Team was led by a representative of the Ministry of Energy. These sector teams were charged with collecting data from the operators in that particular sector.

Forest and Other Land Use (FOLU) sector, the process started with review of previous emission estimation methods and estimates, identification and formation of the teams, allocation of tasks, technical training, data collection, data analysis, QC/QA procedures, and finalized with a compilation of the GHG inventory. The process was completed by external independent review and elaboration of an improvement plan (see Figure 1.4).

The GHG national inventory coordinator, from the National Climate Change Office, was responsible for the identification and sourcing of all datasets at the national level, in collaboration with the sector lead institution for the FOLU Sector, the Forest Department, who identified all the national experts and/or institutions where the data would be sourced. All data are documented and stored as per archiving and documentation procedures, with the main custodian being the NCCO, in its database for archiving and retrieval.

The archives database contains; (a) all inputs datasets and datasheets; (b) country-specific excel calculation tool, including GHG emission and removals estimates from the AFOLU sectors from 1994-2017, (c) manuals and protocols, (f) literature reviewed, (g) completed QA/QC templates and protocols, and (h) all reports and documentation.

Figure 1.4: FOLU Schedule of Inventory Tasks

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

NCCO: National Climate Change Office, CfRN: Coalition for Rainforest Nations, FAO: Food and Agriculture Organization, R+CU: REDD+ Unit of Belize. QC: Quality Control, QA: Quality Assurance. *Details of the role of the institutions and expertise of the data collection team are described in *Annex 1*.

1.7 Outline of the national inventory report

1.7.1 Key economic sectors covered

The national inventory report described greenhouse gas emissions and removals in the Energy; Industrial Processes and Product Use; Agriculture, Forest and Other Land Use; and Waste Sectors.

Activities contributing to GHG emissions in the Energy sector included electricity generation, transportation, Other, and International Bunkers. Belize is not a highly industrialized country, so there were few sources of emissions within the IPPU sector such as lime production, road paving, refrigerants, and alcohol and bread production. The AFOLU sector contributed to both emissions and removals of GHG through sources such as enteric fermentation, crop residue burning, tillage, rice cultivation, and changes in land use, while the maintenance and management of forests helped to remove Carbon dioxide from the atmosphere. Waste sector emissions were produced from the solid waste production and disposal sub-sector, and waste water management.

1.7.2 Gases included in the inventory

Gas emissions to be estimated and reported on include Carbon dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). However, emissions of Non-methane volatile organic compounds and fluorocarbons would also be estimated and reported.

1.7.3 Reporting years

Reporting years for Belize's fourth national inventory were established as 2012, 2015, and 2017.

1.7.4 Recalculations

Recalculations were done for past inventories, where possible, beginning with that of 1994 reported in the Initial National Communication that Belize submitted. In the Energy sector, recalculation of previous inventory reference years proved to be difficult because the data available was recorded in a manner unsuitable for disaggregate analysis using the IPCC 2006 software. For example, it was not possible to segregate the fuel consumption between road and maritime transport because the fuel data obtained from the source was not recorded with that level of detail. Similarly, the Waste sector recalculation was not possible because different methods of determining waste generation rates were used by different studies, rendering older data incompatible.

For the IPPU Sector, recalculations were done for F-gases, however lime production data as early as 1994 was very limited, therefore reliable estimations were only made for the covered reference years.

For the FOLU sector, the 1994-2017 time series includes: (a) by extrapolation, recalculated 1994-1999 estimates year by year, (b) 2000-2017 new annual estimates. Extrapolation 1994-1999 was done only for final emissions and removals [CO2-eq] because of the limitations of the method used for assessing Land Use and Land Use Change, which is possible only from year 2000.

1.7.5 Description of methodologies and data sources

Following paragraph 13, annex to 17/CP.8, a brief description of procedures and arrangements undertaken to collect and archive data for the preparation of the national GHG inventories is included, as well as efforts to make this a continuous process, including information on the role of the institutions involved.

Fuel data for the Energy sector inventory was obtained from local sources including the main importer of fuel, PUMA; the Energy Unit in the Ministry of Public Service, Energy and Public Utilities; and the Farmers' Light Plant of Spanish Lookout. Other relevant data for this sector was obtained from the Department of Transport.

The Tier 1 approach for calculations was used for most of the sectors including Energy, IPPU, and Waste due to the detail of the available that was available. The various authorities, institutions, and companies who were the sources generally do not collect or record data in detail. Tiers 1 and 2 were applied in the Agriculture sector since some level of detail was available in the data provided.

Tiers 1, 2 and 3 were utilized for the Forest and Land Use sector due to the data that was available or developed through the ongoing REDD+ Readiness Plus project being implemented with the support of the Forest Carbon Partnership Facility "FCPF", and the Coalition for Rainforest Nations. 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 (IPCC approach 3) using Collect Earth, in which the land-use condition was determined for each year of the time series 2000 - 2017. The information on Emission Factors was obtained from country specific research, scientific literature, and default values of the 2006 IPCC Guidelines and 2013 IPCC Wetlands supplement. For the estimation of GHG emissions and removals the 2006 IPCC Guidelines were applied, following the Gain-Loss method and implementing a country-specific excel calculation tool. The information on wood removals was derived from the Collect Earth assessment. Disturbances were also identified including Hurricanes, Fires, Logging, Grazing, Shifting Cultivation, Infrastructure, Pests and Other Human Impact.

Belize's National GHG Inventory includes a distinction between of managed and unmanaged lands, following the 2006 IPCC guidelines and the managed lands proxy (MLP). Therefore, the GHGI excludes the effect of recurrent hurricanes and pests, which have historically dominated emissions and removals in the country. Unmanaged Land is Forest land with no evidence of human activity. Managed Lands cover the entire territory in Belize that does not fall under the definition of Unmanaged Lands. Following IPCC's best practice, the area of unmanaged lands is monitored by Belize. Emissions and removals are estimated for both types of land, as this is important information for the Government of Belize. The current GHG

Inventory includes only emissions and removals in Managed Lands. Unmanaged lands converted to managed lands will be tracked in the future and those emissions and removals will be considered.

1.7.6 Global warming potentials (GWP) Applied

The greenhouse gas emissions are usually reported as units of Carbon dioxide equivalents (CO_2e). This value is obtained by multiplying the amount of the gases by their Global Warming Potentials (GWPs). The Global Warming Potentials used for these inventory calculations were those based on the 100-year time horizon and are presented below. GWPs from the IPCC Second Assessment Report (SAR) were used for Energy, IPPU, Waste, and Agriculture sectors, and GWPs from the IPCC Fifth Assessment Report (AR5) were used for the FOLU sector.

Table 1.2: Global Warming Potentials

Gas	GWP (SAR)	GWP (AR5)
CO_2	1	1
CH_4	21	28

1.7.7 Key Category Analysis

A look at the Key Category Analyses reveals that **The Agriculture, Forestry, and Other Land use sector** plays a significant role in the emission and removals of Greenhouse Gases in Belize. However, this same sector was also the greatest emitter of GHGs for the same reference years. The two major contributing sub-sectors were "Forest Land converted to Cropland' and Forest Land converted to Grassland". Both sub-sectors showed increased emissions between 2012 and 2015, but then declined to lower levels in 2017. The "Road Transportation" sub-sector of the **Energy sector** remained the third most significant emitter of GHGs in the three reference years. Other sources included in the top ten producers of GHG gases were Enteric Fermentation (AFOLU), Nitrous oxide emissions from Managed Lands (AFOLU), Gaseous and Liquid Fuel consumption in the Energy sub-sector, nitrous oxide from biomass burning in cropland, and Refrigeration and Air-conditioning in the Industrial Processes and Product Use sector.

In general, and at the other end of the range there were a few sub-sectors from which the emissions were estimated to be negligible. These included N2O from Open burning of Waste and Solid Waste disposal in the **Waste sector**. Lime production in the IPPU is dwindling in emissions. For the Energy Industries sub-sector emissions of N20, and CH4 from Gaseous and Liquid fuels respectively were very low.

Details of the Key Categories Analyses are provided in Table 3.1,Table 3.2Table 3.3.

1.8 The Benefits of Developing Inventories

In addition to enabling the country to meet national UNFCCC reporting obligations under the convention, the GHG Inventories report can otherwise provide benefits such as:

- Provision of data and information useful to economic development programming and planning, including information on the state of the natural resource base, e.g., croplands, forests, wetlands, energy resources and information on industrial demand and production;
- Data and information useful for addressing other environmental issues like land use changes and waste management;
- Identification of data gaps for improved resource management;
- Evaluation of GHG mitigation options; and
- Providing the data and information applicable for emissions trading schemes;
- Compliance with commitments under the Convention.

2. Belize's Fourth National Greenhouse Gas Inventory

2.1 National emission and removal related trends

Table 2.1: Belize's net greenhouse gas emissions by sectors for reference years, 2012, 2015, 2017 (Gg CO2 eq)Table 2.1 below outlines the total emissions and removals for each sector for the three reference years evaluated. Description of trends by sectors is further detailed in this section below.

Table 2.1: Belize's net greenhouse gas emissions by sectors for reference years, 2012, 2015, 2017 (Gg CO2 eq)

Sector	2012	2015	2017
Total National Emissions and Removals	-7210.42	-5291.22	-5871.54
Energy	538.07	781.83	786.36
Industrial Processes and Product Use	31.43	42.50	43.69
Agriculture, Forestry, and Other Land Use	-7802.65	-6135.45	-6728.40
Waste	22.73	19.89	26.81

The estimates for the **Energy Sector** were affected by increased imports of petroleum fuels since 2012. There was a general increase in the emissions of CO_2, CH_4, and N_2O over the period across all the sub-sectors except for the transport sub-sector showing a slight decrease from the 2015 level. The electricity generation sub-sector saw a slightly increase in the use of petroleum fuels. The use of renewable energy sources combined with the importation of electricity from Mexico helped to mitigate GHG emissions for electricity generation. The largest increase in use of petroleum fuel during this study period was in the transport sub-sector which contributed to increasing the greenhouse gas emissions. The increase in petroleum fuel consumption was in three sub-sectors; land, sea and air, and this sub-sector contributed to the greater proportion of the sector emissions. However, there was a decrease in petroleum products consumption and emissions for the transport sub-sector in 2017. Fuel consumption for national aviation has now become significant compared to the period of the last national report which had categorized it as insignificant source of emissions; by 2017 it was becoming a significant source of GHG emissions in the Energy sector. At the same time, there was a large increase in consumption of aviation fuel used by international flights arriving in Belize. The greenhouse gas emissions for international aviation were reported under the caption of international bunkers.

Biomass usage for industrial and domestic energy production continued to increase as an alternate to petroleum products. Biomass is primarily used in the generation of energy for the sugar industry. There was an increase in the use of this fuel over the past two years due to a second sugar-producing company, Santander Sugar Energy Ltd., coming on stream and producing electricity for the national grid. According to the Belize Electricity Limited Annual Reports the share of biomass source in electricity generation mix increased from 12% in 2012, to 14% in 2015, and to 50.1% in 2017. SSEL began cultivation of sugarcane on 20,000 acres of land, and entered into a Power Purchase Agreement with BEL for the supply of up to 8 MWh of electricity. The increase of biomass also increased the greenhouse gases emissions from this source. However, the sugarcane plants that are the source of the biomass capture contribute to the recycling of some volumes of CO_2 through photosynthesis, thus mitigating the negative impact of the additional generation of this gas.

Industrialization is Belize is advancing at a slow pace being somewhat limited by energy and labour costs. Activities which release greenhouse gas emissions within the **Industrial Processes and other Product Use Sectors** are only a few. There are very few of the sub-sectors displaying any reasonable level of activity to be estimated, these being lime production and road paving with asphalt in the Mineral Products sub-sector; and the production of beer, wine, and spirits, production of bread in the Food and Drink production sub-sector. The fourth greenhouse gases inventory shows that emissions from the *IPPU* sector continued to be released from the same sources as those for the previous inventories. The main gas released from this sector in any appreciable quantity was Carbon dioxide. Emissions of this gas from the lime production sub-sector increased between 2012 and 2015, and then declined considerably between 2015 and 2017. CO_2 emissions from the road paving sub-sector similarly increased between 2012 and 2017, then decreased between 2015 and 2017, but not as sharply as in asphalt use. Emissions from refrigerants showed a continuing increase from between 2012 to 2017.

The most noticeable trend in the **Agriculture, Forest, and Other Land Use** sector is a steadily narrowing difference between the level of emissions and the removals by the national forests. This is not unexpected given the continuing deforestation and conversion of forests to other land use.

The estimates of all the emissions within the **Waste Sector** show continuous a general increasing trend over the study period, although 2015 was noted to be lower than 2012. The combined emissions from the solid waste and wastewater sectors results in a total of 16.24 Gg CO2eq of methane in 2012, to 12.889

in 2015 and an increase to 14.51 in 2017. CO_2 was measured at 0.054Gg in 2012, to 0.057 in 2015 and increasing to 0.072 in 2017. Nitrous oxides showed similar increases from 6.31 Gg in 2012 to 6.82 in 2015 and 9.72 in 2017 (ref Table ES 2

Table ES 3

Table ES 4 for trends by gas). The combined total emissions of these gases in the waste sector are 22.73 Gg in 2012, 19.89 in 2015 and 26.813 in 2017.

If Belize's GHG emissions are measured without considering AFOLU the country is increasingly an emitter of GHGs. However, the extent of the national forests, results in the country being a net sink, albeit removing smaller amounts of CO_2 for each successive reference year the inventory is conducted is estimated.

2.2 Energy Sector

a. Sector Background

Belize has made considerable advances in the usage of alternative energy sources such as biomass and hydro power, but petroleum fuels are still the main sources of energy as is described in this report through the analysis of fuel importation and usage. The generation of electricity saw slight increases in the usage of petroleum fuels combined with the continual use of hydro power, biomass and the importation of electricity from neighboring Mexico. As the economy grows, and the population rises, the increasing demand for vehicle and flights in the transport sector has increased the use of petroleum fuels such as gasoline (premium, regular, and aviation), diesel and kerosene. Furthermore, local aviation, once considered insignificant in relation to greenhouse gas emissions reporting, has started to show an increase in petroleum fuel usage. This can be tied to the usage of fuel by the domestic airlines, but this is supplemented by the increased number of international airlines landing in Belize. The fuel usage by international airlines is described under the international bunkers section.

The period 2012 to 2017 displayed steady increases in Carbon dioxide, Methane and Nitrous Oxide emissions in the Energy sector. The Transport sub-sector, however, displayed a slight decrease in the amount of emissions compared to 2015. Methane and Nitrous oxide emissions in this sub-sector showed the same lower level of emissions compared to 2015. This may be the result of a number of changes observed within the sub-sector, particularly road and marine transport. The majority of the public transport (bus) operators have been converting from the older V8 diesel engines six-cylinder in order to reduce their fuel costs. These other engines can deliver up to fifty percent better mileage. Reduced fuel consumption means reduced emissions. Many of the taxi drivers have also shifted to smaller cars with smaller engines, again with a view to reducing operating costs in the face of increasing fuel costs. Marine transport has also demonstrated some changes as many of the fishermen and water-taxis have converted to four-cylinder outboard motors. There has been an increase in both dealers and variety of new vehicles being made available to the customers, mostly in the form of diesel engine pickup trucks and small cars.

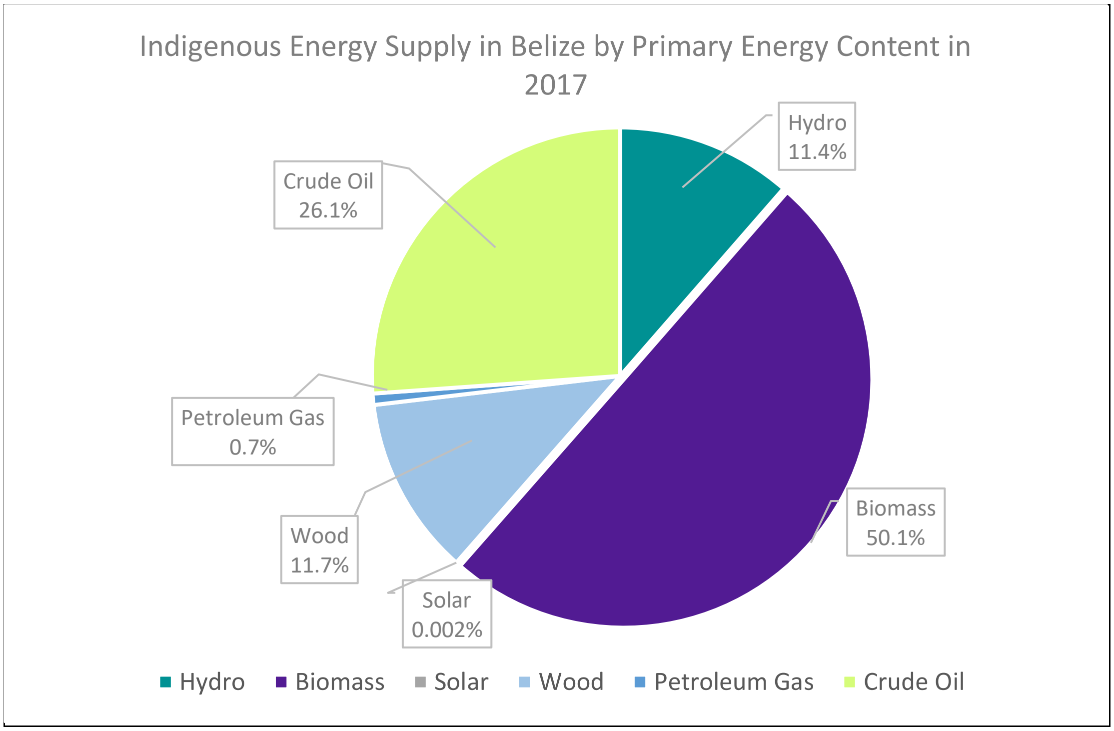
These again contribute to lower national fuel consumption and the better efficiency of the engines mean lower emissions.

Biomass use for industrial and domestic energy supply continued to increase as an alternate to petroleum products. Biomass is used primarily in the generation of energy by the sugar industry companies. This proportion of this energy source in the “mix” also increased during the latter part of the study period due to the commissioning and operation of the Santander Sugar Energy Ltd. Plant, producing sugar and electricity.

a.1 Electricity Generation

Energy production in Belize continues to be derived from a mixture of primary sources such as wood (11.7%), petroleum gas (0.7%), hydro (11.4%), biomass (50.1%) and crude oil (26.1%) (Figure 2.1). Solar energy sources are relatively insignificant at 0.002%. Belize Natural Energy (BNE) is currently the only agency that produces oil (about 900 barrels a day) within the country with an estimated 10 million barrels of recoverable oil reserves (MED, n.d.). Currently there is still no refining of oil locally and most of it is exported. Up to 40 percent of the country’s electricity energy supply is also provided through a purchase agreement with the Federal Electricity Commission of Mexico. This is based on changes in demand from consumers and supply from power producers. For example, supply from power producers may vary depending on the time of year when the hydrodams reservoirs are low in water, or in the case of bagasse, when fuel is decreased as a result of non-milling periods.

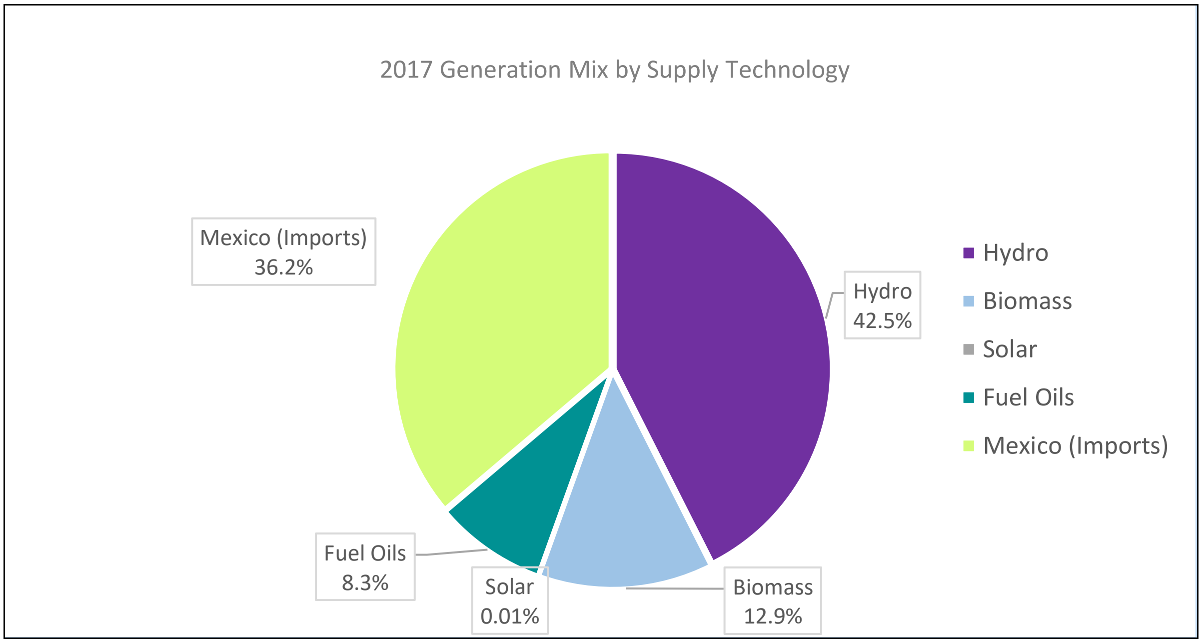
Figure 2.1: Electrical Energy Supply by Primary Energy Content in Belize in 2017



Source: Energy Report, 2017

There are four (4) hydro power plants, three (3) on the Macal River in the Cayo District, and one on the Columbia River, Toledo District supplying electricity to the national grid. These are the Mollejon, Chalillo and Vaca hydroelectric plants and Hydro-Maya Limited (HML), respectively. Sugarcane processing by the ASR/BSI and Santander Sugar Energy Ltd. are also producing electrical energy from biomass while wood was used by local entities to produce charcoal for consumption by households and small scale commercial and industrial entities (Tillett et al., 2012). Thirty-six-point two percent (36.2%) of energy supplied in 2017 was from the above-mentioned domestic primary energy sources (Figure 2.1).

Figure 2.2: Electricity Supply Technology in 2017

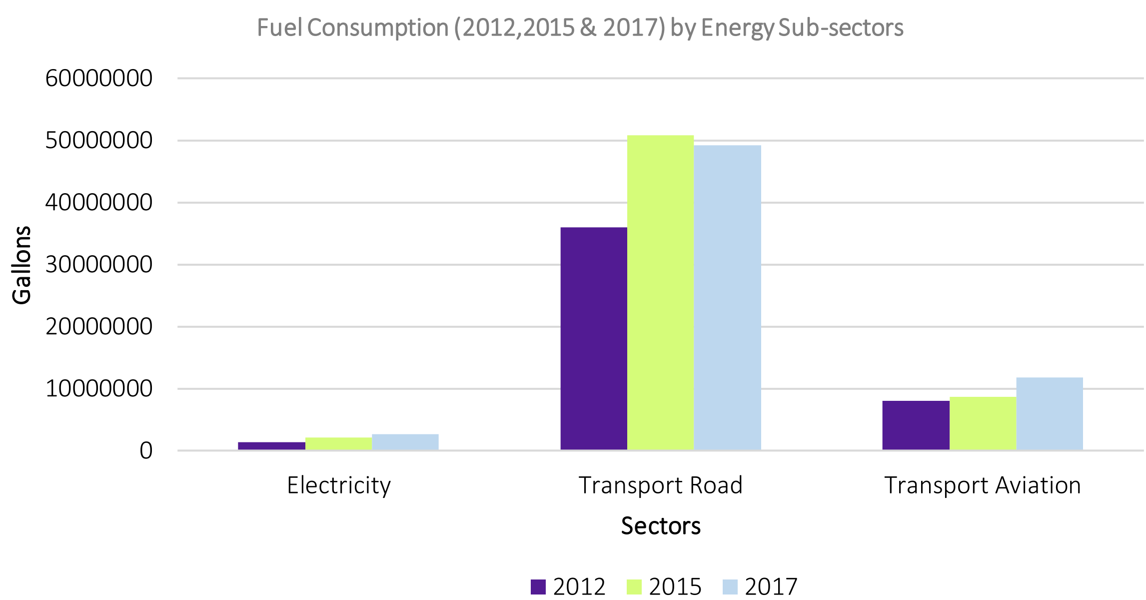


Source: Energy Report, 2017

In addition to its domestic fossil fuel sources, Belize imports a significant amount of its energy supply in the form of petroleum products and as electricity (49.83% in 2017) as compared to 56.37% in 2014. Products such as liquefied petroleum gas (LPG), gasoline, kerosene, light fuel oils and diesel oil make up 57.85% of the imports in 2017 compared to 88.52% in 2014, while electricity made up 24% (Energy Report, 2017). Most of the oil products were imported from Venezuela under the Petro-Caribe Agreement and transported to Belize via ocean tankers. However, due to the economic instability in Venezuela and the embargoes imposed by the USA, there have been delays in transactions at times. As a result, fuel has to be imported from other sources. In 2017, 36.2% of the electricity generation output was sourced from Comisión Federal de Energía in Mexico as compared to 36.82% in 2014 while 78.7% was sourced from the aforementioned local providers (ref. Figure 2.2).

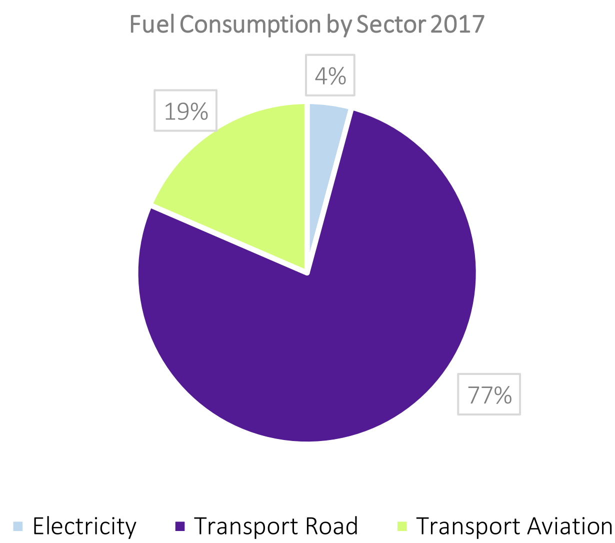
BEL used 4.19% of the total fuel imported for energy generation (ref: Figure 2.4). There was 2.1% of energy growth and the demand for electricity will continue to grow in Belize (BEL Annual Report 2017). However energy efficiency use can reduce that demand while the use of renewable energy continues to increase. The report notes that Belize is said to have unrealized sustainable energy potential worth approximately BZE $524 million which can last up to 2033, continues to apply. To make this a reality, it is envisaged that renewable sources could represent 89% of the supply, with a 24% decrease in electricity use resulting from energy efficiency. In the report, for the development of Belize's renewable energy and energy efficiency strategy, Castalia Limited (2014) recommends the increased use of methods such as the biomass, solar and hydropower and a broad range of energy efficiency methods by businesses, citizens and government agencies in order to achieve efficient and reliable energy supply for the future (Castalia, 2014) (Figure 2.5).

Figure 2.3: Fuel Consumption by Sector for Reference Years



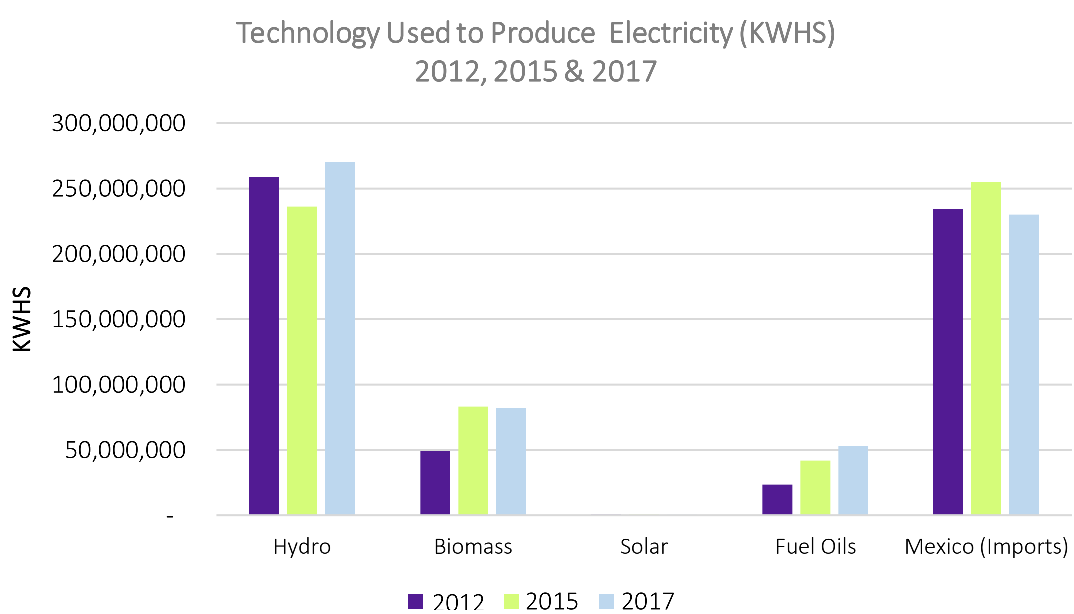
Source: PUMA Statistics 2017.

Figure 2.4: Fuel Consumption by Sector - 2017.



Source: PUMA Statistics 2017

Figure 2.5: Technology Used to Produce Electricity (KWh) 2012, 2015 & 2017



Source: Energy Report, 2017

a.2 Transport sub-sector

- Land Transport

The Belize road stock is considered to be relatively low compared to its surface area with a network consisting of 3,281 km of roads. There is low road utilization due to low population density and the dispersed nature of housing and economic activities. The rate of road fatalities (23 per 100,000 people) is one of the highest in the world and is said to result from the lack of proper traffic signs, pavement markings, limited enforcement of speed limits and lack of driver education (Martin and Manzano, 2010).

Belize's road network is made of primary, secondary and rural roads, 30% of which are paved, to connect the major urban settlements and border areas. Secondary roads make up 25% of the road network and consists almost entirely of unpaved roads with either gravel or marl surfaces. These roads link areas of agricultural production with the main market areas around the country and also provide linkage to the primary road system (18% of road network). Rural roads make up the bulk of the network (59%) and were built specifically to facilitate agriculture production activities.

Apart from private vehicles, buses and taxis transport the Belizean public at the national level. Various bus companies have daily schedules between the six districts. Large buses transport the cruise tourists arriving in Belize to visit the Mayan ruins, protected areas and other recreational areas that offer zip lining and cave tubing.

The transport sector, including aviation, is the biggest consumer of energy from petroleum products in Belize, accounting for 95.81% of total consumption in 2017 (Figure 2.4).

- Maritime Transport

Trade to and from Belize is facilitated through the Port of Belize and the Big Creek Port. The Big Creek Port usually facilitates the trade of fruits, vegetables and crude oil while all other items go through the Port of Belize. The majority of the petroleum fuel is pumped to the PUMA Belize reservoirs (located near the Port of Belize) from the anchored transport vessels.

Tour operators cater to both the overnight and cruise tourists that arrive in Belize. The tourists, who visit the Mayan sites or the other inland attractions, are transported by tenders from the cruise ships to the

Tourism Village in Belize City. About 60% of the overnight tourist visits the marine environment. The vessels used to cater to the tourism sector consume petroleum products such diesel and gasoline.

There are various water taxi operators catering to the Belizean population throughout Belize. The main routes are from Belize City to the islands of San Pedro and Caye Caulker. Daily trips also run from San Pedro to Corozal and Chetumal, Quintana Roo, Mexico.

Belize also has a fishing fleet of about 600 vessels that operate all year round. Many are wooden sailing boats ranging from 18 to 30 feet which also carry outboard engines. The remainder of the fleet is mainly fiberglass skiffs ranging from 23 to 28 feet with outboard engines. These vessels make daily or three-day trips from the mainland to the three atolls (Glovers Reef, Turneffe Islands and Lighthouse Reef) and the cayes. The fishing fleet consumes mainly regular gasoline.

- Air Transport

In terms of air travel, Belize has an international airport and a network of domestic airstrips. The Phillip S. W. Goldson International Airport (PGIA) is privately managed by the Belize Airport Concession Company Limited and is currently Belize's biggest and only international airport. Several government-owned municipal airstrips also exist in Belize City, San Pedro, Dangriga, Caye Caulker, Orange Walk, Belmopan, San Ignacio, Sarteneja, Placencia, Corozal and Punta Gorda. Only the Sir Barry Bowne Municipal Airstrip, in Belize City, meets International Civil Aviation Organization requirements for operational safety. Most of the domestic air traffic in Belize operates during day light hours. Local airlines operate small aircraft ranging from 4 to 13 seating capacity.

a. 3. "Other" sub-sector

Wood was used by local entities to produce charcoal for consumption by households and small scale commercial and industrial entities. Wood is also used as a fuel for cooking in many rural households across the country. Carbon dioxide emissions from this sub-sector continued to increase as shown in Table 2.3.

a.4. International Bunkers

International aviation includes international flights originating from countries such as Canada, El Salvador, Mexico, Panama and a number of states in the US. One or two of these airlines have flights from different origins. Much of the increase in flights has occurred between 2015 and 2017.

International marine transport also considers frequent water taxi routes connecting Belize City to Chetumal, Mexico, as well as Dangriga Town to ports in Honduras.

b. National Legislation

In 2011 Belize drafted a **National Energy Policy Framework** that was determined to be a roadmap that would put Belize on a path to energy efficiency, sustainability and resilience over the next 30 years. It provided policy recommendations to policy-makers and decision-makers, and discussed various policy instruments that could be used to achieve policy objectives.

The Goals of the *National Energy Policy Framework* include;

- fostering the sustainable production, distribution and use of energy as a critical resource needed to achieve the overarching national goals of economic growth and long-term prosperity, security, poverty reduction and social equity.
- minimizing the cost of energy in the local economy:
- mitigating the impacts of uncontrollable events such as external market price and supply shocks and natural disasters on the cost of energy and on the reliability of energy supply, and
- creation of a national energy-efficiency-focused culture that is fully aware of how its actions (or inactions) affect energy use and that is pro-active about the conservation and efficient use of energy.

This policy framework was supplemented by a **Sustainable Energy Action Plan (2014-2030)** built on five pillars; namely:

- ***Efficient Energy End-Use*** – Dramatically lower the energy intensities compared to business-as-usual in Transport, Industry, Residential and Commercial buildings, and Public buildings and Lighting,
- ***Renewable Energy*** – Shift the energy matrix from for electricity, heat, and mechanical power away from fossil fuel,

- *Upgrade Production* – upgrade production systems using the output from agriculture, forestry and the co-production of food, feed, fibre, chemicals, and fuel (including electricity and heat).
    - Solids – pellets, charcoal
    - Gases – biogas, syngas
    - Liquids – ethanol, pyrolysis, liquids, biodiesel
- *Governance* – Enhancing national capacity in clean energy and clean production
- *Infrastructure* – Universal access to affordable, modern energy services, including having a resilient grid.

c. Gases included

The profile of the Belize energy sector shows greenhouse gas emissions from sources such as: electricity generation; road, local aviation and marine transport; biomass consumption; and Others.

The gases emitted within the Energy sector include Carbon dioxide, Methane and Nitrous oxide.

d. Reporting years

Reporting years for this fourth national inventory is 2012, 2015, and 2017.

e. Recalculations

Recalculations for past inventories of the Energy sector have proven difficult since the data is unavailable; this due to incomplete activity data used for the previous estimates. In particular the fuel data needed to be separated and recorded as amounts of fuel consumed in each sub-sector such as energy generation and transport. There is no way of identifying the quantities of fuel used for each activity.

This continues to be a problem for this sector. The relevant permitting authorities may need to introduce some strategy or methodology including data format, reporting time frames, and quality control.

f. Description of methodologies and data sources

- Emission factors

Emission factors used in the calculations of emissions in the Energy sector are presented in the table below (Table 2.2).

Table 2.2: Emission Factors applied in the Energy Sector GHG inventory

Energy Sector	Fuel Type	Fuel Description	CO_2	CH_4	N_2O
Energy Generation					
	Liquid	Other Petroleum Products (Residual Fuel Oils)	77400	3	0.6
		Gas/diesel	74100	3	0.6
		Lubricants	73300	3	0.6
		Crude oil	73300	3	0.6
	Gaseous	LPG	63100	1	0.1
	Biomass	Solid biomass	100000	30	4
Transportation					
International Aviation	Liquid	Aviation fuel	70000	0.5	2
National Aviation	Liquid	Jet Kerosene	71500	0.5	2
Road Transportation	Liquid	Gas/diesel	74100	3.9	3.9
		Other Kerosene	71900	3.9	3.9
Other					
Residential	Biomass	Wood	112000	300	4

- Activity Data

Data sources include PUMA for fuel imports for transportation and energy generation. The Ministry of Public service, Energy and Public Utilities provided access to the Energy Reports (2012, 2015 and 2017). The aviation fuel data was also obtained from PUMA. Fuel usage data for 2012, 2015 and 2014 was obtained directly from one of the two local airlines.

Belize Electricity Limited also imported and utilized heavy fuel oil for electricity energy generation. The Farmers Light Plant Corporation of the Mennonite community used locally produced crude oil for non-national grid energy generation.

Data for the estimation of greenhouse emissions in this sector was derived from energy production including electricity generation using fossil fuels, and biomass. Fuel-wood combustion remains as a source of emissions as it continues to be used for cooking in homes, particularly in rural areas.

The transport sub-sector continues to be a significant source of emissions. It comprises road, sea and local air transportation. This mix of equipment is fueled by diesel and gasoline, kerosene, aviation gasoline, and with some LPG converted vehicles included. Public transport in Belize is characterized by old school buses averaging 20 to 25 years old imported from the US. Although powered by diesel engines, they obtain low mileage, while both the condition and the age contribute to GHG emissions. The taxi services are almost the same, with many of the vehicles being older and larger American vehicles with eight-cylinder engines. However, the need for the owners to generate more income is driving this sub-sector towards the use of smaller Japanese cars with smaller more efficient engines. Many of the privately-owned vehicles are also imports from the US with the larger high consumption engines.

The tourism and fishing industries have driven the development of fleets of water taxis, charter boats and fishing boats powered by gasoline and diesel engines. The numbers are such that this sub-sector adds to the emission of GHG gases in Belize. The growth of the tourism industry has also resulted in increased frequency of local flights using turbo-prop aircraft (up to 13-seat capacity) which consume kerosene fuel. It has been observed that the emissions from this category (local aviation) have now become significant when compared to the national total of emissions.

- Description of methodologies

This report seeks to fulfill the requirements of article 4, paragraph 1(a) and article 12, paragraph 1(a) of the United Nations Framework Convention on Climate Change (UNFCCC), by communicating a national inventory of anthropogenic emissions by sources and removals by sinks in Belize by the energy sector. Efforts were made to capture new sources and sinks that arose from recent developments in the country in addition to those described in the past three National Communications.

The National Climate Change Office and staff of government departments were stakeholders in the process to collect and validate activity data for the inventory. The recommendations from the peer review were shared with data collectors in order to provide additional guidance to their work.

g. Results of GHG emissions and removals

Table 2.3 presents some details of the emissions generated through activities within the Energy sector. Biomass continued to be a major contributor in the mix for energy generation in Belize. It is noted that biomass for residential consumption is also increasing as a source of CO2 emissions, indicating that the use of wood for residential energy (cooking) is increasing.[2] Continually increasing cost of kerosene and propane/butane is probably influencing the increased use of firewood for cooking.

It was observed that consumption of Petroleum fuels increased within the Transport sub-sector although the values for land and marine showed slight decreases in 2017 (Table 2.3). It further shows that CO2 emissions by residential use of biomass continue to increase.

Table 2.4 summarizes the Energy sector emissions by sub-sector and by fuel types.

Table 2.3: Summary of Energy Sector GHG Emissions by gas and sub-sectors, 2012, 2015, 2017 (Gg CO2 eq)

Sub-Sector	Fuel	2012			2015			2017		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Energy Industries										
Electricity	Liquid	14.274	0.012	0.036	25.259	0.022	0.064	31.053	0.026	0.078
	Gas	13.582	0.005	0.008	54.930	0.021	0.030	66.945	0.025	0.037
	Biomass	413.630[1]	2.606	5.129	494.040[1]	3.113	6.126	561.25[1]	3.536	6.960
Transport										
Domestic Aviation	Liquid	9.293	0.001	0.082	11.898	0.002	0.105	12.776	0.002	0.112
International Aviation[2]	Liquid	40.009	0.0003	0.001	39.869	0.0003	0.0001	71.248	0.001	0.0001
Land/Marine Transport	Liquid	480.183	0.480	7.087	663.554	0.678	10.007	648.192	0.655	9.675
Others										

[2] Wood consumption for residential use was derived from a linear correlation based on population.

Residential	Biomass	78.610[1]	4.422	0.870	88.730[1]	4.992	0.982	93.451[1]	5.257	1.035

[1] CO_2 emissions from biomass not included in national total

[2] International Aviation is a memo item, not included in national total

Table 2.4: Summary of Energy Sector CO2, CH4 & N2O Emissions by Fuel Types - 2012, 2015 and 2017 (Gg CO2 eq)

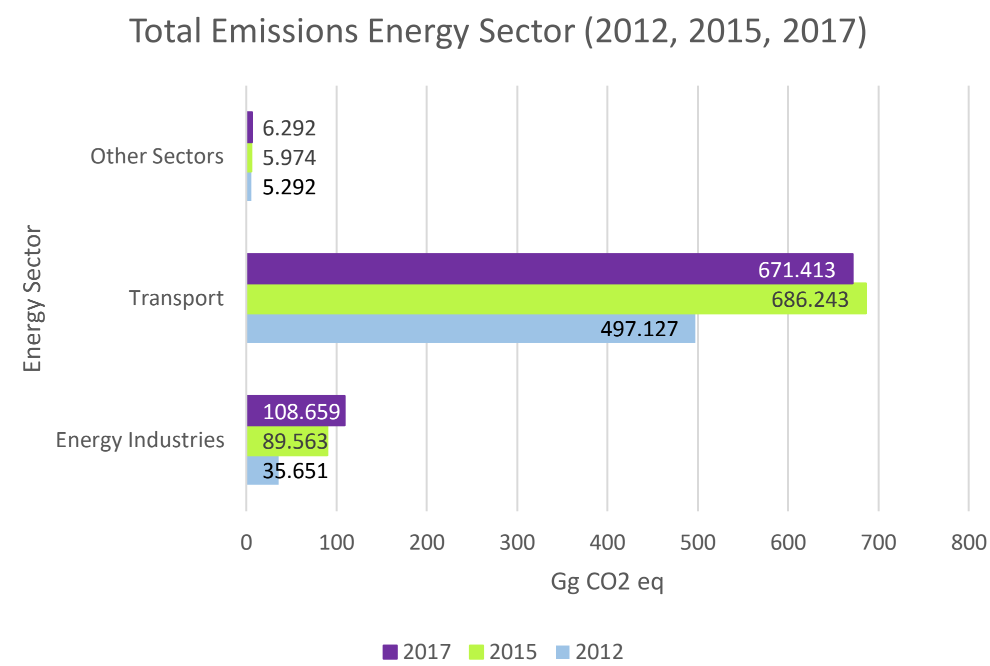
			2012			2015			2017		
Sub-Sector	Fuel Type	Fuel Name	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Energy Industries											
Electricity Generation	Liquid fuel	Heavy Oil	0.249	0.0002	0	7.850	0.0067	0.034	13.5400	0.0116	0.0341
		Crude Oil	17.008	0.0147	0.031	15.417	0.0126	0.031	17.0318	0.0147	0.0310
		Diesel	13.981	0.0120	0.034	17.356	0.0147	0.043	17.4377	0.0149	0.0434
		Lubricants	0.043	0	0	0.076	0	0	0.0650	0	0
	Gaseous fuel	LPG	13.582	0.005	0.006	54.930	0.0206	0.030	66.940	0.0250	0.0372
	Biomass	Bagasse	413.637[1]	2.606	5.131	494.04[1]	3.1125	6.126	561.23[1]	3.5358	6.9595
Transportation											
Domestic Aviation	Liquid fuel	Aviation fuel	9.293	0.0014	0.082	11.898	0.0018	0.105	12.7762	0.0019	0.1108
Road/Marine Transport	Liquid fuel	Gas/Diesel	434.340	0.480	6.820	613.330	0.6720	9.920	592.990	0.6554	9.6720
		Kerosene	45.830	0	0	50.210	0	0	55.19	0	0
Other											
Residential	Biomass	Bagasse	78.610[1]	4.422	0.870	88.730[1]	4.9916	0.982	93.450[1]	2.257	1.035
International Bunkers[2]											
International Aviation	Liquid fuel	Aviation fuel	40.009	0.0003	0.001	39.869	0.0003	0.0001	71.248	0.0005	0.0001

[1] CO_2 emissions from biomass not included in national total

[2] International Bunkers is a memo item, not included in national total

Examination of Figure 2.6:Total Emissions for all Energy Sub-Sectors (Gg CO2 eq)Figure 2.6 demonstrates that the Transport sub-sector was the most significant source of GHG emissions during this study period. Throughout the study period, emissions from the Transport and Energy generation sub-sector have taken a steady increase, highlighting the increasing energy demand, as well as increased vehicle use. The emissions due biomass use for “Other”, residential cook stoves, is significantly less than other energy uses, and indicates a steady trend throughout the study period.

Figure 2.6:Total Emissions for all Energy Sub-Sectors (Gg CO2 eq)



g.1 Emissions from Energy Generation

The primary sources of emissions for the production of energy in Belize are petroleum products and biomass. Table 2.6 below shows the various fuel types utilized in Belize during the reference years 2012, 2015 and 2017. Figure 2.7 below shows emissions all increasing steadily from 2012 to 2017. Such increases in emissions are expected as the country continues to develop, and there is increasing demand for electricity supply. Belize also continues to apply a mix of technologies to try to meet that demand.

Table 2.5 below is a summary of the fuels utilized (converted to Gigagrams although reported in gallons and metric tons) for energy generation in the reference years.

Table 2.5: Fuel types used for Energy generation (Gg)

Energy Source	2012	2015	2017
Type	Gg	Gg	Gg

Electricity Generation	Residual Fuel Oil	0.0847	2.6649	4.5983
	Crude Oil	5.4855	4.9723	5.4931
	Diesel	4.3879	5.4472	5.4727
	Lubricants	0.0147	0.0261	0.0223
Data source: PUMA, MPSE&PU, NCCO	LPG	5.0437	20.3988	24.8611
	Bagasse (MT)	356.584	425.905	483.823

Figure 2.7 presents the total emissions for the Energy Industries sub-sector for the study period. Figure 2.8 demonstrates the disaggregated emissions (CO2 emissions Non-CO2 emissions -Methane, and Nitrous oxide emissions), and

Figure 2.9 the emissions associated with fuel type.

Figure 2.7: Total Emissions - Electricity Generation for 2012, 2015 and 2017 (Gg CO2eq)

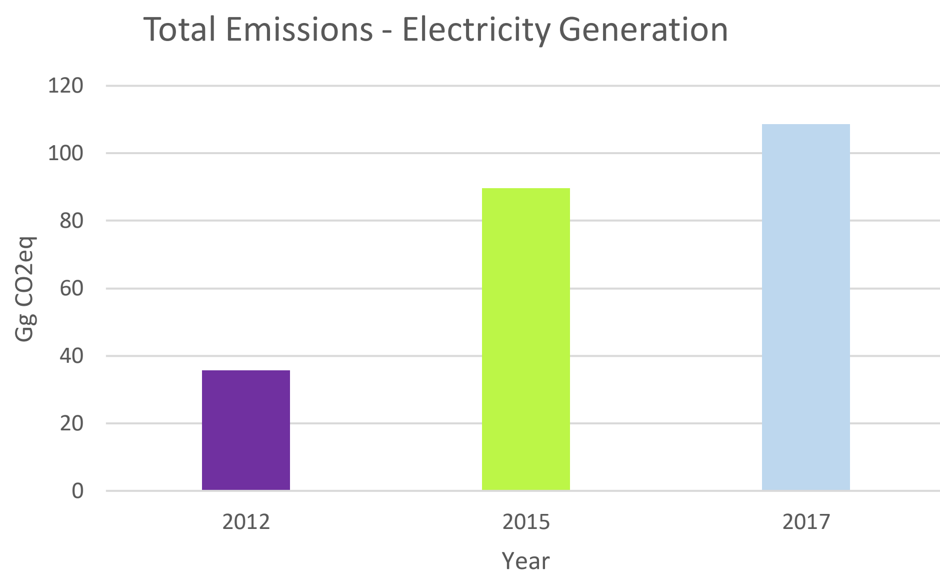


Figure 2.8: Emissions by Gas - Electricity Generation for 2012, 2015, and 2017 (Gg CO2eq)

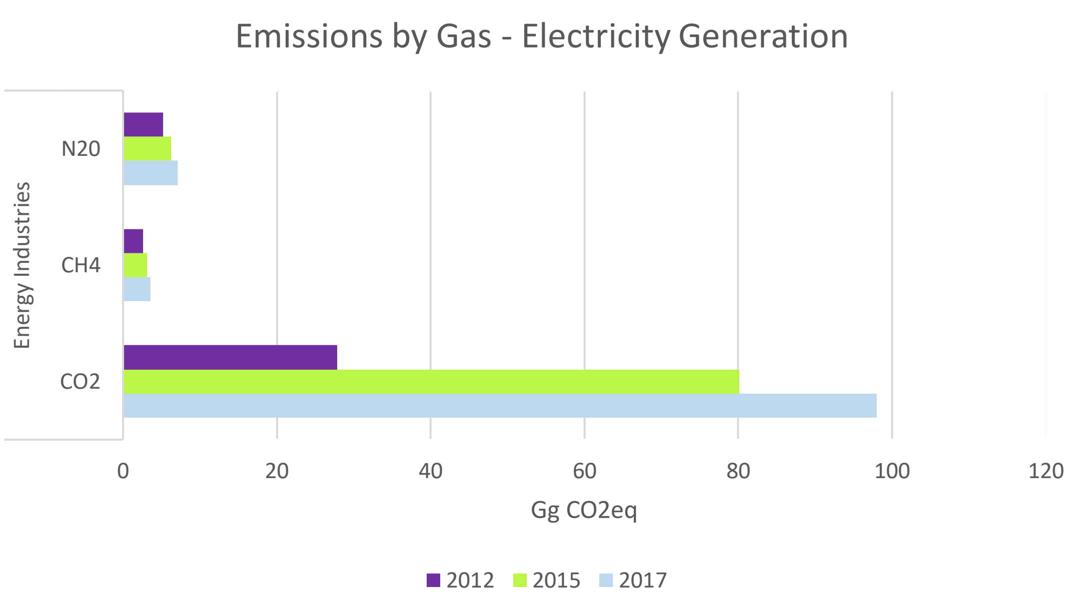
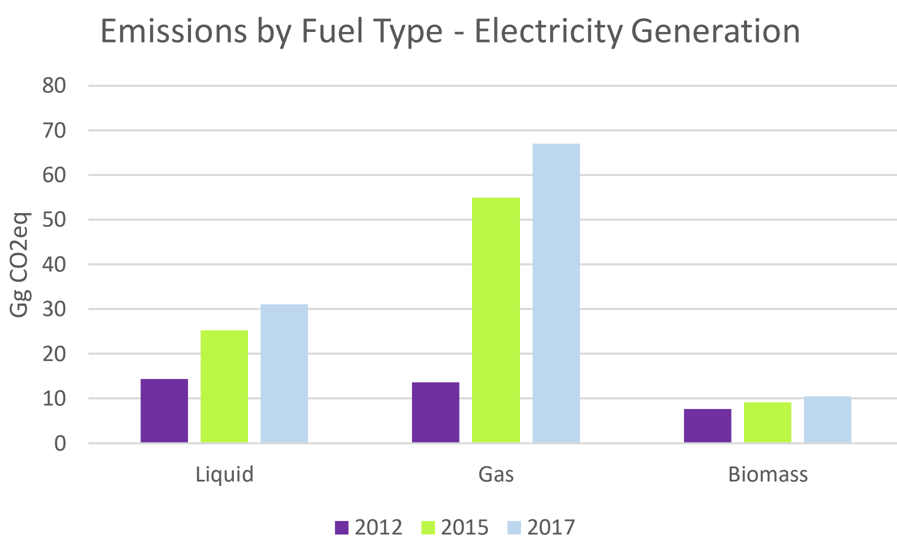


Figure 2.9: Emissions by Fuel Type - Electricity Generation for 2012, 2015, and 2017 (Gg CO2eq)



g.2 Emissions from Transport

The primary sources of emissions in the transport sub-sector are the petroleum products such as gasoline (premium & regular), diesel, kerosene and aviation fuel. In Table 2.6 these products are presented as sources GHG emissions in the transportation sub-sector. The fuel uses are separated between land and air transportation.

Figure 2.10 shows an increase in total emissions in the Transport sub-sector from 2012 to 2015 but with a slight decrease in 2017. The same pattern is shown in Figure 2.11 for CH_4 N_2O emissions.

Table 2.6: Transport Sub-Sector Emissions, 2012, 2015, 2017 (Gg CO2eq)

Transportation	Type	2012	2015	2017
		Gg CO2eq	Gg CO2eq	Gg CO2eq
Land/Marine Transportation	All fuel oils	487.47	674.13	658.51

Figure 2.10: Total Emissions in Transport sub-sector for 2012, 2015 & 2017 (Gg CO2eq)

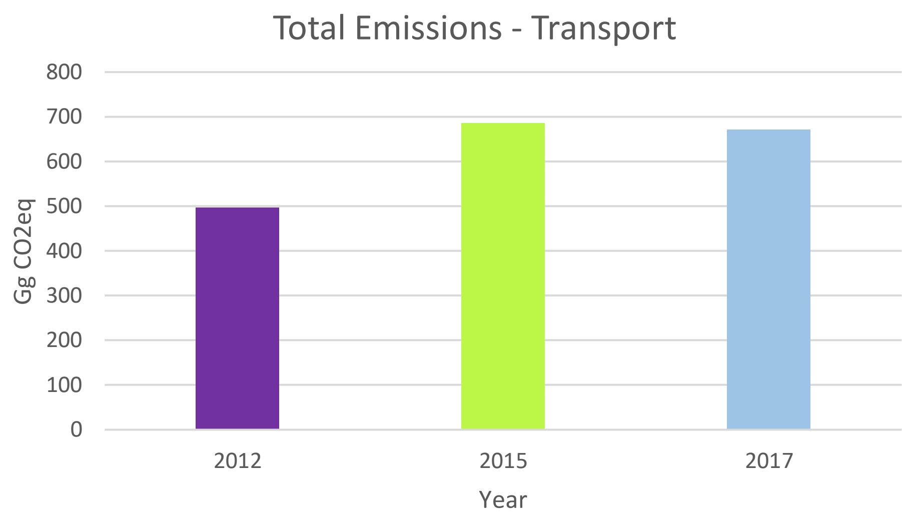
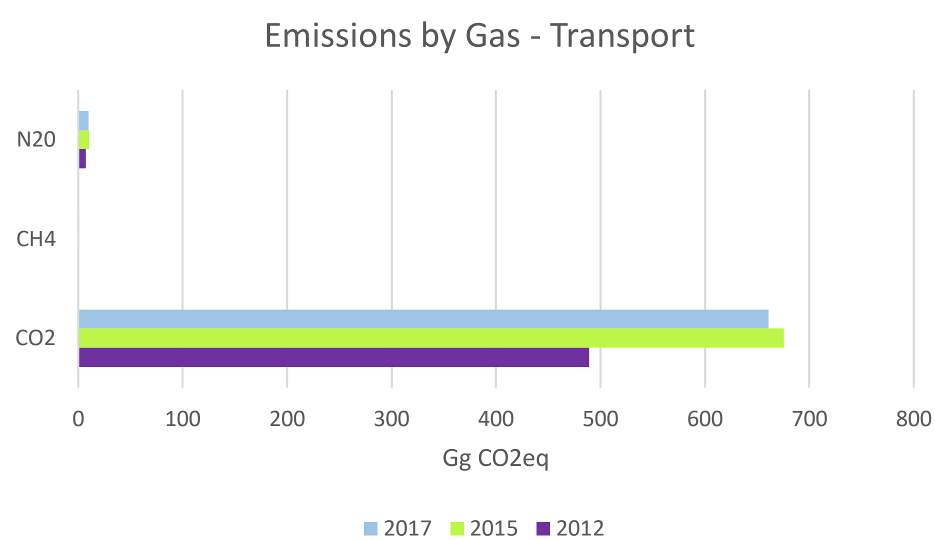


Figure 2.11: Emissions by Gas– Transport for 2012, 2015, and 2017 (Gg CO2eq)



g.3 Emissions for "Other" sub-sector

Table 2.7 lists the sources of emissions within the "Other sub-sector" under Energy generation, which is primarily biomass/wood for residential uses. Overall emissions show a gradual increase from 2012 to 2017 (Figure 2.12). The difference in the levels of Nitrous oxide and methane generated respectively, were very small, although demonstrating a slight increase across the reference years (Figure 2.13).

Table 2.7: "Other" sub-sector Emission Sources

Other sub-sector	2012	2015	2017
Source	Metric Tons		
Biomass	46.9947	50.7894	53.4879

Greenhouse gas emissions by gas produced in the "Other' sub-sector is presented in Figure 2.13 below.

Figure 2.12: Total Emissions in Other sub-sector (Residential) for 2012, 2015 & 2017 (Gg CO2eq)

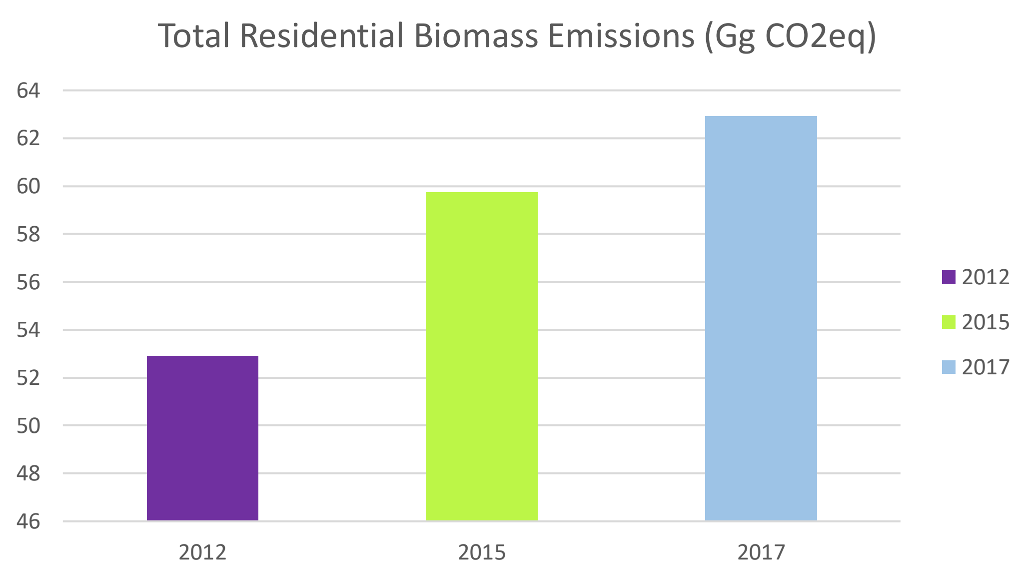
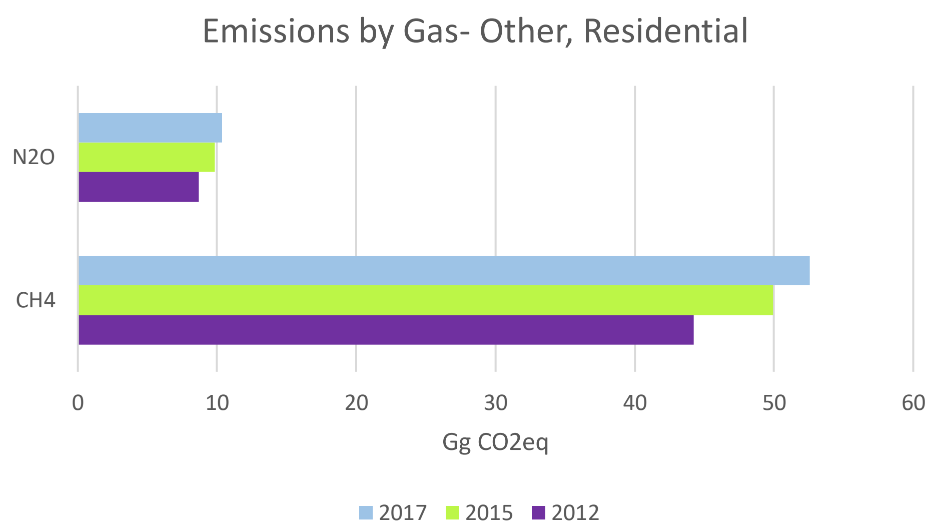


Figure 2.13: Emissions by Gas– Other, Residential for 2012, 2015, and 2017 (Gg CO2eq)



No secondary sources of emissions were identified from the Energy sub-sectors.

g.4 Emissions from International Bunkers

Much of the increase in flights has occurred between 2015 and 2017. Their impact is reflected in the increase in emissions from aviation fuel especially in 2017. Figure 2.14 shows overall emissions by international bunkers. CH_4 and N2O emissions in comparison to primary CO2 emissions were not significant throughout the study period (Figure 2.15). These emissions are not attributed to Belize. As could be expected with increased air and ocean traffic, emissions from international bunkers would increase because of the increased volumes of fuel stored for such purposes.

Figure 2.14: Total Emissions, International Bunkers for 2012, 2015 & 2017 (Gg CO2eq)

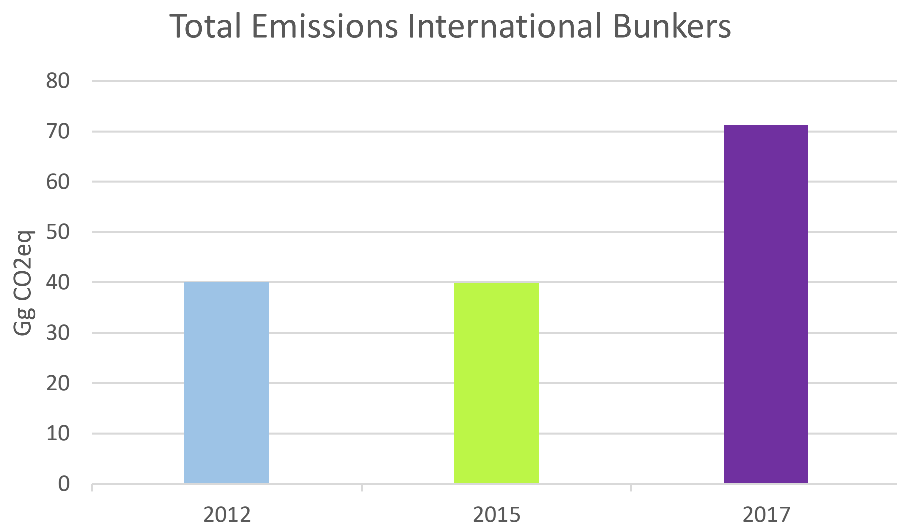
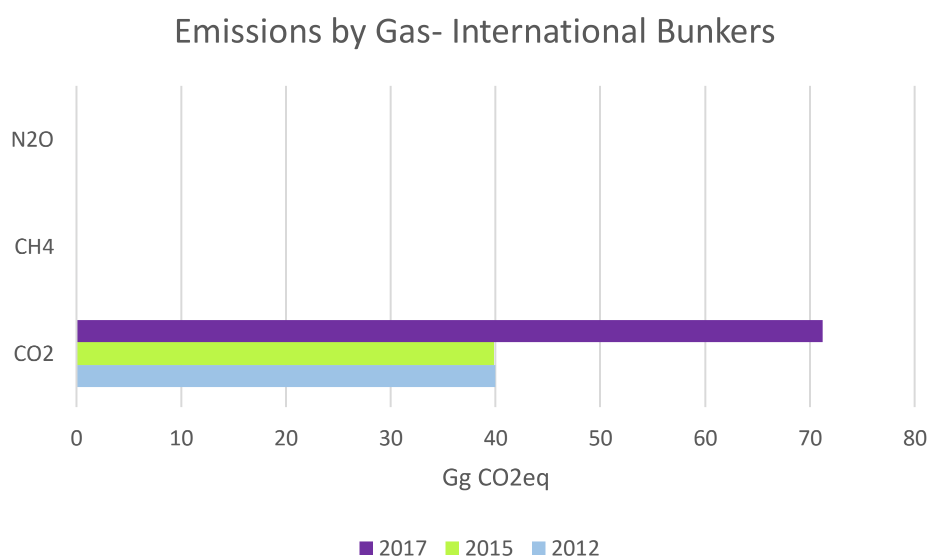


Figure 2.15: Emissions by Gas– International Bunkers for 2012, 2015, and 2017 (Gg CO2eq)



h. Analysis of Results

Petroleum fuels imports increased since 2012. The electricity generation sub-sector saw a slight increase in the use of petroleum fuels. The usage of renewable resources along with the importation of electricity from Mexico mitigated greater greenhouse gases emissions for electricity generation. The largest increase of petroleum fuel usage for the same study period was in the transport sub-sector which increased the greenhouse gases emissions between 2012 and 2015. The increase in petroleum fuel usage was for land, maritime and air transportation. However, there was a decrease in petroleum products usage and emissions for the transport sub-sector in 2017. The fuel usage for national aviation has now become significant compared to the last national report which categorized it as insignificant. There was a large increase in aviation fuel which was used by international flights arriving in Belize. The greenhouse emissions for international aviation were reported under the caption of international bunkers and not accounted in national total.

Biomass usage for industrial and domestic energy production continued to increase as an alternate to petroleum products. Biomass is primarily used in the generation of energy by utilizing sugarcane bagasse from the sugar industry. There was an increase for the past two years especially with the addition of Santander Sugar Energy Ltd. producing electricity for the national grid. The increase of biomass use also increased the greenhouse gases emissions. However, the sugarcane plants that are used as biomass capture nearly the equivalent amount of CO_2 through photosynthesis which contributes to removal of CO_2 generated from the combustion of this biomass. For his reason, CO_2 emissions from biomass combustion are not included in national total, however non-CO_2 emissions are.

2.3 Industrial Processes and other Product Use Sectors

a. Sector Background

Industrialization is Belize advancing at a slow pace being somewhat limited by energy and labour costs. Activities which release greenhouse gas emissions within the Industrial Processes and other Product Use Sectors occur within a narrow range. There are very few of the sub-sectors displaying any reasonable level of activity to be estimated, these being lime production and road paving with asphalt in the Mineral Products sub-sector; and the production of beer, wine, and spirits, production of meat, fish, poultry, production of bread, and production of animal feed in the Food and Drink production sub-sector.

Activities within this sector resulting in GHG emissions include industrial processes such as fermentation, lime-kiln and dolomite operations and road paving with asphalt. The fermentation processes, commonly used in the production of bread and alcoholic beverage; and road paving, produce Non-methane Volatile Organic Compounds (NMVOC). Limekilns produce quantities of CO_2 as the rocks are burned and converted to calcium oxide. Liming applications, for citrus and sugarcane, using crushed calcite or dolomitic limestone do not produce measureable emissions when applied by spreading. Emissions in the industrial process and product use sectors remained negligible throughout the period under review despite the increases in sugar production.

Also accounted for in the IPPU sector are GHG emissions used in products such as refrigerators, foams and aerosols. The estimation of GHG emissions from non-energy sources is often difficult, because they are widespread and diverse. The difficulties in the allocation of GHG emissions between fuel combustion and industrial processes arise when by-product fuels or waste gases are transferred from the manufacturing site and combusted elsewhere in different activities.

a.1 Lime Production

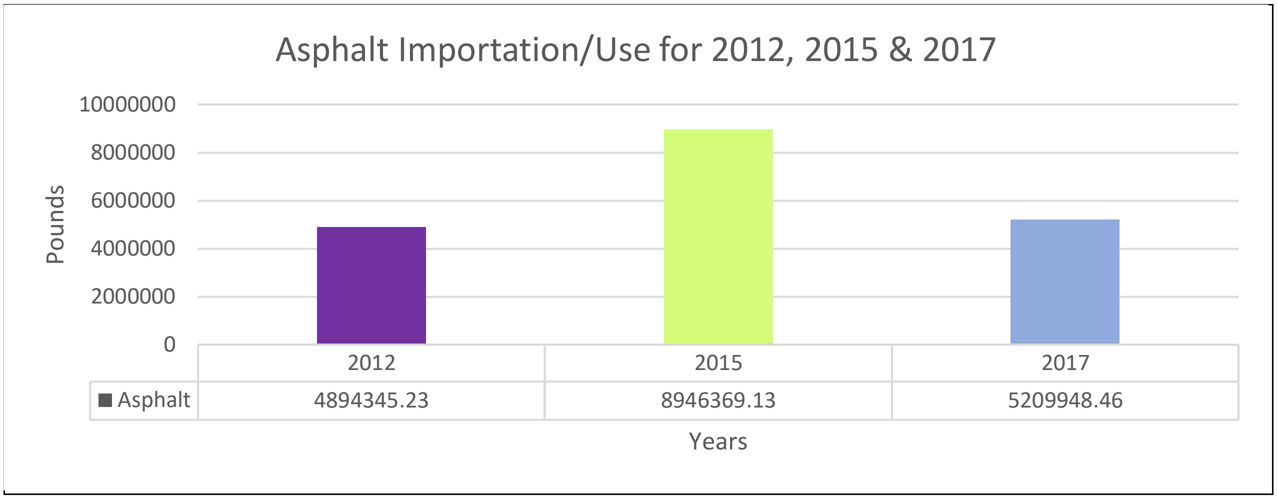
This is one of the main sources of CO_2 emission in this sector, of which there are two types of lime that are produced in Belize. These are white lime (calcium oxide) and dolomite lime (calcium magnesium carbonate). Calcium oxide production is found primarily along the Hummingbird Highway within the Cayo District. The major users of burnt or quick lime (CaO) are the shrimp industry, citrus industry, sugar production, and more recently the coconut industry. There is a recent surge in coconut plantations. In the latter two, it is used to alter the soil pH. Consumption of this product fluctuated during the study period, partly as a result of what was happening in the shrimp industry. The shrimp industry has been plagued by diseases, and competition from production in other parts of the world, affecting the local demand for the lime treatment of the ponds.

The production of dolomite lime, for local use and export, takes place primarily in the Toledo District. Dolomite lime is applied to farmlands to raise the pH levels in acidic soils and is a quality source of calcium and magnesium. In Belize, it is used primarily in citrus, banana, cacao, vegetable and coconut farms, as well as within shrimp ponds. A significant quantity is used in the sugar industry during juice clarification.

a.2 Asphalt – Road Paving

Asphalt was imported (Figure 2.16) and used in Belize for repairing old roads and surfacing new roads. Since only 30% of the primary roads are surfaced, there is the continual need for improvement. Asphalt usage varies from year to year especially when repair, new road surfacing or building projects are implemented.

Figure 2.16: Asphalt Importation and Use for 2012, 2015 and 2016



a.3 Refrigerants

Data on refrigerants was obtained from the Department of the Environment (DOE). The data for 2017 was extrapolated in order to separate the stationary and mobile amounts from the aggregated totals. Table 2.8 shows the gas composition by percentages for the various refrigerants. Various gases were not supported by the software and as a result they were not enclosed in the analysis. The IPCC software allowed input data for only one (1) gas, Refrigerant - 134a (R-134a) (CH2FCF3); therefore, the emission calculation reported is only for this gas. This was the only gas for which the date (1994) marking its initial use in the country was recorded.

Table 2.8: Refrigerants Compositions

Refrigerants	Composition	Gases	Percentage
R-134a		CH2FCF3	100%
R-404a	HFC-125	CHF2CF3	4%
	HF-143a	CH3CF3	44%
	HFC-134a	CH2FCF3	52%
R-407c	HFC-32	CF3CHF2	23%
	HFC-125	C2HF5	25%
	HFC-143a	CH2FCF3	52%
R-410a	R-32	CH2F2	50%
	R-125	CHF2CF3	50%
R-507a	R-143a	CH2FCF3	50%
	R-125	C2HF5	50%
R-290	HC-290	C3H8	100%
R-600a	HC-600a	HC(CH3)3	100%
R-717		NH3	100%

a.4 Other

Previous inventories had required that alcohol, beverage, and bread production be reported separately. These activities are now grouped under one sub-sector. There were three distilleries and one brewery, for alcohol and beverage production, which were in operation throughout the study period. These are listed in

Table 2.9 below. The Customs Department, which is the source of the data, makes regular monitoring inspections of these facilities. During these inspections the amount of liquor produced is measured and tapped off. The holding tank is closed, and a Customs Department seal placed on it. This seal should be in place for the next inspection.

Some effort was made to assess the impact of alcohol and beverage production on GHG emissions in Belize.

Table 2.9: Distilleries and Breweries in operation in Belize

COMPANY	ACTIVITY	BASE MATERIAL	LOCATION
Cuello's	Distillery	Sugar molasses	Orange Walk Town
L and R Distillery	Distillery	Sugar Molasses	Orange Walk Town
Traveller's Liquors	Distillery	Sugar Molasses	Belmopan, Belize City
Belikin Brewing Co.	Brewery	Hops	Ladyville

a.5 Summary of Activities within the Industrial Processes and Product Use Sector in Belize

Table 2.10: Activities within the Industrial Processes and Product Use Sector in Belize

Greenhouse Gas Source Categories in the IPPU Sector	Status
A. Mineral Products	
1. Cement Production	Not occurring
2. Lime Production	Present
3. Limestone and Dolomite Use	present
6. Road Paving with Asphalt	Present
B. Chemical Industry	Not occurring
C. Metal Production	Not occurring
D. Other Production	
1. Food and Drink	
production of beer, wine, spirits	Present
production of meat, fish, poultry	Present
production of bread	Present
production of animal feed	Present
E. Consumption of Halocarbons and Sulphur Hexafluoride	Not present
1. Refrigeration and Air Conditioning Equipment	Present

b. National Legislation

A few pieces of legislation relevant to the Industrial sector in Belize include the following:

- The Environmental Protection Act of 1992
- Refrigeration Technicians (Licensing) Act, 2010
- Environmental Protection Act, Amendment 2009
- The Environmental Protection (Effluent Limitations) Regulations, 1996.

The ***Environmental Protection Act*** established the Department of the Environment (DOE), and entrusted it the responsibility to monitor the implementation of the Act and subsequent Regulations and to take necessary action to enforce the provisions of the Act and Regulations. The enabling legislation provides the Government with comprehensive environmental protection authority it needs in order to address modern environmental pollution problems. The Act grants the Department of the Environment broad regulatory and enforcement authority for the prevention and control of environmental pollution, conservation and management of natural resources, and environmental impact assessment. The Environmental Protection Act entrusted the Department of the Environment with a broad range of functions relating to the protection of the environment, including the assessment of water pollution, the coordination of activities relating to the discharge of wastes, the licensing of activities that may cause water pollution, the registration of sources of pollution and the carrying out of research and investigations as to the causes, nature and extent of water pollution, and the necessary prevention and control measures.

In April 2009, the Environmental Protection Act was amended primarily to provide for greater environmental control and management of the petroleum industry, to make improved provisions for the protection of the Belize Barrier Reef System, to establish an environmental management fund, to provide for out-of-court settlement in appropriate cases, and to provide for the issue of violation tickets for pollution offences.

The ***Effluent Limitations Regulations*** came into force in 1996, and were intended to control and monitor discharges of effluent into any inland waters or the marine environment of Belize. These Regulations prohibited the discharges of effluent from new and altered point sources. The Effluent Limitations Regulations established a licensing system for discharging effluents under specific conditions. The main objective of this licensing system was to have industries improve in their treatment of effluent before discharging into the environment. The Effluent Limitations Regulations also established the requirement for the treatment of effluent, as well as limitations or standards for physical and chemical parameters to be monitored for various industries.

In August 2009, the Effluent Limitations Regulations were amended to primarily include provisions for the treatment of domestic wastewater and the categorization of Class I and II Waters that differentiate waters with unique ecological characteristics that are sensitive to impacts of domestic wastewater. This amendment also made improvements for effluent standards for both industrial and domestic effluent.

The ***Pollution Regulations*** have provided the enabling environment to develop mechanisms to monitor and control air, noise, water, and land pollution. These Regulations established the prohibition of releases into the environment of contaminants, unless done so with a permit issued by the Department of the Environment and at acceptable levels of contaminants from certain installations. The Pollution

Regulations also establish the prohibition of industries operating and emitting contaminants into the environment, without a permit from the DOE.

In June 2002, the Pollution Regulations were amended to include, among other things, issues related to the commitments made under the Montreal Protocol on Ozone Depleting Substances. The major changes made were the prohibition on the imports of equipment using ozone depleting substances and the establishment of a licensing system for the importation of these substances. Again, in August 2009, the Pollution Regulations were amended basically to allow Belize to strengthen a requirement of the Montreal Protocol related to the licensing system for the importation of refrigerants into the country for data gathering purposes only. This amendment also complements the Act in addressing the petroleum industry, including refining.

The ***Refrigeration Technicians (Licensing) Act of 2010*** provides for the registration and licensing of refrigeration and air conditioning technicians operating in Belize.

c. Gases included

Greenhouse Gases included in the estimate of emissions for the IPPU sector included Carbon dioxide, Methane, Nitrous Oxide, and Hydrofluorocarbons. Emissions of Non-methane volatile organic compounds were also considered.

d. Reporting years

The reporting years for the IPPU sector were the same as the rest of the fourth national inventory, 2012, 2015, and 2017.

e. Recalculations

It should be noted that the data on consumption of refrigerants for 2017 was not segregated by type (composition or formula) or use. The recorded (available) data does not separate mobile refrigerants from the rest such as domestic, commercial or industrial. The state of the data was determined to be incompatible with the 2006 software inputs and would be incomplete, therefore calculations for this year varied slightly.

f. Description of methodologies and data sources

- Emission factors

The emission factors applied for the calculations in the IPPU sector are presented in the table below.

Table 2.11: Emission Factors for the IPPU Sector

IPPU Sector	Activity Type	Description	CO_2	CH_4	N_2O
Mineral Industry	Lime production	Dolomite	0.77	n/a	n/a
		Lime	0.75	n/a	n/a
Non-energy products from petroleum	Lubricant use		0.2	n/a	n/a
	Asphalt		0.00001	n/a	n/a
Product uses as substitutes for ODS	ODS use	Stationary refrigeration	CO_2 equivalent CF= 15		
		Mobile refrigeration	CO_2 equivalent CF= 15		
Other	Food & Beverage Industry	Wheat	0	n/a	n/a

- Activity Data

Data were obtained from sources including government agencies and directly from producer organizations and/or private companies. Data on refrigerants was obtained from the Department of the Environment (DOE). Lime production data was obtained from the kiln owners. Alcohol production and asphalt import data was obtained from the Customs Department.

Activity data for Lime Production: Lime production data was obtained from the kiln owners who are the main producers for commercial use.

The Figures below (Figure 2.17, Figure 2.18) show the production of white lime and dolomite between 2012 and 2017.

Figure 2.17: White Lime (Calcium Carbonate) Production

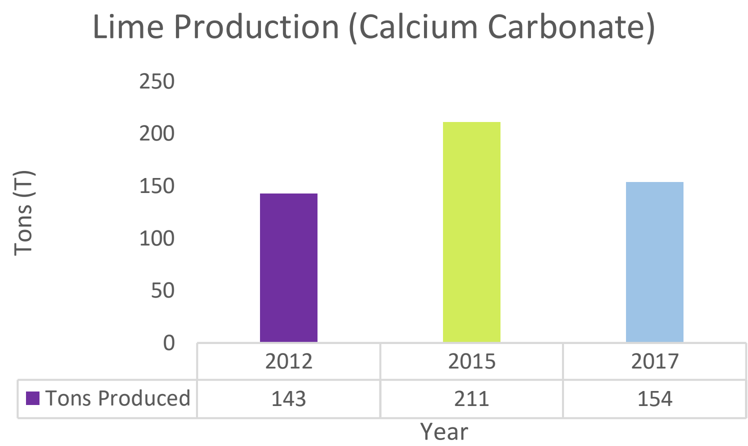
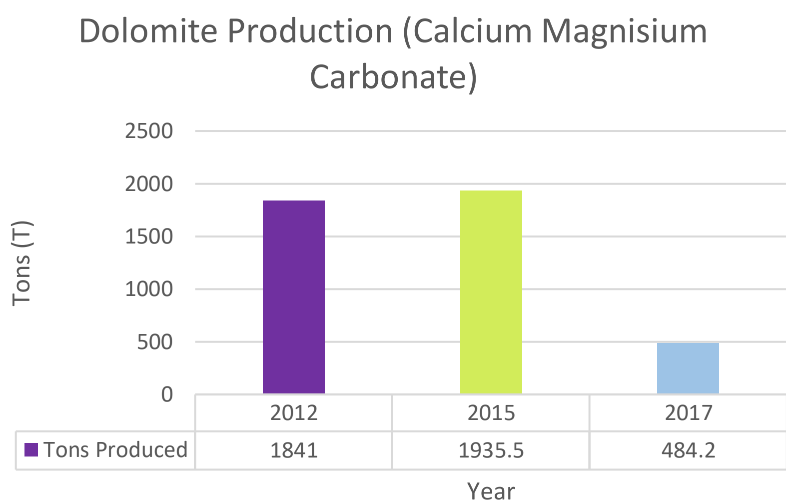


Figure 2.18: Dolomite (Calcium Magnesium Carbonate) Production



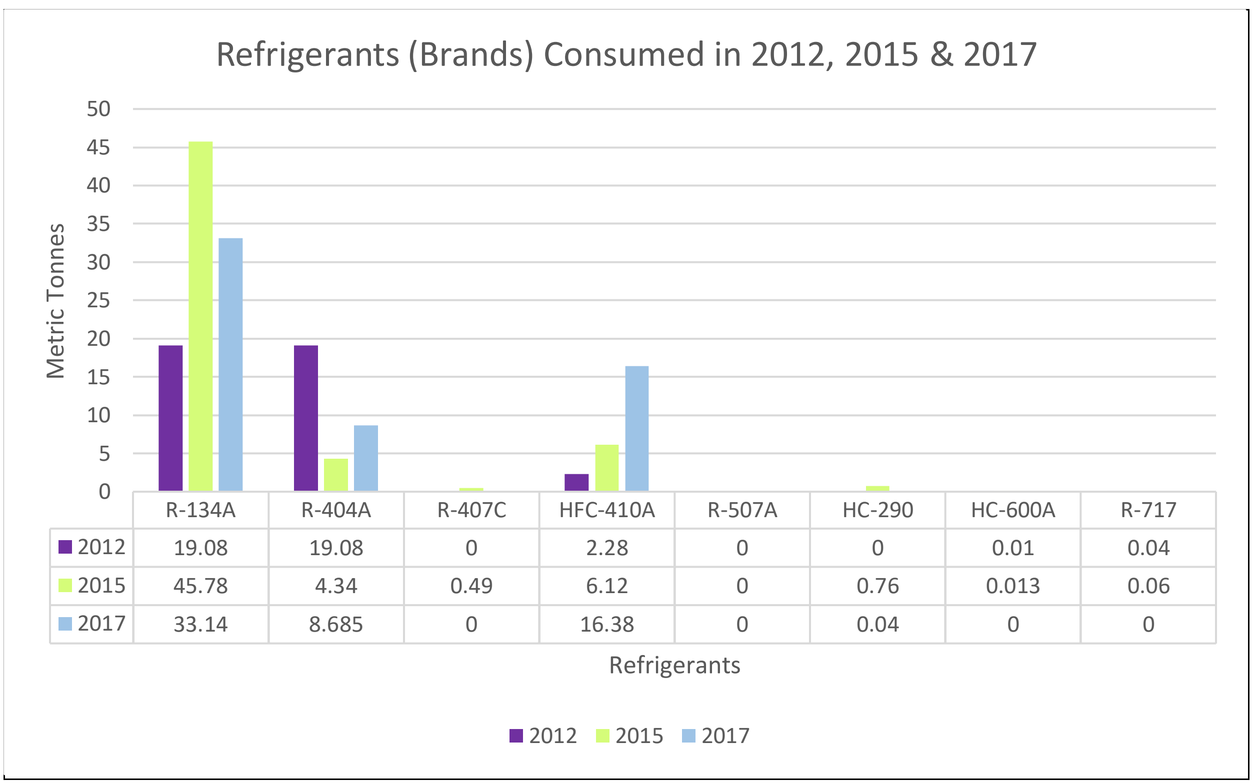
Activity data for Asphalt – Road Paving: Data on asphalt was obtained from the Ministry of Finance with the intervention of the National Climate Change Office.

Activity data for Refrigerants: Data on refrigerants were obtained from the Department of the Environment (DOE) and the Statistical Institute of Belize (SIB). However, detailed data was only available for years 2012 and 2015.

The data on consumption of refrigerants for 2017, as obtained from the DOE was not segregated by type (composition or formula) or use. The recorded (available) data does not separate mobile refrigerants from the rest such as domestic, commercial or industrial.

Refrigerants are widely used in two situations, mobile and stationary. Mobile refrigerant use would be for air-conditioning in vehicles (maybe some boats), while stationary applications include residential, commercial, industrial and public buildings. Various gases (formulas) were not supported by the software and as a result they were not enclosed in the analysis. The program utilized, allowed input data for only one (1) gas, Refrigerant - 134a (R-134a) (CH_2FCF_3), therefore the emissions calculation reported is only for this gas. Figure 2.19 shows all refrigerants consumed for the study period.

Figure 2.19: Refrigerants Consumed in 2012, 2015, and 2017 (MT)



	R-134A	R-404A	R-407C	HFC-410A	R-507A	HC-290	HC-600A	R-717
2012	19.08	19.08	0	2.28	0	0	0.01	0.04
2015	45.78	4.34	0.49	6.12	0	0.76	0.013	0.06
2017	33.14	8.685	0	16.38	0	0.04	0	0

Activity data for "Other": Bread production in Belize is divided into production by bakeries and home production, but this level of data in unavailable. Due to their methods of operation, bakery data is difficult to obtain, and when obtained are often unreliable. Therefore, an assumption is being made that bakeries rely on baker's flour only for use in making bread. Most bakeries continue to report that only a small amount of all-purpose flour is used in the production of bread. It is estimated that 1.2 loaves of bread is produced for every pound of flour. The data reported is therefore based on baker's flour sold rather than data from individual bakeries which would appear to be less reliable.

The reported values for alcohol and beverage production were not released by the SIB due to trade security concerns for the companies involved (limited sector). In order to derive the final values, the Annual Production Index (API) was used. The API was calculated by the SIB after obtaining information from the various sectors. The API provides a good indication of the production activity in the various sectors. A default value of 14 was used for spirits instead of 15. This is the default value being used in Mexico and is based on the use of molasses, as this is the same feedstock as in the Belizean situation.

- Description of methodologies

Tier 1 level of calculations was used to determine the amount of emissions in this sector.

g. Results of GHG emissions and removals

The Fourth National Greenhouse Gas Inventory shows that emissions from the industrial sector continue to be released from the same sources as those for the previous inventories. Indications are that industrial activities continue to increase slowly as Belize's economic development progresses.

Error! Reference source not found. summarizes the emissions from the activity areas for the reference y ears under study. The results obtained for the study period indicated that overall emissions from the IPPU sector have shown slow increase between 2012 and 2015, and remained relatively consistent between 2015 and 2017.]

The current inventory results show that only two areas are significant sources of GHGs in the IPPU sector in Belize. These are product uses as substitutes for ozone depleting substances, and mineral production. Mineral production includes lime production and use of asphalt for paving. Emissions from food and drink processing include the production of liquor, bread, processed meats, sugar and animal feeds. Based on the available data, the software revealed negligible levels of emissions. Similar results of negligible emissions (in some cases displaying as “zero” through software calculation) were obtained from the estimations of emissions from bread production.

Table 2.12: Summary of GHG Emissions from Industrial Processes & Product Use Sectors –2012, 2015, 2017 (Gg CO2eq)

CATEGORY	Sub Category	GHG Produced	2012 (Gg)	2015 (Gg)	2017 (Gg)
Mineral Industry	Lime and dolomite production	CO2	1.525	1.649	0.488
Non-energy Products from Fuel	Road paving with asphalt	CO2	3.75E-12	9.29E-08	9.16E-08
Product Uses as Substitutes for Ozone Depleting Substances	Refrigerant Use CH2FCF3 (Mobile and Stationary)	HFC (CO2eq)	29.904	40.855	43.199
Others – Food and beverages	Use of wheat	CO2	0	1.12E-06	6.52E-07
TOTAL		All gases (Gg CO2eq)	31.43	42.50	43.69

The fourth greenhouse gases inventory shows that emissions from the IPPU sector continue to be released from the same sources as those for the previous inventories. The main gas released from this sector in any appreciable quantity was carbon dioxide; with the results of the calculations showing a net decrease in CO_2 emissions by the end of the study period. Total Emissions of the gas (carbon dioxide) increased slightly between 2012 and 2015, and then declined between 2015 and 2017.

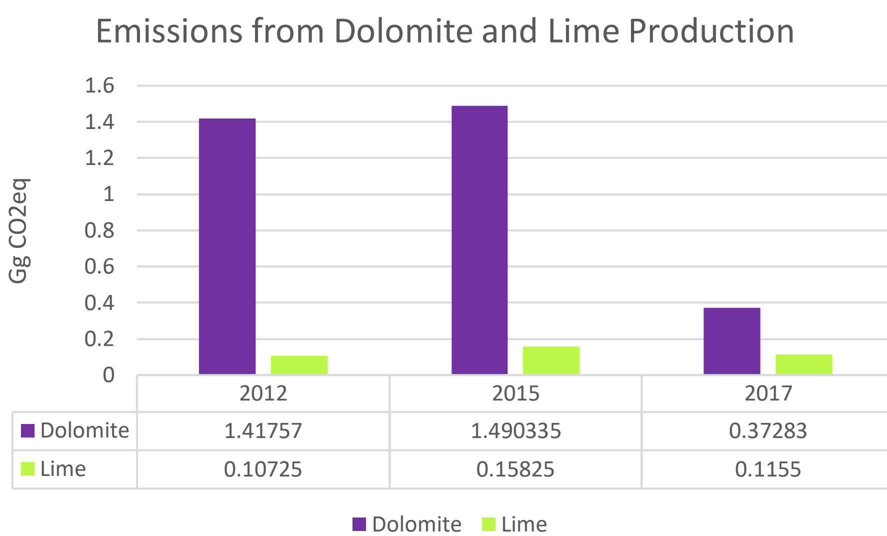
Emissions from the road paving sub-sector increased between 2012 and 2015, but decreased between 2015 and 2017. This trend suggests that road paving activities increased considerably between 2012 and 2015, but marginally declined between 2015 and 2017. Emissions from refrigerants also showed an increase between 2012 and 2015. CO2 Emissions from lime and dolomite production increased slightly between 2012 and 2015, then declined between 2015 and 2017.

Emissions from Lime Production :

Figure 2.20 below shows the estimates of the level of emissions from Lime and Dolomite production for the reference years under study. The results obtained for the study period indicated that CO_2 emissions from lime production increased by 30% during the period 2012 to 2015. However, in 2015 this sector saw a decline returning to 2012 levels.

This latter decline in the emissions is likely due to the decreased consumption/production of the lime brought by lower demand in the shrimp and citrus industries. The shrimp industry in Belize, like a number of other nations, has recently been negatively impacted by diseases resulting in closure of some of the ponds. The citrus industry has been affected by the disease citrus greening, resulting in rehabilitation of some of the orchards, as a result requiring lower applications of lime.

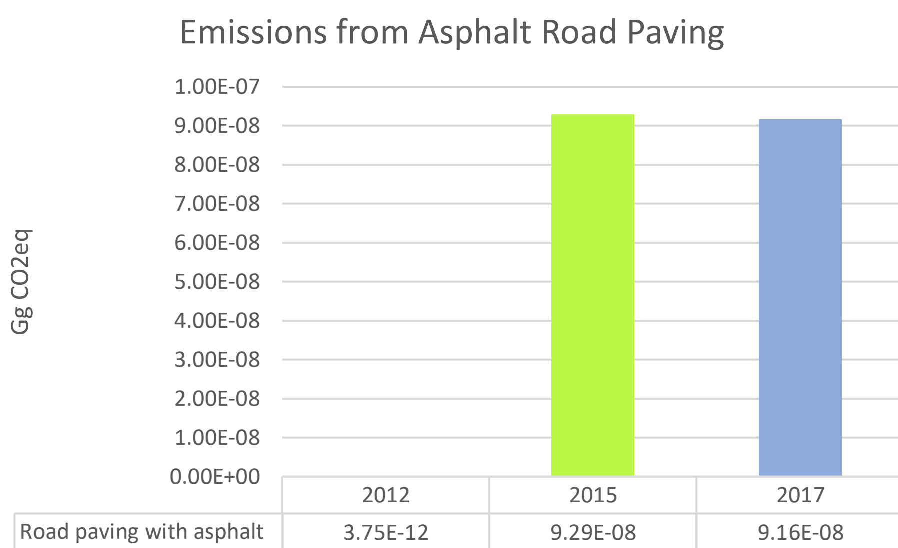
Figure 2.20: Emissions from Lime and Dolomite production, 2012, 2015, 2017 (Gg CO2eq)



	2012	2015	2017
Dolomite	1.41757	1.490335	0.37283
Lime	0.10725	0.15825	0.1155

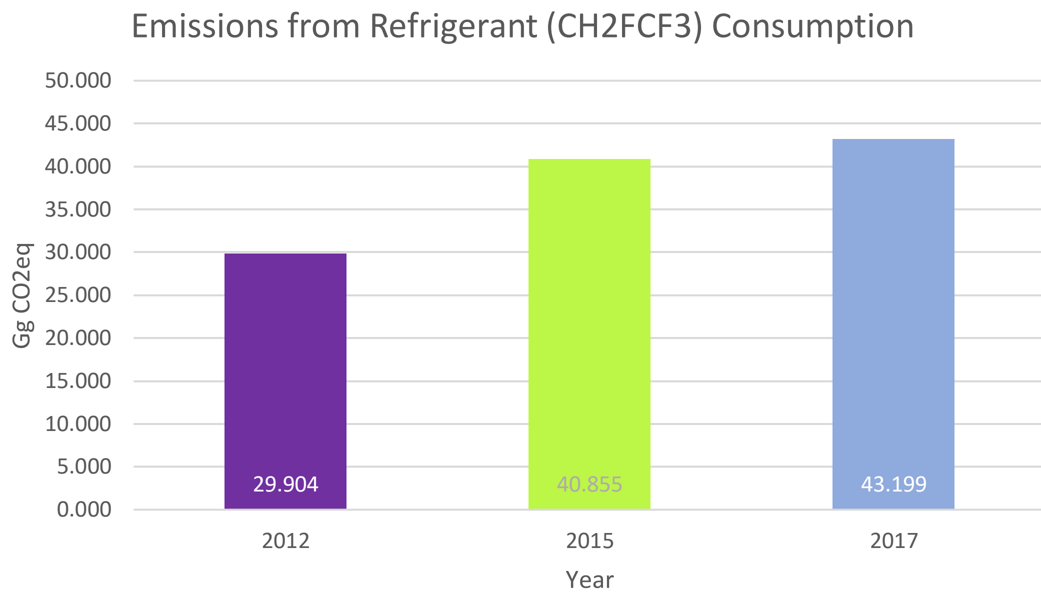
Emissions from Road Paving: Asphalt usage increased by 45.3% from 2012 to 2015 and decreased by 41.8 in 2017. CO_2 emissions followed the same pattern and are considered very low. Emissions from road paving increased between 2012 and 2015, and then decreased between 2015 and 2017 **(**Figure 2.21**).**

Figure 2.21: Emissions from Asphalt Road Paving, 2012, 2015, 2017 (Gg CO2eq)



Emissions from Refrigerants: For the period under review, the use of R-134a increased by twenty-six and seven tenths (26.7) metric tons, which is one hundred and forty percent (140%) increase over 2012 but decreased by 27.6% in 2017. In terms of CH2FCF3 gas, there was a consumption increase of nineteen (19) metric tons or sixty seven percent (67%) when compared to 2012 but decreased by 21.6% in 2017. As a result, emissions increased by 13 GgCO2 eq or thirty percent (30%) from 2012 to 2017 (Figure 2.22). This can be attributed due to the vast increase in the number of vehicles present in the country, as well as buildings being equipped with air conditioning units.

Figure 2.22: Emissions from Refrigerants Consumption for 2012, 2015, and 2017 (Gg CO2eq)



h. Analysis of Results

The inventory estimates the primary emissions from the sector is HFCs followed by CO2, mostly from refrigerant use in stationary and mobile sources, and lime production which involves the heating of limestone rocks in kilns over a three-day period. GHG emissions were also derived from food and beverage production, and road paving with asphalt.

The inventory also shows that the source of emissions from the IPPU sector remain the same as in earlier inventories. Increasing refrigerant use caused emissions to increased by 30% between 2012 to 2017. This can be attributed due to the vast increase in the number of vehicles present in the country, as well as buildings being equipped with air conditioning units.

There was a net decrease in CO_2 emissions by the end of the study period. Total emissions of the CO2 gas increased slightly between 2012 and 2015, and then declined between 2015 and 2017. This is mainly attributed to emissions from lime production, reflecting the decreased consumption/production of the lime brought by lower demand in the shrimp and citrus industries.

Lastly, CO_2 emissions from road paving sub-sector increased between 2012 and 2015, but decreased between 2015 and 2017, suggesting that road paving activities increased considerably between 2012 and 2015, but declined between 2015 and 2017.

2.4 Agricultural, Forestry, and Other Land Use Sector

a. Sector Background

As indicated in the Annex III of Decision 2/CP.17, the UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention, this inventory of the Agriculture, Forest and Land Use (AFOLU) Sector has been organized, to conform to the relevant sections of the UNFCCC Guidelines for the preparation of Biennial Update Reports from Parties not included in Annex I Parties to the Convention (Annex III of decision 2/CP.17), and the user manual for the guidelines on national communication from non-Annex I Parties (decision 17/CP.8)[3].

a.1 General Context of Agriculture

Agriculture remains one of the pillars of the Belizean economy. The vast majority of the rural population and the livelihood of the rural communities are also dependent on the environment through farming and forestry activities[4]. A census of farms in Belize in 2003 indicated that 24% of farms have less than 5 acres, 33% between 5 and 20 acres, and 74% of farms in the country is below 50 acres[5]. Toledo District has one fourth of all farms in Belize and the highest level of concentration of small farms (77% below 20 acres). Orange Walk is next with 22% of farms and Corozal with 21%. The farming population of approximately 11,000 farmers operates on about 5% of the agricultural land area. Small farmers account for more than 75% of the farming population. A large percentage of these small farms produce primary export crops

[3] The user manual was prepared based on decision 17/CP.8 by the UNFCCC secretariat in 2003

[4] Barnett et. al, 2010

[5] MAF Farm Registry

such as sugar, bananas, and citrus, while others concentrate on domestic food crops, viz., rice, corn, beans, root crops and vegetables.

Agriculture in Belize is characterized by three main sub-sectors: a) a fairly well-organized traditional export sector for sugar, banana, citrus, and marine products, b) a more traditional, small-scale farm sector, producing food mainly for local consumption, and c) a large-scale commercial sector.

The existing production structure represents a mix of modern and traditional farms with the latter being characterized by low technology systems and low levels of production[6]. The agricultural production systems in Belize can be considered bimodal with small producers and commercial producers who can then be categorized in four main types.

a.1.1 Small Farmer Sector

In Belize, several criteria are used to identify small farmers. If farm size is used, the distribution by acreage indicates that small farmers operate less than 20 acres. They are characterized by their labour intensive production systems and land holdings, including size, tenure, cultivation and location, and production technology (slash and burn, rained, low input, sale of surplus production and do not live on the farm), crop mix (corn, rice, beans), labour uses/needs, and income differ tremendously across Belize. Small farmer agriculture constitutes a critical component of Belize's food production and agro-export sectors. In general, small farmers produce rice, beans, corn, vegetables, bananas, plantains, fruits, and livestock for home consumption and the domestic market. In addition, small farmers produce sugarcane, citrus, hot pepper, and cacao for export.

a.1.2 Commercial Farmers Sector

These farms are characterized by having large acreages in most cases over 100 acres. The operations are capital intensive and business-oriented systems, producing commodities mostly destined to the export market on a large scale for a quality conscious market. Most are mechanized and own their own equipment for all farm operations and the land tenure is freehold or leasehold. High technical input is also characteristic; therefore, drainage and irrigation infrastructure is present and have well established

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[6] National Food and Agricultural Policy, 2002–2020, MAFC, 2003

marketing systems. The farms are under monoculture and therefore require high labor inputs especially the traditional export crops. The main commodities grown are citrus, bananas, sugarcane and shrimps.

The commercial farms managed and owned by the Mennonite commercial scale farmers normally produce rice, beans, corn, cattle, pigs, poultry and other crops for the domestic and export markets. These farms are the ones that are mostly mechanized and automated. They are found in the Cayo and Orange Walk Districts in settlements having varying degrees of technological inputs.

a.1.3 Production systems/farming systems

The term farming system is used to refer to the whole farm business operation of a family or company: it covers all crop and animal husbandry enterprises and their linkages, together with the inputs utilized, whether formal (credit, agrochemicals) or informal/traditional (clearing of forest for crop cultivation).

There is a great diversity of enterprises and ranges of scale in Belizean farming systems. Even at the level of the individual farm unit, farmers typically cultivate 2 or more crops in diverse mixtures that vary across soil type, topographical position and distance from home. The systems falls within the following framework:

<u>Traditional or Milpa</u> – This historic system consists of felling and burning high forest, planting food crops for subsistence for one or two years; however, given the current land pressures it might be for up to five years, then the land is left to recover under fallow for at least three years. Staple food is grown such as corn, rice and beans. Intercropped are pumpkins, plantains, yams, cocoyams and sweet potatoes. Normally found in all districts and in rural areas where the farmers have limited opportunities to capital and in vulnerable areas due to land pressures.

<u>Small commercial farms for domestic markets</u> - The principal characteristic is a transition between milpa and mechanized production. Various levels of milpa and mechanization, primarily uses family labour (occasionally hired labour). Mechanically prepared land, all other production practices done manually by family, women responsible for marketing. Land is leased from the government and immigrant farmers are significant producers. Technological inputs such as improved seeds and inputs are widespread; irrigation is by hand and located near ponds and river for water supply. Output is staggered to provide small but steady stream of income. Subsystems are:

- *Domestic crops* - Plantains, rice, corn, beans, peanuts grown in all districts.
- *Vegetables* - Potatoes, onion, cabbage, tomatoes, sweet peppers, carrots mostly grown in Cayo, Orange Walk, Corozal and Belize Districts.

- *Fruit Trees* - Mangoes, coconuts, soursop, guavas, grapes, avocado, cashew grown throughout the country.
- *Livestock* - Beef, pigs, poultry, eggs, dairy, sheep, goats (local breeds and some improved breeds grown on mostly natural pastures) mostly in Cayo, Orange Walk and Corozal districts.

Small commercial farms for export – The small farmers have been able to break into the traditional crops such as sugar and citrus. These are small family owned commercial farms, mostly of 50 acres and use family and hired labor during harvest. Normally the land is cleared by hand and then planted and mechanized after a few years. Most farms are owned by persons having other employment. There is also use of improved technology and inputs. Two subsystems are identified:

- *Traditional crops* – sugarcane and citrus primarily grown with other food crops on a smaller scale. Located mostly in Cayo, Stann Creek for citrus and Corozal and Orange Walk for sugarcane.
- *Non-traditional crops* – papayas, hot peppers, and cacao. Mostly found in Corozal, Orange Walk, Cayo and Toledo for cacao.

Large commercial farms and estates – These are farms with large acreages, highly mechanized and large investments that include technological inputs as well as secure land tenure. In this category are included the Mennonites who grow grains and other non-traditional export crops such as soybeans and sorghum. The principal characteristic is that they have a well-established marketing system. The traditional crops grown on a large scale are in Stann Creek, Orange Walk and Corozal. The Mennonites are concentrated in Cayo and Orange Walk Districts.

a.1.4 Liming

Liming is a practice conducted in the citrus and banana industries to reduce the acidity of the soils in southern Belize. Currently liming is done using either limestone or dolomite. Additionally, dolomite is also used in aquaculture applications.

a.1.5 Rice management

Rice production is grown under three systems in Belize, namely: Milpa or upland rice, mechanized and irrigated. Mechanized rice production uses farming equipment, but is rain-fed instead of being irrigated mechanically. In flood irrigation between 15-30 cm of water is applied to the field and only one crop harvested per annum.

a.1.5 Livestock and manure management

The animal waste management system most common in Belize is the open range and paddock systems where the nitrogen from animal waste is considered as fertilizer. Most of the livestock herds are reared on natural range except for dairy cattle, some feedlots and poultry.

Some dairy farmers and beef feedlot farmers would apply manure directly to the fields. In poultry, manure management is based on the use of litter which is left in ambient temperature and used after a couple of months. This is also used as soil amendment in the rural areas where the Mennonite farmers produce vegetables such as Springfield and Barton Creek. However, the poultry manure cannot be applied immediately to plants as due to its high Nitrogen content, because it "burns" the plant. Poultry manure needs to be aged or composted before use.

Field burning is a practice that is normally used in the traditional Milpa system and in other production systems. However, in the mechanized systems of production the crop residue is normally incorporated and is especially done in crops such as the legumes to add nitrogen to the soil, especially where they are in rotation with grain cereals.

a.2 General Context of Forestry and Other Land Use

Belize is endowed with vast and unique tropical forests that are also habitat to unique biodiversity of global significance[7]. Most of the country and the entire coastal area consist of low-lying plains. Belize is known for its abundant natural resources and vast array of ecotypes especially with respect to water and biodiversity. Belize hosts more than 150 species of mammals, 540 species of birds, 151 species of amphibians and reptiles, nearly 600 species of freshwater and marine fish, and 3,408 species of vascular plants[8]. In fact, Belize has the highest forest cover in both Central America and the Caribbean, including

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

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

the largest intact blocks of forests in Central America, namely the Selva Maya and the Maya Mountain Massif [9].

Forest conservation has, historically, been a major priority for Belize. This is evidenced by the country's extensive protected areas system[10]. The Protected Areas of Belize have evolved over the last few decades from being considered primarily as a resource bank, typically for forestry, to become a complex network of large and small "enclaves" having a diversity of purposes and under a variety of management regimes, some more effective than others, reflecting changing conservation attitudes, as has the scope and direction of the various agencies responsible for their administration[11].

The country has 44% (1.22 million hectares) of its land and sea resources protected under a variety of management structures: 769,093 ha of terrestrial reserves, 159,030 ha of marine reserves, and a further 128,535 ha protected through 'officially recognized' private conservation initiatives[12]. Belize has 102 protected areas (PAs) representing 22.6% of its national territory (land and marine). These include 19 Forest Reserves, 17 National Parks, 3 Nature Reserves, 7 Wildlife sanctuaries, 5 Natural Monuments, 9 Archeological Reserves, 8 Private Reserves, 8 Marines Reserves, 13 Spawning Sites, 6 Public Reserves, and 7 Bird sanctuaries. The terrestrial PAs cover 34.9% of the total land surface, while the marine reserves cover 10.6% of the country's marine area[13].

These forests also provide sustenance for a majority of the population. Unfortunately, the forests have been under increasing pressures from land conversion and degradation activities[14]. Belize's biodiversity is exposed to various direct anthropogenic and natural threats both within and outside of the Protected Areas (PAs). Over the last five decades the forest cover in Belize had steadily decreased due in general, to the expansion of unsustainable economic activities, such as large-scale and slash and burn agriculture, aquaculture, illegal logging, unsustainable logging, encroachment, forest/bush fires and other uncontrolled conversion of forest to intense anthropogenic land uses and extensive damages from climate related hurricanes and storms. These include unregulated development of urban and coastal areas and

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[9] FCPF R-PP Belize https://www.forestcarbonpartnership.org/redd-countries-1

[10] FCPF R-PP Belize https://www.forestcarbonpartnership.org/redd-countries-1

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

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

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

[14] FCPF R-PP Belize https://www.forestcarbonpartnership.org/redd-countries-1

the rising pollution from cruise ship tourism leading to the degradation of mangroves and coral reefs and deforestation and unsustainable extraction of non-timber forest products in hotspot areas [15,16,17].

In 2010, hurricane damage led to extensive forest areas being destroyed leaving much debris which that accumulated and dried up to form fuel. Consequently, during the 2011 dry season, Belize experienced some of the most extensive forest fires all over the country. The large fire in the Broadleaf forest was in Central Belize, with was mostly in the Belize and Cayo District, some south of Orange Walk District. These fires and other forest degradation are leading to loss of biodiversity and emissions of GHGs into the atmosphere and contributing to further climate change .

b. National Legislation

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

In addition, as a Party to the Paris Agreement Belize has submitted its Nationally Determined Contribution (NDC) to the UNFCCC in 2015 and in accordance with the guidelines adopted by the 24th Conference of the Parties (COP) to the UNFCCC and the first Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA) in Katowice in 2018 has indicated that there are plans to update its NDC. It is also important to emphasize that Belize is currently also undertaking a full review of existing policies such as forest and land use policies with the aim to enhance their effectiveness and to better align them with the national climate change commitments.

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

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

[17] Drivers Deforestation report 5

Moreover, the Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration (MAFFESDI) did detailed policy review called 'Legal and Institutional Framework for REDD+ implementation in Belize". Description and the reference/links to forest, forest users, and REDD+ can be found in this report.

All strategic documents mentioned below provide policy guidance on the forest and land used sector, amongst others:

<u>Strategic policy frameworks</u>

- National Development Framework for Belize (2010-2030), "Horizon 2030", 2016
- Revised Low Carbon Development Roadmap for Belize
- Growth and sustainable development strategy (GSDS), 2016-2019,
- National Change Policy, Strategy and Action Plan (NCCPSAP), MAFFESDI, 2014
- Framework environmental protection law
- National Environmental Policy and Strategy (2014-2024), 2014
- National Environmental Action Plan (2015– 2020), 2014
- The Environmental Protection (Amendment) Act, 2009

<u>Forest</u>

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

<u>Agriculture</u>

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

Land tenure

- National Land Use Policy and Integrated Planning Framework for Land Resource Development (Draft), Ministry of Natural Resources, November 2011
- National Lands Act, 2003
- The Land Utilization (Amendment) Act, 2017
- Land Tax Act, 2003
- Land Acquisition Act, 2000
- Spatial Planning
- National Protected Areas Policy and System Plan, 2015
- National Protected Areas System Act, 2015
- Protected Areas Conservation Trust (PACT) (Amendment) Act, 2017
- Integrated Coastal Zone Management Plan, 2016
- Coastal Zone Management Act, 2003

Biodiversity

- National Biodiversity Strategy and Action Plan (NBSAP) (2016- 2020), 2018
- Biodiversity Initiative – Biodiversity Policy and Institutional Review, October 2018 (DRAFT)
- Taxation
- Environmental Tax (Amended) Act, 2017
- The Fiscal Incentive Program, 2016
- The Fiscal Incentives Act, 2011
- Finance and Audit (Reform) Act, 2011
- The Mines and Minerals Act

c. Gases included

The inventory covers sources of GHG emissions which results from anthropogenic activities for direct GHGs, including carbon dioxide (CO2) and their removals by sinks. Methane (CH4) and nitrous oxide (N2O) emissions from fires on land remaining in same category and conversions to other land uses are also included where data is available. Methane (CH4) and nitrous oxide (N2O) are the main gases emitted from agriculture practices. Carbon monoxide (CO) and nitric oxide (NOx) produced from fires of crop residues have been estimated for the year 2009 due to availability of data. Emissions for each GHG have been presented in carbon dioxide equivalents (CO2eq) terms using the 100-year global warming potentials (GWPs) contained in the IPCC Fifth Assessment Report.

d. Reporting years

For agriculture, this inventory is reporting for the years 2012, 2015 and 2017. The base year is 2009. The reporting years of this inventory for the FOLU Sector covers the period 1994 to 2017. The 1994-2017 time series includes: (a) 1994-1999 estimates year by year calculated by extrapolation, (b) 2000-2017 new annual estimates.

e. Recalculations

For agriculture, recalculation from previous years (1994, 1997, 2000, and 2003) was undertaken after a Peer review from previous GHGI underlined some shortcomings. For FOLU, estimates for 1994-1999 were done through extrapolation.

f. Description of methodologies and data sources

- Emission factors

- Agriculture

Tier 2: Country specific data was used for the emission factors for the burning of crop residues of sugarcane from the 2006 study by Booker/Tate Consultant Mr. David Eastwood “Sugarcane crop residue contribution to Nitrous oxide”.

Tier 1: As Belize does not have sufficient information on emissions factors in agriculture, the majority of the emission factors for agriculture are default values from the 2006 IPCC. These factors were used for enteric fermentation, manure management, direct and indirect N_2O emissions from soils and CO_2 emissions from liming. Table 2.13 below shows factors used for livestock.

Table 2.13: Emissions Factors for Agriculture (Livestock)

Species	Emission Factor
Dairy	72 kg CH_4 per head/year
Beef	56 kg CH_4 per head/year
Buffalo	55 kg CH_4 per head/year
Sheep	5 kg CH_4 per head/year
Goat	5 kg CH_4 per head/year

Horses	18 kg CH_4 per head/year
Mules and asses	10 kg CH_4 per head/year
Swine	1 kg CH_4 per head/year
Poultry	0.02 kg CH_4 per head/year

- Forest and Other Land Use

A combination of Tier 1, 2 and 3 values were used.

Tier 3: Broad-leaf Mature Forest: the study "Rapid carbon sequestration following hurricane disturbance in mature tropical forest: new insights and methods from Central America" by Cho et al. (2013) was used. In this study, 304 trees of 48 species ranging in diameter from 10 to 223 cm were harvested in forests across Belize. An algometric model was designed to estimate stem Above Ground Biomass (AGB) separately from crown AGB, thereby allowing for more sensitivity to stem and crown damage. It is a volume to biomass model, which is useful for both timber and biomass purposes, where the volume of the stem is converted to biomass by multiplying by wood density. This study can be found at the Ministry of Agriculture, Fisheries, Forestry and the Environment of Belize.

Tier 2: Broad-leaf Mature Forest: The information comes from the study "An investigation of tropical forest response to hurricane disturbance with evidence from long-term plots and earth observation in Central America" by Dr. Percival Cho (Ministry of Agriculture, Fisheries, Forestry and the Environment of Belize and Lancaster University) published in September 2013. During the period 1992 to 1998, 32 one-hectare permanent forest plots were established in mature, hurricane-disturbed and/or selectively-logged broadleaf forests of Belize and censused multiple times using the same standardized pan-tropical methodology used in other networks. Measurements were quality-controlled and well documented, which provides a robust basis for evaluating growth rates.

A relational database was constructed in MS Access to house and link individuals to their respective repeat measurements. The aim of the database is to store and make available long- term forest monitoring data from the forest ecosystems of Belize and to facilitate linkages to other databases of permanent forest plot measurements such as 'Forestplots.net'. This database was published, and more details can be found in the paper "*The FORMNET-B database: monitoring the biomass and dynamics of disturbed and degraded tropical forests*"[18].

Mangroves: The methodology for the estimation of Mangrove biomass originates from the protocol: "Mesoamerican Barrier Reef Systems Project (MBRS) Manual of Methods for the MBRS Synoptic Monitoring Program/Selected Methods for Monitoring Physical and Biological Parameters for use in The Mesoamerican Region" .

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

Tier 1: Default 2006 IPCC values were used for all other parameters in Forest lands, Croplands, Grasslands, Wetlands, Settlements and Other lands.

Harvested Wood Products: The data was obtained from the FAO website.

In summary:

Data utilized for reporting period were based on FAO estimates from official data and recalculations of previous reference years where yearly official data was not available.

Based on the use of the 2006 IPPC guidelines, Tier 1 approach

These default coefficients are for tropical countries with high uncertainties, therefore not as reliable so the results do not accurately reflect country activities.

- Activity Data

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

- Agriculture

Over the years, Belize has done various agriculture censuses [2003, 2009, and 2011]. Another was initiated for 2018 and was underway during the GHG inventory exercise. These censuses provide the basis for activity data for this sector. In particular, the census collects data on the number of heads per livestock sub-categories, areas and production of major crops as well as fertilizers applied to the soils. For some values, however, international dataset were used as the censuses do not provide it. For instance, the number of mules and asses for the years 1994, 1997 and 2000 was obtained from this source. For the other years an extrapolation from the 2007 Belize Farm Registry census was done.

To the extent possible, activity data used in this report are based on officially published data: Abstract of Statistics 2017 (SIB), Central Bank Reports, World Bank data, FAO, BLPA, Ministry of Agriculture, Expert Knowledge, personal interviews, and literature reviews.

A major constraint related to Agriculture data is the difficulty of obtaining accurate and reliable information. This is in part due to a lack of consistent data collection and challenges in reporting on a continuous basis by the source of such data.

Additionally, since specific activity data for the reference years is difficult to access, extrapolations and other data calculations based on the expert's knowledge combined with wide literature review have been utilized. The base year selected was 2009 as the emissions have been calculated for that year so it allows for comparison.

Agricultural Production: Agriculture contributed 15% of GDP on average, with exports of approximately BZ$ 465 million per year for the years 2011 to 2015 (SIB, 2017). The leading agricultural export commodities were sugar (23% by value), orange concentrate (21%), banana (20%), papayas (4%), and animal feed (3%). Approximately 96,000 acres are planted to sugarcane, 48,000 acres to citrus, and 48,500 acres to corn (MAFFESDI). Additionally, 351,700 acres in pastures are grazed by approximately 135,400 head of cattle (BLPA, 2017).

Data on crop Production in millions of pounds and acreages under production 2000 to 2017 can be found in Annex 2.

Livestock: Livestock in Belize is generally grown under open range or pastures so manure management is limited. Dairy animals are normally fed and kept in paddocks where the manure is normally collected daily and also use as spread, therefore, the animal waste management system most common in Belize is the open range and paddock systems where the nitrogen from animal waste is considered as fertilizer.

In poultry, manure management is based on the use of litter. This is also used as soil amendment in the rural areas where Mennonites farmers produce vegetables such as Springfield and Barton Creek. However, the poultry manure cannot be applied to plants immediately due to its high nitrogen content which "burns" the plant, and can kill it. So the poultry manure is piled and left in the ambient conditions for a period before it is utilized as fertilizer.

The livestock sub-sector continued to grow in value and importance. Using the 2009 Livestock census as the base year, there was substantial increase in cattle and pig production. Pig production went up by 48% from 17,038 in 2009 to 32,674 pigs in 2017. Sheep production has remained similar to the 2009 figure. Dairy cattle recorded a small decrease from 3,877 in 2009 to 3,676 heads indicating that dairy producers are not too optimistic given the challenges posed by milk imports. For beef cattle once again, population increased by 27.7% from a total in 2009 of 91,125 to a total of 126,129 heads in 2017. There has been a renewed surge in production given the prices being offered to farmers by Guatemalan buyers.

The livestock species identified for the purpose of this inventory and for which data was obtained can be observed in Table 2.15. While BLPA collects data on most of the livestock on an annual basis, data for buffaloes was obtained directly from the rancher. The data for horses and goats were obtained from the FAO website. Other data not specifically listed were calculated.

During the recent peer review, some observations were made with respect to some results of the previous inventories, therefore more accurate and complete datasets were sought in order to more accurately report on the GHG emissions by the relevant sectors. As a result, the recalculation for all the past inventories years beginning with 1994 was done.

Data on Livestock Production for 2000-2017, Livestock Production (heads) based on Ministry of Agriculture and BLPA data can be found in Annex 3.

Nitrogen fertilizers: The data on total Nitrogen fertilizers are shown in Table 2.14 below obtained from World Bank and FAO. For the purposes of this inventory the N content are namely: Urea (46% N), Ammonium Nitrate (33% N) and Ammonium sulfate (21% N) plus all other mixed formulae containing N by 21%.

Table 2.14: Total Nitrogen Fertilizers in kilograms

Fertilizer Type	2009	2012	2015	2017
Urea	9,105,733	15,353,877	15,915,111	10,875,721
Ammonium Sulphate	334,136	1,817,174	2,380,651	8,112,983
Ammonium Sulphate solution	na	na	405222	na
Ammonium Nitrate	696,577	2,738,853	3,062,553	4,409,307
Diammonium phosphate	7,695,840	10,381,369	14,547,035	12,785,790
Nitrogenous Fertilizer	370095	6 470	na	na
NPK Fertilizers	1902602	18,807,924	29,600,932	42,268,400
Fertilizer Mixes	1,812,897	941	695,838	648,604
Monoammonium phosphate	254	2,000	111,977	65,263
Ammonium carbonate	2131	na	na	na

Source: World Bank

Fertilizers are generally applied to crops, unless it is produced under the milpa system. The perennial crops are where the majority of the fertilizers are utilized. Based on data from the World Bank the fertilizer usage per hectare in Belize can be observed in Table 2.14.

Rice management: Rice production is grown under three systems in Belize, namely: *Milpa, mechanized (upland) and irrigated. Milpa* refers to production using the traditional Mayan agricultural production system of slash and burn. *Mechanized production* is rice production using machinery to prepare the fields. However, it is totally rain-fed and not irrigated. *Flood irrigation* is only between 15-30 cm of water and only one crop harvested per annum.

The data for the production of rice described in Table 2.15 was obtained from the Ministry of Agriculture. Milpa and mechanized rice production is totally rain-fed, however, in Toledo the rainfall is such that the rice is flooded for most of the growing season. Generally, the crop is produced within 125 days. It must be noted that due to policy decisions, rice is being grown under irrigation and upland conditions while the milpa farmers are being displaced and disappearing with the decision of the closure of the Big Falls mill in Toledo. Traditionally, the Ministry of Agriculture, through the Belize Marketing and Development Corporation supported the Toledo producers, but this is no longer in place.

In should be noted that no organic amendment is applied to the soil and all the fertilization is done using synthetic fertilizers.

The table below describes data on Rice production for years 2009 to 2017, measured in acres cultivated.

Table 2.15: Rice production for years 2009 to 2017 (acres cultivated)

Year	2009	2012	2015	2017
Milpa	6170	219	326	162
Mechanized	1004	4626	2123	3950
Irrigated	4137	1850	4666	5700
Total	11311	6695	7373	9812

Source: Min of Agriculture, 2019

Crop Residue Management: Field burning is a practice that is normally used in the traditional Milpa system and in other production systems. However, in the mechanized systems of production the crop residue is normally incorporated and is especially done in crops such as the legumes to add nitrogen to the soil, especially where they are in rotation with grain cereals.

Belize is self-sufficient in grains and its main export commodities are agricultural products, namely sugarcane, bananas, and citrus. For this assignment the data used in the calculations are found in Table 2.15 and is based on the Ministry of Agriculture data as well as SIB.

In the Milpa system of production, agricultural residues are normally burnt before the next planting. In the mechanized system, the crop residues are generally incorporated before the crop, however some burning occurs depending on the type of flora that is regenerating. In sugarcane production, the crop is normally burnt before harvest, as well as after harvest. The emissions for this activity cannot be estimated because of lack of reliable data.

Data on Major Crop Production in pounds can be found in Annex 2.

Liming: Liming is a practice conducted in the citrus and banana industries to reduce the acidity of the soils in southern Belize. Currently liming is done using either limestone or dolomite. Additionally, dolomite is used in aquaculture and aquaculture emissions will need to be looked at in the near future.

- Forest and Other Land Use

According to the 2006 IPCC guidelines, Belize 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, and therefore Collect Earth is not used to produce Land use and Land use change maps.

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

For the purpose of this activity data assessment Belize's forest land definition is "Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 30 percent or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use", to facilitate the land use identification using remote sensing techniques, with medium resolution satellites. A sampling plot size of 0.5 hectares with distance separation of 1km was used. The total land area for Belize is 22,700 square kilometers, which resulted in a total of 21,911 plots.

With this method it was possible to obtain spatially explicit annual data for time series of 2000-2017. Auxiliary data -maps- were used to stratify the information by districts, climatic zones, conservation areas, forest concessions, etc. For each plot the land use for each year, the subdivision, the conversion class and year of conversion, topography, human impact type (disturbance levels 1, 2 and 3), elevation, slope, aspect, climate, soil class, district, community; protection organization, level and year, and ecosystem is known. This information allowed a very detailed annual analysis of the dynamics of land use. More details about the methodological processes of the Collect Earth Assessment can be found in the document called "Collect Earth Assessment Protocol" by the Forest Department of Belize.

Belize followed 2006 IPCC guidelines structure for the AFOLU sector, including the six main land uses proposed: Forestlands, Cropland, Grassland, Wetlands, Settlement and Other lands (Level 1).

Forestland (Level 1) forest sub-categories (Level 2): Primary Broad-leaf dominated semi-deciduous/semi-evergreen forest; Secondary Broad-leaf dominated semi-deciduous/semi-evergreen forest, Pine forests, Mangroves, Forest Plantations. Croplands (Level 1) are reported as annual and perennial crops, plus fallow lands (Level 2). Grasslands (Level 1) are reported as Shrublands, Pastures, Thickets and Savannahs in one category and Regenerating Grasslands as a second category (Level 2). Wetlands, Settlements and Other lands do not have further sub-classification (Level 1).

Annual Land Use and Land Use Change Matrices were derived from the Collect Earth Assessment for the time series 2000 to 2017, following the six IPCC 2006 Categories and country-specific sub-categories, indicating area (ha) remaining in the same category or conversion to another category or land use. In addition, Annual Disturbance Matrices were derived indicating area (ha) affected by a specific natural or anthropogenic disturbance. Following the rule of Forest definition and the Collect Earth approach, disturbances were not considered permanent conversions. Only until the forest definition threshold is crossed, these will be considered as land use change.

- Description of methodologies

The table below presents the methods and emission factors used for the AFOLU-GHG. This inventory uses mostly Tier 1 methods with default values for the agriculture emissions. Belize has not yet produced country specific information for most of the categories. Only the burning of sugarcane used country specific values.

Table 2.16: Emission factors for AFOLU Sector

Category	CO_2 Methods	CO_2 EF	N_2O Methods	N_2O EF	CH_4 Methods	CH_4 EF
3 - Agriculture, Forestry, and Other Land Use	T2, T1	CS, D	T2, T1	CS, D	T1	D
3.A.1 Enteric Fermentation					T1	D
3.A.2 Manure Management			T1	D	T1	D
3.C - Aggregate sources and non-CO2 emissions sources on land					T1	D
3.C.2 - Liming			T1	D		
3.C.3 - Urea application			T1	D	T1	D
3.C.7 - Rice cultivations			T2, T1	CS, D	T1	D
3.B.1 FOLU						
3.B.1 a. Forest Lands	T3, T2, T1	CS, D	T2, T1	CS, D	T2, T1	CS, D
3.B.1 b. Croplands	T2, T1	CS, D		NE		NE
3.B.1 c. Grasslands	T2, T1	CS, D		NE		NE
3.B.1 d. Wetlands	T2, T1	CS, D		NE		NE
3.B.1 e. Settlements	T2, T1	CS, D		NE		NE

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

- Agriculture

The methodology applied to estimate the emissions from agriculture are based on Tier 1 equations provided by the 2006 IPCC guidelines. Activity data such as head of livestock have been taken from national censuses conducted in 2003, 2009, and 2017, and extrapolated for the missing years. The areas of major crops such as sugarcane and rice are based on date from the Ministry of Agriculture and expert knowledge.

The emission factors are default values provided by the IPCC 2006 adapted to Belize's climate and region. Please refer to

Table 2.23 above.

The methodology utilized to estimate the emissions from agriculture, namely enteric fermentation and manure management, was based on obtaining the population per livestock species and for the calculations of emissions using Tier 1 equations and default factors provided by the 2006 IPCC guidelines.

For aggregate sources the data was obtained for the national level especially from the World Bank and FAO for fertilizers applied, for liming and land areas the data was obtained from the companies, SIB and Ministry of Agriculture. Tier 1 calculations were utilized as well as the default coefficients.

Table 2.17: Main IPCC categories/subcategories for estimation of emissions for AFOLU Sector

3 - Agriculture, Forestry, and Other Land Use	
3.A - Livestock	3.B Land
3.A.1 - Enteric Fermentation	3.B.1. Forest Land
3.A.1.a - Cattle	3.B.1. Cropland
3.A.1.a.i - Dairy Cows	3.B.1. Grassland
3.A.1.a.ii - Other Cattle	3.B.1. Wetlands
3.A.1.b - Buffalo	3.B.1. Settlements
3.A.1.c - Sheep	3.B.1 Other Land
3.A.1.d - Goats	3.C - Aggregate sources and non-CO2 emissions sources on land
3.A.1.f - Horses	3.C.1 - Emissions from biomass burning
3.A.1.g - Mules and Asses	3.C.1.a - Biomass burning in forest lands
3.A.1.h - Swine	3.C.1.b - Biomass burning in croplands
3.A.2 - Manure Management	3.C.1.c - Biomass burning in grasslands
3.A.2.a - Cattle	3.C.1.d - Biomass burning in all other land
3.A.2.a.i - Dairy cows	3.C.2 - Liming
3.A.2.a.ii - Other cattle	3.C.3 - Urea application
3.A.2.b - Buffalo	3.C.4 - Direct N2O Emissions from managed soils (3)
3.A.2.c - Sheep	3.C.5 - Indirect N2O Emissions from managed soils
3.A.2.d - Goats	3.C.6 - Indirect N2O Emissions from manure management
3.A.2.f - Horses	3.C.7 - Rice cultivations
3.A.2.g - Mules and Asses	3.C.8 - Other (please specify)
3.A.2.h - Swine	3.D - Other
3.A.2.i - Poultry	3.D.1 - Harvested Wood Products

Notes:

- *3C: Aggregate sources and non-CO2 emissions sources on land – Burning of forest land is addressed by REDD+ project in the Forestry and Other Land Use sub-sector.*
- *3C.1.b: Biomass burning in croplands - Not estimated since data is unreliable*
- *3.C.5: Indirect N2O Emissions from managed soils – The software did not produce any results for this activity.*
- *3.D.1: Harvested Wood Products – Data from FAO website was used*

- Forest and Other Land Use

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

As indicated in Annex III of Decision 2/CP.17, for the estimation of GHG Forest and Land Use emissions and removals, the 2006 IPCC Guidelines were applied, following the indications of Volume 4, Chapter 2 "Generic Methodologies Applicable to Multiple Land-use Categories", for change in biomass carbon stocks (above-ground biomass and below-ground biomass) and Non-CO2 emissions. It includes the analysis for Land remaining in a land-use category and Land converted to a new land-use category, selecting the Gain-Loss method and implementing a country-specific excel calculation tool. Forest land was stratified by forest type (Broad-leaf dominated semi-deciduous/semi-evergreen mature forest, Broad-leaf dominated semi-deciduous/semi-evergreen secondary forest, Pine forests, Mangroves, Forest Plantations). Croplands are reported as annual and perennial crops, plus fallow lands. Grasslands are reported as Shrublands, Pastures, Thickets and Savannahs in one category and Regenerating Grasslands as a second category. Wetlands, Settlements and Other lands do not have further sub-classification.

The information on wood removals was derived from the Collect Earth assessment. Disturbances were also identified including Hurricanes, Fires, Logging, Grazing, Shifting Cultivation, Infrastructure, Pests and Other Human Impact.

Following Annex III of decision 12/CP 17 and paragraphs 10[19] and 21[20], annex to 17/CP.8, information on the specific category-level methodologies employed, including a description of the data and assumptions used to estimate GHG emissions and absorptions are provided in Annex I.

The methods selected allowed to fulfill the IPCC TACCC principles:

- Transparent, as data sources, definitions, methodologies and assumptions are clearly described.
- Accurate, as country specific activity data, emissions factors and calculation tool were used.
- Consistent, as it allows representing 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 and it represents land-use categories and conversions between land-use categories, as needed to estimate carbon stock changes and GHG emissions and removals.
- Comparable, as it allowed a full time series analysis using same definitions, methodologies and assumptions.

g. Results of GHG emissions and removals in this sector

- **Agriculture**

Recalculated emissions of past inventories: Analysis of the recalculated data illustrates normal trends over time based on the level of activity per sector. However, it should be noted that the 1994 recorded higher

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[19] 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.

[20] 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.

emissions than in 1997. From Figure 2.23, it can be determined that enteric fermentation was the major contributor to emissions followed by emissions from managed soils.

The amount of emissions from enteric fermentation for 1994 was estimated to be higher than for 1997, but this appears to be the result of the reported population for cattle for the latter year. The livestock herd was smaller in 1997 than in 1994, then the numbers increased in the following years. The trends continue upwards as expected based on natural growth of the population and the accompanying expansion of productive activities.

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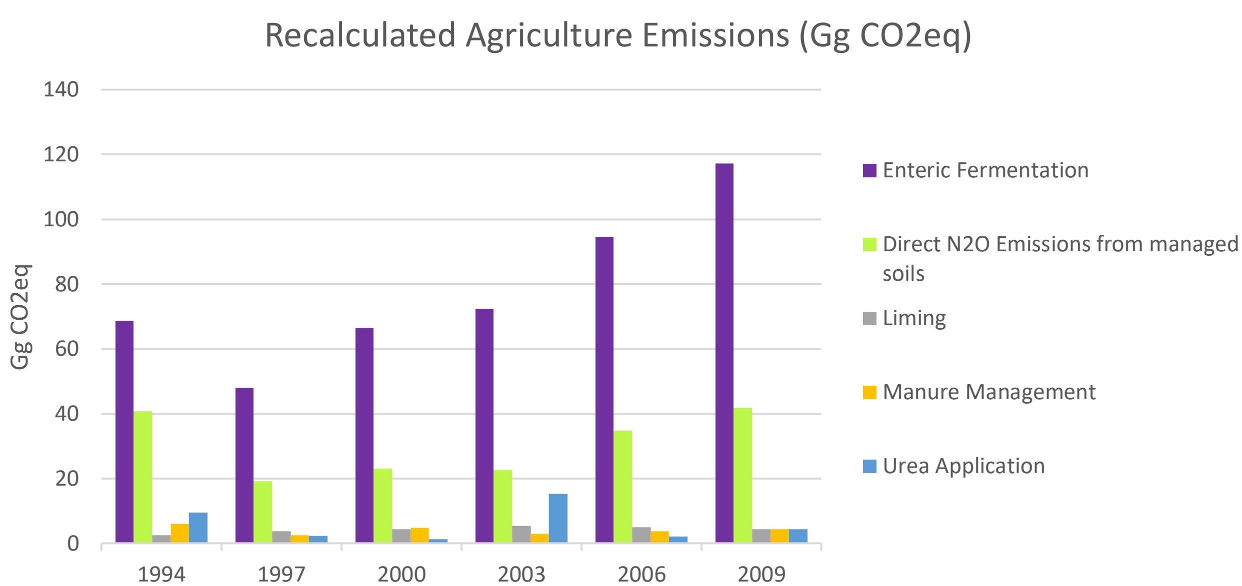
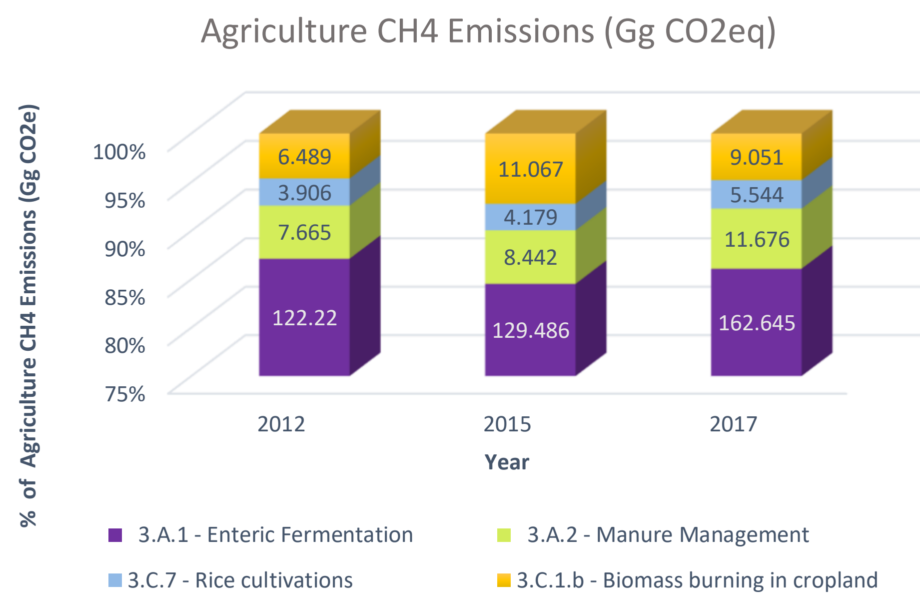
Figure 2.23: Recalculated Agriculture emissions of previous inventories



Methane Emissions from Enteric Fermentation, Rice and Agriculture Residue Burning (CH_4 in Gg CO_2eq):

The result for emission from enteric fermentation is reflective of the current situation in the country with respect to livestock population. Methane emissions from enteric fermentation shows a steady increase with respect to 2009 and it is expected as it is directly related to the population (heads) of livestock in the country as can be observed in Figure 2.24 below. The increase approximately averages 1Gg per year. Given the cattle prices and demand of export to neighboring countries, it is expected to grow more rapidly in the subsequent years.

Figure 2.24: Agriculture Methane Emissions 2012, 2015, and 2017 (Gg CO2eq)



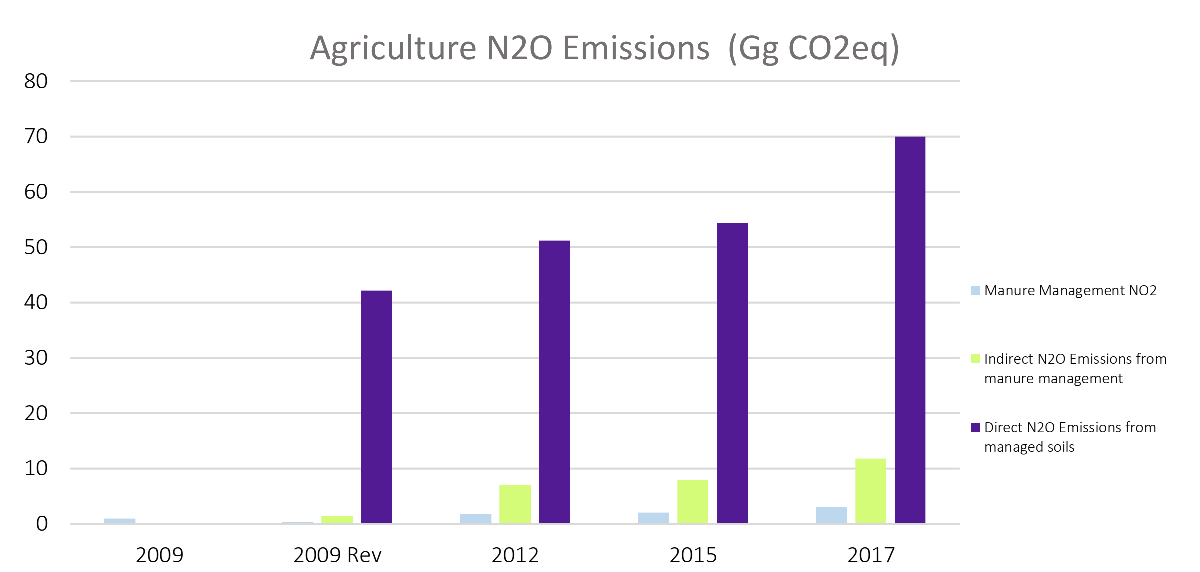
One of the advantages of using the 2006 IPCC software is that it allows for the calculation of emissions from the manure management systems utilized for the reporting periods. Unlike the previous years the manure management systems which include open pasture for the cattle and for poultry which are the ones accounting for the majority of these emissions. The increase approximately averages 1Gg per year. Given the cattle prices and demand on exports, it is expected to grow more rapidly in the subsequent years.

As can be seen in Figure 2.24 the larger share of methane emissions is from enteric fermentation while manure management account for approximately 7% of sector emissions. The manure management systems utilized in Belize are open pasture; and for dairy cattle, the manure is piled and then applied to pasture and crops. For poultry, the litter is removed with the manure, dried and then sold or used in crop production.

Furthermore, methane emissions from rice cultivation and from biomass burning in cropland (attributed to secondary burning of sugarcane in the field), are based on productive acreage, however both represent relatively constant markets.

Nitrous Oxide Emissions: With respect to nitrous oxide emissions the trend also is as a result of the activities in the sector related to the livestock populations. Again the 2006 software is more efficient in capturing the full activities such as manure management, enteric fermentation and from managed soils that have been fertilized with nitrogen fertilizers and crop residues. The practice in Belize is the use of unmanaged manure systems for which the results reported were generated by the software.

Figure 2.25: Agriculture Nitrous oxide emissions (Gg CO2eq)



h. Analysis of Results

- Agriculture sub-sector

The results of the estimations of the GHG emissions in Table 2.18 from the AFOLU sector suggest that the emissions from the agriculture sector vary depending on the annual crop and livestock production. Methane emissions from livestock demonstrated a trend of constant increase over the study period. On the other hand, emissions from rice production remained almost constant over the same period. This is probably related to the level of production maintained by the Mennonite farmers who are the major commercial producers. They produce in order to satisfy the national local demand as there is no export of this commodity. Rice consumption has not increased rapidly, and might even be affected by clandestine imports. Observations also suggest that the trends in local production also respond to the global markets for these commodities in any given year.

Agriculture residue burning is linked to the volume of sugarcane harvested and milled. The lower level of emissions estimated for 2012 could therefore reflect similarly lower volume of sugar cane processed by the factory in that year. Otherwise the GHG emissions from this source appear to remain almost constant.

Table 2.18: Agriculture Emissions and Removals from sector sources (Gg CO2 eq)

Code	Source Category	1994	1997	2000	2003	2006	2009	2012	2015	2017
		Gg CO2 eq								
Total Emissions Agriculture		131.88	78.05	107.74	125.32	145.27	184.50	207.04	232.07	293.40
3.A	Livestock	74.51	50.33	71.26	75.33	98.39	121.63	131.65	138.85	177.27
3.A.1	Enteric Fermentation	68.64	47.89	66.44	72.36	94.63	117.30	122.23	128.43	162.64
3.A.2	Manure Management	5.87	2.45	4.82	2.97	3.76	4.32	9.42	10.42	14.63
3.C	Aggregate sources and non-CO2 emissions sources on land (Agriculture)	57.37	27.72	36.48	49.99	46.87	62.87	75.39	93.22	116.13
3.C.1	Biomass burning (Agriculture)	NE	NE	1.21	1.21	NE	4.67	7.74	12.79	15.75
3.C.2	Liming	2.54	3.67	4.39	5.31	4.89	4.27	0.94	1.01	0.30
3.C.3	Urea application	9.37	2.33	1.26	15.18	2.10	4.30	4.47	12.92	12.33
3.C.4	Direct N2O emissions from managed soils	40.67	19.06	22.94	22.61	34.69	41.83	51.33	54.42	70.43
3.C.5	Indirect N2O emissions from managed soils	3.88	0.34	4.42	0.61	1.31	1.40	7.01	7.90	11.78
3.C.6	Indirect N2O Emissions from Manure Management	3.88	0.34	4.42	0.61	1.31	1.40	7.01	7.90	11.78
3.C.7	Rice cultivations	0.90	2.33	2.26	5.07	3.89	6.40	3.90	4.18	5.54

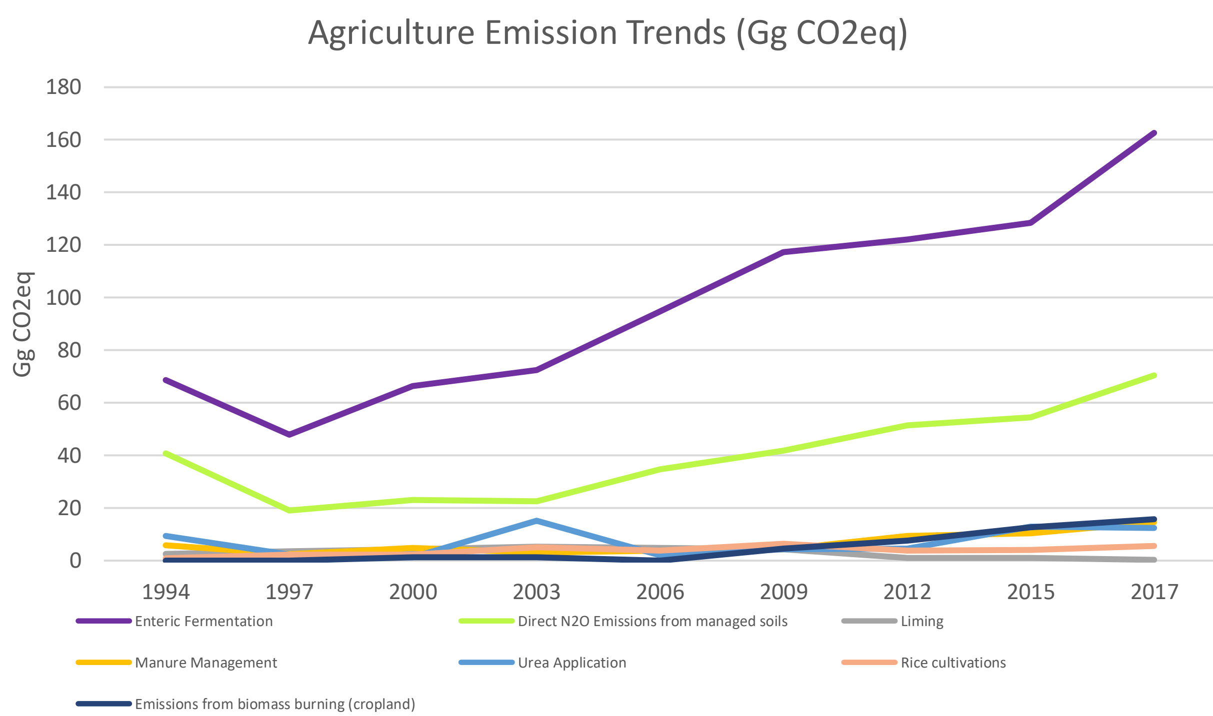
Notes:

3.A.2: –This value is the total emissions for CH4 and N20, but the estimate is negligible.

3.C: - Rice was separated as the aggregate for Land Use was split between Agriculture and FOLU.

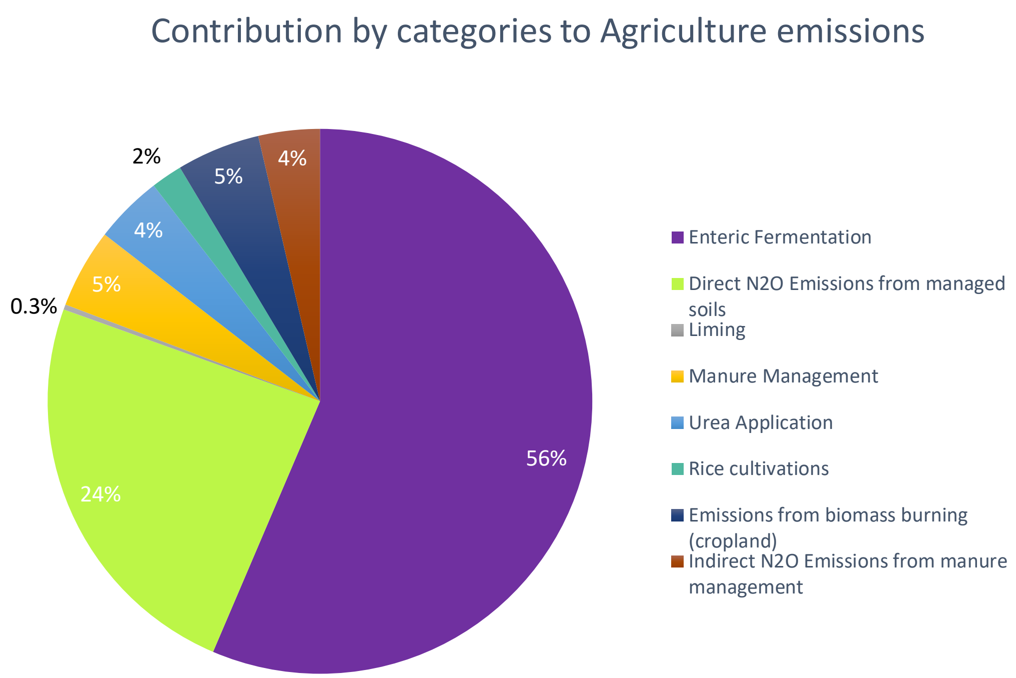
The trend displayed in Figure 2.26 is a gradual increase over the assessed period, during which it can be observed that the major contributor to emissions in the Agriculture sector is livestock mainly through enteric fermentation; followed by agriculture biomass burning, and manure management (see Table 2.18).

Figure 2.26: Agriculture Emissions from Sector sources (Gg CO2 eq)



Furthermore, Figure 2.27 below illustrates the main categories from which these emissions are coming from. Enteric fermentation accounts for 56% of the emissions from agriculture on an annual average over the study period, 2012-2017. N2O emissions from soil management accounts for 24%, followed by biomass burning and manure management at approximately 5% respectively. Rice cultivation accounts for 2% of emissions in the sector.

Figure 2.27: Major contributors to emissions in the Agriculture sector



- Forest and Other Land Use sub-sector

Highly accurate activity data for Forestry and Other Land Use sector was derived from the Collect Earth image visualization tool to obtain spatially explicit annual data of land use and land use change for time series of 2000-2017. For this inventory, emissions and removals are shown for the reference years and the recalculated years (1994-2017), and year by year data on FOLU emissions and removals can be found in Annex 4. A visualization of this entire time series, however, can be seen in Figure 2.28.

The Forest and Other Land Use sub-sector as shown in Table 2.19, shows a generalized increase in emissions from 1994 to 1997. However, for the time 2000 onward the generalized trend is one of fluctuating decreases and increases which can be attributed to natural disturbances, and in some instances attributed to the change in land-use. More detailed changes in land uses by hectares which contribute to the overall GHG emissions and removals is shown in Table 2.19.

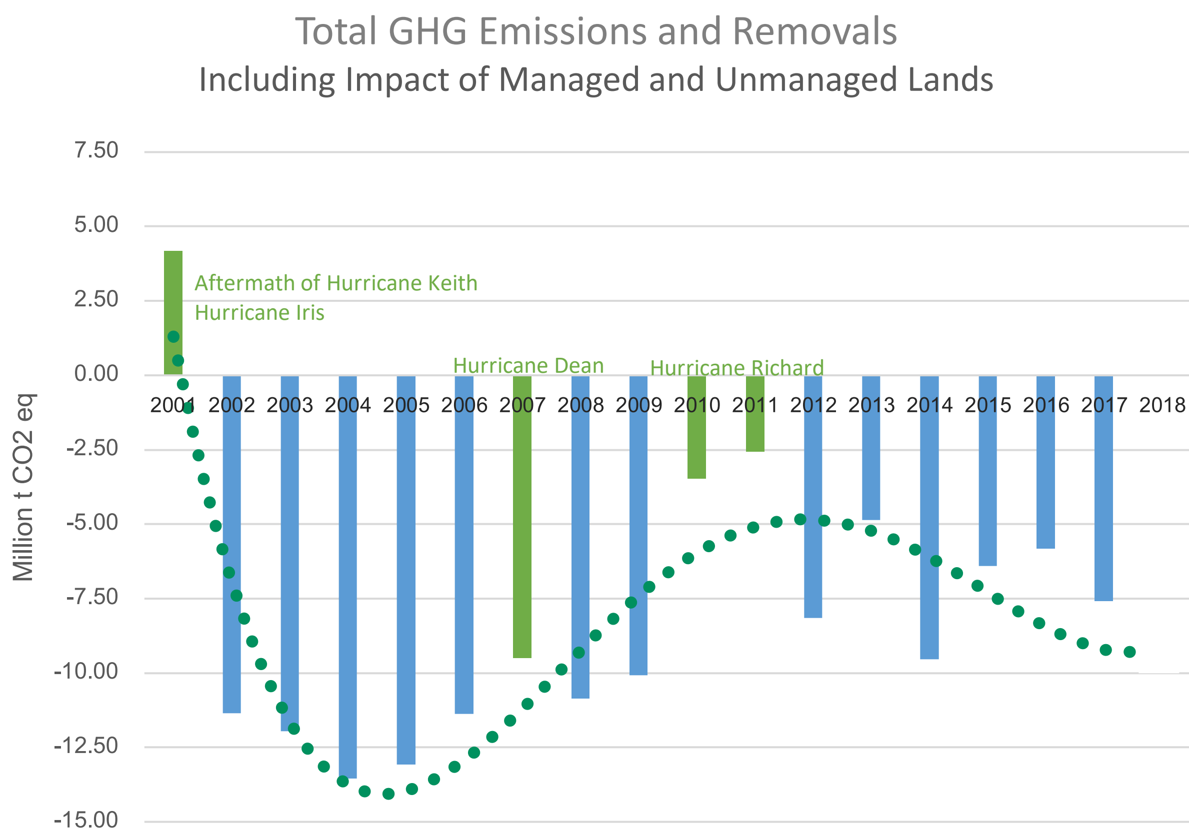
Table 2.19: Summary of Emissions and Removals from AFOLU sector 1994 – 2017 (T CO2eq)

	IPCC Source Category	Gases	1994	1997	2000	2003	2006	2009	2012	2015	2017
3	Agriculture, Forestry, and Other Land Use		-6,614,016	-7,197,206	-7,725,051	-11,755,290	-11,218,400	-9,868,805	-7,771,371	-6,104,957	-6,683,156
3.A	Livestock	CH4 & N2O	74,511	50,332	72,361	75,329	98,392	121,627	131,649	138,853	177,268
3.A.1	Enteric Fermentation	CH4	68,641	47,886	66,439	72,359	94,630	117,303	122,228	128,428	162,642
3.A.2	Manure Management	CH4 & N2O	5,871	2,446	5,922	2,970	3,761	4,325	9,421	10,424	14,626
3.B	Land	CO2	-6,777,535	-7,307,694	-7,837,854	-11,885,207	-11,391,358	-10,089,052	-8,011,329	-6,344,682	-6,986,500
3.B.1	Forest Land	CO2	*	*	-6,679,819	-14,575,305	-14,249,679	-14,040,096	-13,250,304	-12,289,920	-10,935,231
3.B.2	Cropland	CO2	*	*	-85,934	1,549,973	1,770,295	2,411,436	3,651,007	4,391,998	2,717,100
3.B.3	Grassland	CO2	*	*	-1,074,237	1,137,989	1,310,018	1,583,780	1,797,166	1,593,853	1,239,398
3.B.4	Wetlands	CO2	*	*	0	0	-198,339	0	-198,339	0	0
3.B.5	Settlements	CO2	*	*	2,136	2,136	-23,653	-44,173	-10,859	-40,612	-7,768
3.B.6	Other Land	CO2	*	*	0	0	0	0	0	0	0
3.C	Aggregate Sources and Non-CO2 Emissions Sources on Land	CO2, CH4 & N2O	105,406	74,835	79,622	65,532	74,807	92,423	106,666	124,394	160,576
3.C.1	Emissions from Biomass Burning (Land F,G)	CH4 + N2O in CO2e	48,034	48,034	43,142	15,541	27,934	29,555	31,280	31,175	44,446
3.C.1	Emissions from Biomass Burning (Agriculture)	CH4 + N2O in CO2e	57,372	26,801	1,210	1,210	NE	4,669	7,736	12,792	15,753
3.C.2	Liming	CO2	IE	IE	4,390	5,310	4,890	4,270	940	1,010	300
3.C.3	Urea Application	CO2	IE	IE	1,264	15,176	2,098	4,296	4,470	12,918	12,329
3.C.4	Direct N2O Emissions from Managed Soils	N2O	IE	IE	22,937	22,612	34,687	41,831	51,328	54,421	70,430
3.C.5	Indirect N2O Emissions from Managed Soils	N2O	NE	NE	NE	NE	NE	NE	NE	NE	NE
3.C.6	Indirect N2O Emissions from Manure Management	N2O	IE	IE	NE	NE	NE	NE	NE	NE	NE
3.C.7	Rice Cultivations	CH4	IE	IE	4,419	611	1,307	1,397	7,014	7,902	11,777
3.C.8	Other		NE	NE	2,260	5,073	3,892	6,405	3,898	4,177	5,541
3.D	Other		-16,398	-14,678	-39,181	-10,944	-241	6,197	1,643	-23,522	-34,500
3.D.1	Harvested Wood Products	CO2	-16,398	-14,678	-39,181	-10,944	-241	6,197	1,643	-23,522	-34,500

Land Use Change in Forests

In reviewing the overall impact of forests and land use change on total emissions and removals, Figure 2.28 below shows a cyclical behavior of increasing and decreasing absorption of CO2. This is largely due to recurring hurricanes that impact national forests, with the most impactful hurricane events highlighted in the graph. Usually in the year of a large-scale hurricane, emissions increase, followed by a period of recovery (increased removals).

Figure 2.28: Total emissions and removals in Belize (including Managed and Unmanaged Lands (Million t CO2eq)

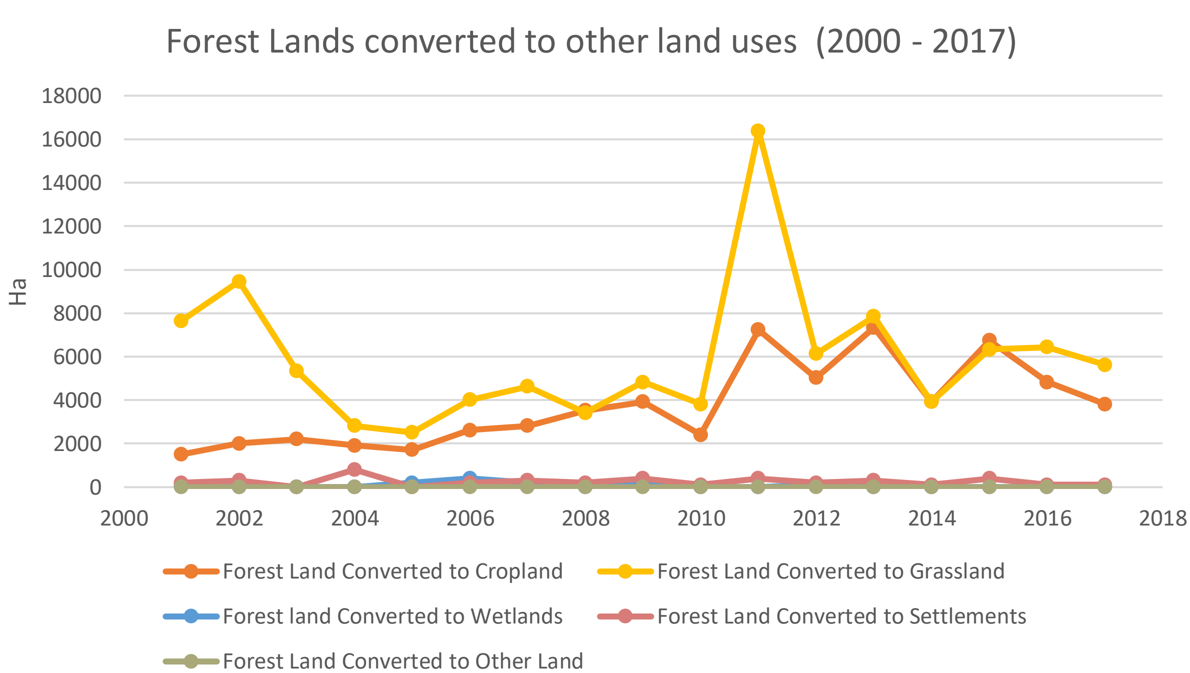


From Table 2.20 below, on land use change conversion, it can be seen that Cropland and Grassland were the major drivers of Forest conversion, with Grassland being the most significant contributor on average for the three reference years. While the forest conversions might have been initiated by natural phenomenon (hurricane events), the continuing changes were mainly caused as farmers and landowners took advantage of the loss of forest cover to convert the land to other use, farm, pasture, or otherwise.

Table 2.20: Land Use Change by Area, 2000-2017 (Ha)

Year	Forest Land Converted to Cropland	Forest Land Converted to Grassland	Forest land Converted to Wetlands	Forest Land Converted to Settlements	Forest Land Converted to Other Land
2001	1508	7640	101	201	0
2002	2011	9450	0	302	0
2003	2212	5328	0	0	0
2004	1910	2815	0	804	0
2005	1709	2513	201	0	0
2006	2614	4021	402	201	0
2007	2815	4624	201	302	0
2008	3519	3418	0	201	0
2009	3921	4825	101	402	0
2010	2413	3820	0	101	0
2011	7238	16386	0	402	0
2012	5027	6132	101	201	0
2013	7339	7841	0	302	0
2014	3921	3921	0	101	0
2015	6736	6333	0	402	0
2016	4825	6434	0	101	0

Figure 2.29: Forest Lands converted to other land uses (2000 – 2017)



These land use change conversions are visually represented in

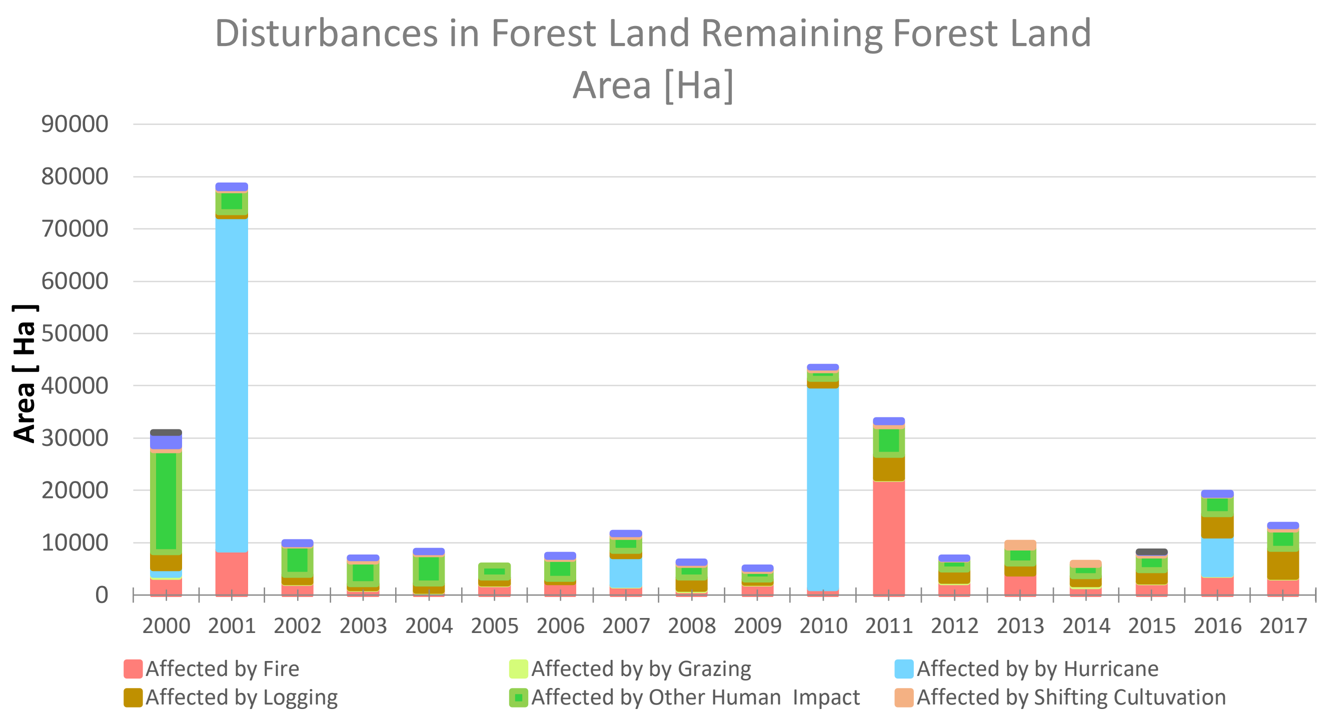
Figure 2.29. There was a major spike in emissions in 2011 when an estimated area of 16386 ha of forest were converted to Grassland. This was due to Hurricane Richard, which hit the country in 2010 and damaged large areas of forests. Large open patches of almost severely destroyed forests were converted to grasslands because of this incident. It is also noted that in the years 2001, 2002, and 2003, there were major conversions of Forest lands to Grasslands. This particular period of conversion was due to thousands of hectares of forested lands in the Mountain Pine Ridge and Coastal Plains area being affected by the southern pine bark beetle pest infestation that impacted the country between 1999 and 2001.

The second main driver for forest land conversion was cropland. From Table 2.20, it shows that Forest converted to Cropland remained relatively constant between 2001 and 2010, with a slow increase in the latter part of the ten-year period. However, after 2010, there were more rapid increases in the conversion of forest conversion to cropland, remaining relatively high until 2017. The more recent forest conversion to cropland after 2010 is believed to be because of Hurricane Richard. Some of the forested areas that were affected by the hurricane were turned into agricultural lands in the mid-western part of the country. This activity seemed to have caused a continuing trend of the conversion of forest lands for crops during the years that followed. Examination of the data for forest conversions for the reference years of 2012, 2015 and 2017, revealed that both Cropland and Grassland were major drivers for forest conversions.

Forest Disturbances

As for the disturbances occurring in national forests, it can be noted in Figure 2.30, that hurricanes have impacted forests sink capabilities, and commonly lead to other disturbance types such as fire, logging activities, conversion to pasture, and cultivation. For the years 2001 and 2010, there were significant disturbances noted in areas that did not have a land conversion but still were affected by Hurricane Iris (2001) and Hurricane Richard (2010) showing once more the significance of the occurrence of Hurricanes over the years.

Figure 2.30: Disturbances in Forest Land Remaining Forest Land



Belize like most countries in the Latin American region shows that one of the major sources of greenhouse gas emissions is deforestation. Increases in land degradation and increased utilization of land with less productive potential coupled with the present rate of population increase all contribute to greater forest conversion.

2.5 Waste

a. Sector Background

The Solid Waste Management Authority Act established the Solid Waste Management Authority and a Board of Directors of the Solid Waste Management Authority (SWAMA). The SWAMA and the Board is charged with the responsibility to deal with all matters pertaining to and conducive to the management of solid waste in Belize. Existing service areas are primarily areas being served by the municipalities (Town and City Councils). The Western Corridor is served by waste disposal services including waste management at the National Sanitary Landfill that presently serves Belize City and the communities along the George Price Highway Corridor. This landfill receives daily garbage waste from transfer stations in San Ignacio, San Pedro, Caye Caulker, Burrell Boom and Belize City.

The Categories for the estimation of the emissions in the Waste sector are listed in Table 2.21Table 2.21 below.

Table 2.21: Categories for estimation of Waste Sector Emissions

Categories
4 – Waste
4.A – Solid Waste Disposal
4.A.1 – Managed Waste Disposal Sites
4.A.2 – Unmanaged Waste Disposal sites
4.A.3 – Uncategorized Waste Disposal Sites
4.B. – Biological Treatment of Waste
4.C - Incineration and Open Burning of Waste
4.C.1 – Waste Incineration
4.C.2 – Open Burning of Waste
4.D – Waste treatment and Discharge
4.D.1 – Domestic Wastewater Treatment and Discharge
4.D.2 – Industrial Wastewater Treatment and Discharge
4.E – Other (please specify)

Belize's waste sector can be divided into the Solid Waste and Liquid Waste Sectors.

b. National Legislation

Legislation pertinent to the Waste sector includes:

- Belize Environmental Protection Act, 1992
- Solid Waste Management Authority Act, 1991

- Effluent Limitations Regulations, 1996

c. Gases included

Carbon dioxide, Methane, and Nitrous oxide were the GHG gases for which the emissions were estimated in this sector.

d. Reporting years

Reporting years for the current Waste sector GHG inventory were similar to the other sectors surveyed, 2012, 2015, and 2017.

e. Recalculations

Efforts were made to recalculate past sector inventories, but this available data in this sector has benefited from the fact that the solid waste generation rate has more scientifically generated rates derived from additional studies (Hydroplan and Hydea). Different methodologies, which were incompatible, were utilized in the two studies. As a result, it was concluded that earlier data was rendered obsolete. Recalculation would have proven extremely difficult.

f. Description of methodologies and data sources

- Emission factors

The Emissions Factors applied to estimate the emissions in the Waste sector are listed in the table below.

Table 2.22: Emission /Carbon – stock change Factors of the Waste Sector

Activity	Emission Factor
Solid Waste Disposal (Tier 1)	0.6 Kg CH4/Kg BOD
Solid Waste Disposal (Tier 2)	0.5 Kg CH4/Kg BOD
Indirect N2O (Tier 2)	0.005 Kg N_2O –N Kg N
Waste water treatment and disposal	0.5 Kg CH_4/Kg BOD (Default value)
Methane Correction Factor – Solid Waste Disposal	
Unmanaged Deep	0.8
Shallow	0.4
Managed Aerobic	1.0
Managed semi-aerobic	0.5

Note: Organically Biodegradable BOD (Biochemical Oxygen Demand) = 14.6 Kg BOD/yr.

- Activity Data

The Waste sector inventory was calculated for GHG emitting activities such as solid waste disposal including landfills, open burning of solid waste, and some limited domestic and industrial waste water treatment and disposal.

Solid Waste Data: The SWAMA has commissioned several investigations and reports in relation to solid waste management. One such investigation was a waste characterization study of the major population centers of the Western Corridor that was carried out in 2011. The study estimated the waste production rate and waste characterization of several municipalities including San Ignacio/Santa Elena, Belize City, San Pedro and Caye Caulker. This study determined that the rate of solid waste coming from the domestic sector was estimated at 1.07 kg or 2.36 pounds per capita per day (Hydroplan for Solid Waste Management Authority, May 2011). This same study also determined that residential waste amounts to 63.8% of all municipal waste produced in the corridor, while waste from the business/commercial sector accounts for 31.8% and the industrial sector produces 4.5% of waste.

Waste in the Western Corridor is comprised as in the table below.

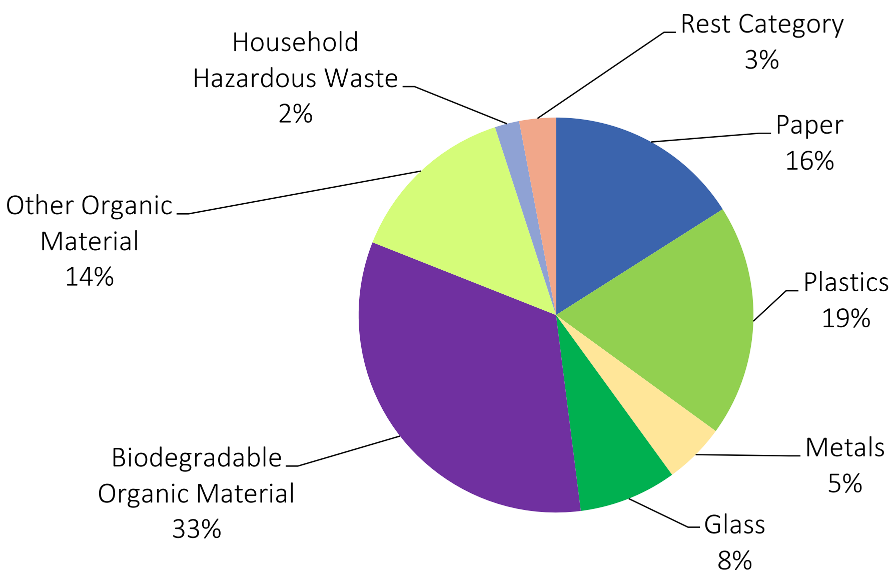
Table 2.23: Waste Composition – Western Corridor

Item	Percentage
Plastics	19%
Metals	5%
Glass	8%
Biodegradable organic material	33%
Other organic material comprises	14%
Household hazardous waste	2%
"Rest"	3%

The "rest" category consists of miscellaneous waste that is not normally categorized in any of the other categories and comprises small quantities of miscellaneous waste. These numbers are illustrated in

Table 2.23 and Figure 2.31. Biodegradable organic material is comprised of (i) food scraps, (ii) yard waste, grass, leaves and twigs, and (wood). Most of this material can be used for composting. The category "other organic materials is comprised of (i) bones, (ii) leather, (iii) textiles, (iv) rubber, and (v) sanitary pads/disposable diapers. This material cannot be used for composting.

Figure 2.31: Solid Waste Composition – Western Corridor



Source: Hydroplan & Solid Waste Management Authority.

This data is important considering that prior to the study by Hydroplan, the available generation rates of solid waste was calculated by the estimation of total quantities received at municipal dumps, and dividing this by the population being served by waste dumping services. This data was only available for urban municipal bodies, considered urban centers in Belize, and excluded most villages or rural communities. These generation rates were used for the inventory years 1994 to 2009. However, for the recalculations, it was decided to apply the Hydroplan rates of 1.07 kg per waste being generated at the Western Corridor, since the study is considered a more reliable data of waste generation rates.

As can be seen in the table below, rates obtained for 2000 to 2009 and used in the previous inventory reports was mostly based on the rates obtained by each local municipal body.

Table 2.24: Estimated Solid Waste Generated by Municipality, 2000 – 2009

Estimated Solid Waste Generated by Municipality, 2000 – 2009. Urban Centre	Population 2004 Mid-year (CSO 2004)	Kg/capita/day (CSO, 2000)	Kg per day (CSO, 2000)	Tons per Day	Tons per Annum	Tons burnt per Annum
Belize City	59,000	1.54	91,476	91.476	33,389	1,002
Orange Walk	15,000	1.27	19,050	19.05	6,593	209
San Ignacio/ Santa Elena	16,100	1.32	21,252	21.252	7,757	233
Corozal	8,600	1.5	12,900	12.9	4,709	141
San Pedro	7,600	2.18	16,568	16.568	6,047	181
Belmopan	12,300	1.18	14,514	14.514	5,298	159
Benque Viejo	6,700	1.13	7,571	7.571	2,763	83
Dangriga	10,400	0.95	9,880	9.88	3,606	108
Punta Gorda	4,900	0.99	4,851	4.851	1,771	53
TOTAL	141,000	12.06	198,062	198.062	72,293	2,169
MEAN	15,667	1.34	22,007	22	8,033	241

Source: SIB, and LIC.

Therefore, for the purpose of this current inventory, this data is now obsolete as the rates of waste generation are entered based on official studies in the IPCC software. The IPCC software requires that total population data at the national level is entered along with waste generation rates, both data which are now readily available.

Similarly, waste composition data that was previously not required in the older software is now available, also based on scientific studies. Prior to the 2012 inventory year, there was no scientific data on the composition of solid waste in Belize. This changed with the Hydroplan study, and the composition was estimated as shown in Figure 2.31 above.

In 2016, another study, also commissioned by the SWMA and produced by Hydea Ltd. Of Italy; resulted in a Solid Waste Master Plan for Northern and Southern Belize, and included waste composition and waste characterization studies carried out in these two regions not previously investigated by previous studies. The Hydea study resulted in new waste generation rates that were previously unknown in the northern and southern corridors, thus skewing the new national rates that were applied to the years 2015 and 2017, being the period of time for which the study was more relevant. A combination of the new generation rate was now 0.71 kg per capita (previously 1.07 kg/capita/day from Hydroplan study). The waste composition component of the new Hydea report also contributed to new figures for the percentage of waste composition, but the changes did not vary significantly from the previously established rates by Hydroplan.

A more accurate generation rate would be to apply generation rate per municipality, however would require more extensive data. As a result, the national average for domestic waste generation was applied. In Summary, Table 2.25 below shows the aggregated averages used in the recalculations and the new inventory years starting from 2012 to 2017.

Table 2.25: National Domestic Waste Generation Rates Applied for the GHG Inventory

Period (Years)	Source of Data	Rate (kg/capita/day)
1994-2012	HYDROPLAN	1.07
2015-2017	HYDROPLAN/HYDEA	0.72

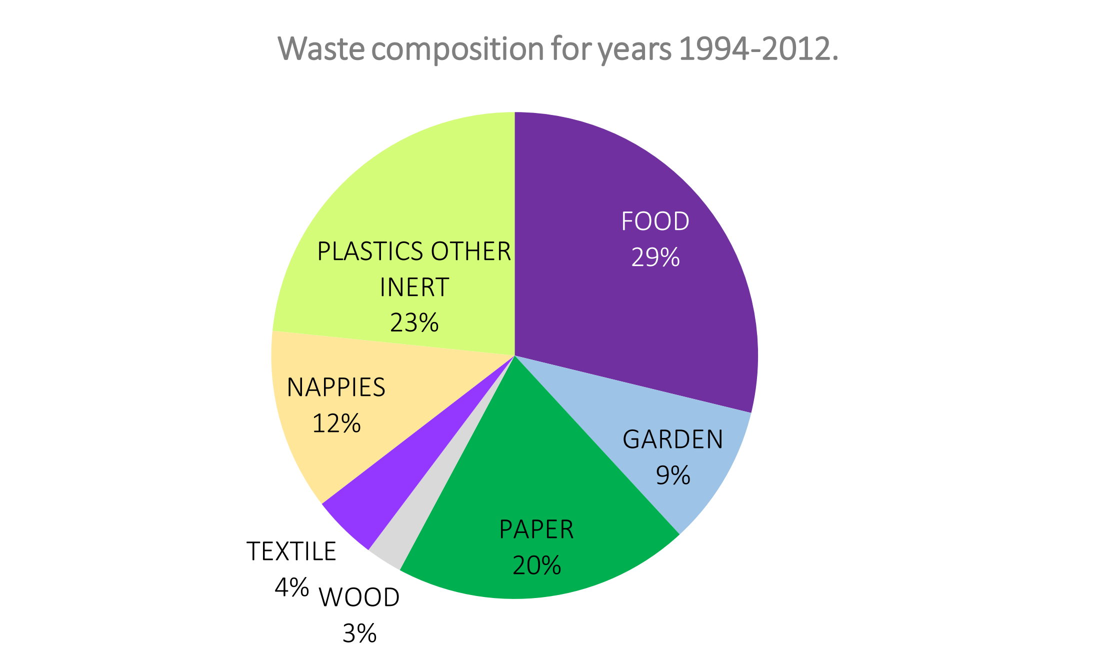
Waste Composition: Considering the application and use of the 2006 IPCC software, knowledge on the composition of solid wastes now facilitates the calculations of emissions. The waste composition analysis of the IPCC 2006 software takes into consideration those materials that have known parameters as well provides useful input into recommended activities such as recycling, composting and other initiatives to reduce emissions. Table 2.26 summarizes the waste composition by percent that was obtained from both the Hydroplan Study of 2011, and the Hydea study completed in 2016.

Table 2.26: Waste Composition Applied for Inventory and Source of Data

Source year	Source	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert
1994-2012	HYDROPLAN	23.40	7.60	16.00	1.98	3.50	9.80	19.00
NA	HYDEA	23.40	7.60	16.00	1.98	3.50	9.80	19.00
2015-2017	Average Used	25.89	7.85	11.71	1.05	4.52	10.76	17.92

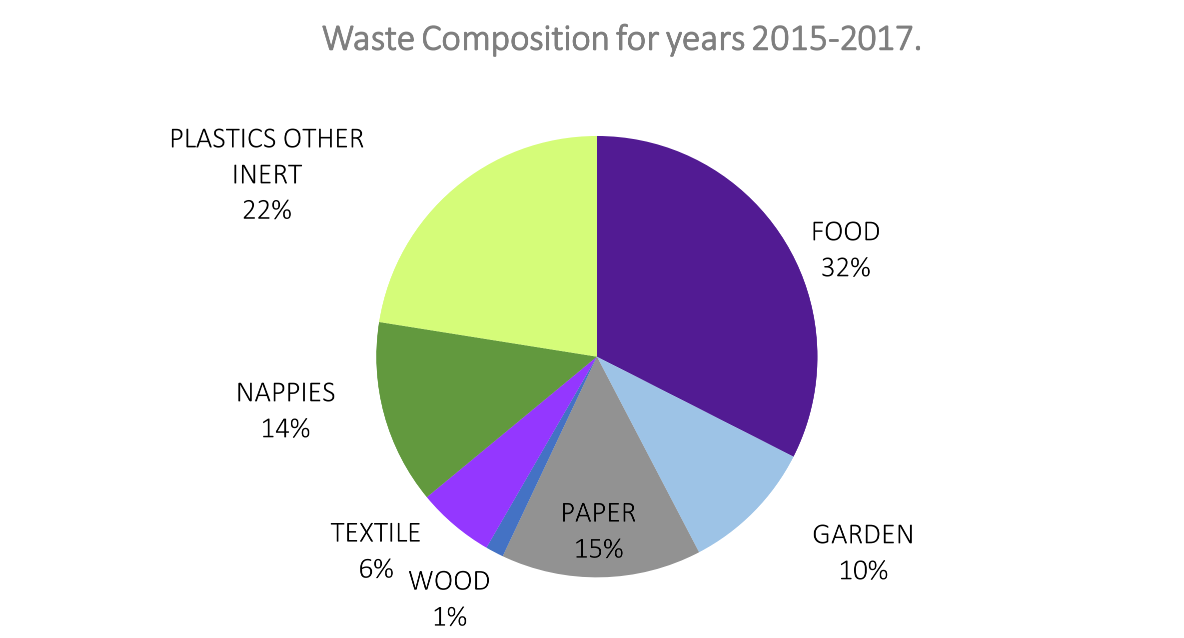
Similarly, during the previous inventory years prior to 2011 when the first waste generation and composition study was done, there was no data on waste composition. It was decided that for the recalculation the Hydroplan study data was used, and for the 2015-2017 inventory years, the average of both results were used, which, as can be seen from Table 2.25 above yielded similar waste composition results. Figure 2.32 and Figure 2.33 show the results of both studies graphically, showing similar waste composition by percent for Belize (with the exception of Paper, with 5% difference).

Figure 2.32:Waste Composition for years 1994 – 2012



Source: Hydroplan 2011.

Figure 2.33: Waste Composition for years 2015-2017



Source: Average from SWMA Hydroplan 2011 and Hydea 2016.

Population Data: Throughout the inventory years, including the years for the re-calculations; the mid-year population estimates for that year were used in the spreadsheets. These figures are official figures produced by the Statistical Institute of Belize. Official Urban/Rural population estimates from this source were also used. These population data were obtained from the SIB's web site.

In Belize, the waste burning that can presently be easily quantified takes place in rural areas where open dumping of solid waste is more frequent. To obtain the estimated population practicing the open burning of waste, the rural population not served by municipal disposal of waste was used based on the SIB's mid-year population for the rural area as it applies to that inventory year, and multiplying this by the SIB's rate of burning of waste at the national level which is 26.9% (SIB 2010). Other municipalities practice occasional burning but it is not possible to quantify this since there is no study or data supporting the rate of burning in towns or cities.

Liquid Waste data: Liquid waste includes domestic and industrial wastewater, although data about both is limited in availability. Domestic wastewater data was obtained from Belize Waster Services Limited (BWSL) generated through official surveys of the population served by septic tank systems, latrines, and open disposal, was entered using the Tier 2 approach. This data was obtained from the Multiple Indicator Cluster Report 2015 to 2016 Report (MICS Report, SIB & UNICEF Belize, 2017). The MICS Report also included data on income level that was also relevant to the country's national inventory efforts, since the software segregates data on the fraction of waste disposal by the percent, or fraction of the population using each particular waste disposal method, according to rural, urban high income and urban low income levels.

It was possible to use country specific data for generation rates since these were derived from official surveys for the population served by septic tank systems, latrines, and open disposal, and open sewer disposal. This data was mostly available from the Multiple Indicator Cluster Report 2015 to 2016 Report (MICS Report, SIB & UNICEF Belize, 2017). The MICS Report also included data on income level that was also relevant to the country's national inventory efforts, since the software allows data to be segregated on the fraction of waste disposal by each type, and also the fraction of the population using each particular waste disposal method, according to the categories for rural populations, urban high income and urban low income populations. The income levels were obtained also from the MICS Report, but for the estimation of data for the IPCC software, the two lowest quintiles were used as the low income population and the remaining three highest quintiles as high income. Therefore, of the national urban population which is 45%, the population income level for urban low income was 25 % of the 45%, and the urban high income was 20.5% of the 45. The rural population using various types of systems was not segregated into urban and rural low income, since most of this population does not use the anaerobic shallow system, and the rates were applied according to that of the MICS report.

Industrial Solid Waste: Both the citrus and the shrimp industry utilize some level of anaerobic treatment in ponds, and therefore, the volume of this effluent was categorized as managed anaerobic, and the volume of the bagasse from the sugar cane as uncategorized waste.

Biological Treatment of Solid Waste: Citrus peels and other solid waste from this industry are mostly re-used after treatment, for organic fertilizer. The remaining waste is composted (and accounted for in "Biological treatment of solid waste". Due to processing for fertilizer volumes are now low. Shrimp farming also produces some waste in the form of shrimp heads with effluent that are treated by burying and is also accounted for in "Biological treatment of solid waste". However, due to the decline of the shrimp industry as a result of challenges such as virus infestations over the past years, the waste from the sector is minimal. Nevertheless, total volumes of waste from this sub-sector ranging between 13,400 to

13,700 metric tons were included in the estimations for the current reference years. The exception is in 2013, where just over 3,000 metric tons of waste was treated by composting.

- Description of methodologies

The calculations of the GHG emissions from the Waste sector utilized the Tier 1 approach as reliable information exists. For the calculations of the MCF and other parameters the default coefficients are utilized and where known figures based on the composition of waste, they are inserted. The total urban and rural populations are based on SIB data. The existing urban centers that are served by waste disposal was utilized to calculate solid waste generation rates and known disposal rates are used to estimate GHG emissions. In rural communities, waste disposal is normally done by burning and other methods (IPCC Guidelines, 2006). However, certain communities considered rural, such as Burrell Boom, Ladyville, Cow Pen and Placencia, Independence, disposal was calculated based on existing national rates since these are served by municipal disposal. Table 2.28 shows the different waste disposal systems in use in Belize.

Solid Waste: In Belize, as a result of increased solid waste management practices, it is now easier than previous years to categorize the population centres that are receiving the above services as shown in

Table 2.27 as required for the IPCC inventory software. As it applies to Belize, the inventory software categorizes a country's waste services as per the population that uses the following types of waste disposal:

Table 2.27: Summary of Disposal Categories and Relevance to Belize

CATEGORY	DESCRIPTION	BELIZE APPLICATION
Unmanaged Shallow	Unmanaged SWDS not meeting criteria of managed SWDS with depths less than 5 meters	All open dumps and illicit dumps (mostly rural population)
Unmanaged Deep	Unmanaged SWDS not meeting criteria of managed SWDS with heights greater than or equal to 5 meters and with low water table	This definition applied to the Belize City dumps operated up until their closure in 2009, thus relevant for inventory years 1994-2009
Managed Anaerobic	SWDS with controlled placement of waste and with some degree of control, including the control of fires and a degree of cover material	All municipal dump sites, including the one used at Independence and Placentia are classified under this category
Managed-Semi-aerobic	SWDS with controlled placement of waste, permeable cover material, leachate drainage system, etc.	In this case, the National Sanitary Landfill meets most of these criteria, thus the population being served by the National Landfill was estimated for each inventory year. The populations and years when the populations were served by the landfill were considered.

Only the Belize City dumps (now closed) were categorized as unmanaged deep, and were used for the inventory years prior to 2009. The known mid- year population estimates for these years were entered into the new software.

The population with limited or no waste disposal services, primarily in the rural areas, was used for the category of unmanaged shallow.

All municipal bodies (not including those in the Western Corridor served by the national landfill) were served by managed anaerobic sites, for which the known population of these areas was entered for each inventory year. These are all municipal dumps, that have some control of the waste being disposed, and included the populations of the Placentia Peninsula and Independence, both which are also served by collection and disposal equivalent to that of municipal dumps.

The SIB'S Mid-year population in the Western Corridor being served by the National Landfill (Managed semi-aerobic) was applied for the years since the landfill came into operation, being for the years 2012 to 2017, but less the population of Caye Caulker, San Pedro and Burrell Boom, which were later served beginning in 2015, and for which the population was accounted for in the inventory years 2015 to 2017.

Liquid Waste: The waste water treatment and disposal calculations included domestic wastewater and industrial wastewater, where data was available. Domestic wastewater treated by the BWSL system was entered using known and available data, which included for the municipalities of Belize City, San Pedro and Belmopan, which are served by anaerobic systems.

Waste-Water treatment and Discharge: This sub-sector comprises domestic wastewater treatment and discharge and industrial wastewater treatment and discharge.

The liquid waste sector has greater limitations in terms of data availability. Domestic wastewater data is available from BWSL, but the population being served by the domestic treatment system is not totally updated.

In the Industrial Sector, there is no formal registration or estimation of liquid waste generated by the stakeholders within this sector, such as the shrimp and other smaller industries. Some waste-water data is available from beer, malt and soft drinks production, fruits (in his case citrus) and vegetables, and sugar extraction. Since the data is not readily available in the format required, it is derived from volumes of annual production converted (to tonnes) for the software (entered using Tier 1approach), along with the projected effluent (in terms of M^3 per tonne of product) and is calculated based on published product by volume or tonnes.

Waste Sector Data used for Recalculations of Previous Waste Sector Inventories: Recalculating the previous inventory years are affected by several factors that determine the waste sector emissions. The estimations for the solid waste sub-sector have benefited from new, more reliable and accurate waste generation rates derived from scientifically designed studies conducted for and by the Solid Waste Management Authority (ref Table 2.28). These are the 2011 Hydroplan and the 2016 Hydea Studies previously referred to in this report.

Table 2.28: Waste Sector Data used for Recalculations

Waste Data (in tons) used for Recalculations												
Source	Years											
	1994	1997	2000	2003	2006	2009	2012	2013	2014	2015	2016	2017
Solid Waste	247.8	218.5	460.5	506.3	699	959.6	364.6	374.2	384	394.1	404.4	415
Industrial Waste	n/a	n/a	n/a	n/a	n/a	n/a	35767796	521313	521312	545971	545475	646697

i. Results of GHG emissions and removals

Emissions from the Waste Sector: The estimation of the total emissions within the Waste Sector shows some small changes over the study period. The combined solid waste and wastewater sectors results in a total of 15.15 Gg of methane emissions in 2012, decreasing to 9.59 and then increasing to 12.09 in 2015 and 2017 respectively. Carbon dioxide was measured at 0.05 Gg in 2012, increasing slowly to 0.06 in 2015 and 0.07 in 2017. Nitrous oxide showed increases from 8.78 Gg in 2012 to 7.54 in 2015 and 9.72in 2017. The combined total emissions of these gases in the waste sector are 24.05 Gg in 2012, decreasing to 17.1 in 2015 and then increasing to 21.88 Gg in 2017.

The level of emissions from the waste sector appears to have increased considerably over the study period. The level of CO_2 emissions changed by 36% between 2012 and 2017, while the difference in methane emissions for the same period was estimated at 24%. Nitrous oxides also increased by 18% from 2012 to 2017. This represents a total of 18% increase of emissions within the sector over the study period.

Table 2.29 below shows the total emissions of all gases emitted (Gg CO_2 eq) from the Waste sector for the current inventory for the three reference years. The combined solid waste and wastewater sectors results in a total of 16.243 Gg CO2eq of methane in 2012, decreasing to 12.889 Gg CO2eq in 2015 and rising to 16.895 Gg CO2eq in 2017. Carbon dioxide, attributable to open burning of waste, was estimated at 0.054 Gg CO2eq in 2012, increasing to 0.057 Gg CO2eq in 2015 and 0.072 Gg CO2eq in 2017. Nitrous oxide showed a pattern similar to methane by decreasing from 8.78 Gg in 2012 to 7.54 in 2015 and increasing to 9.72 in 2017, as the majority of these N2O emissions are attributed to waste water (and a small fraction to open burning). The combined total emissions of these gases from the Waste sector are 22.73 Gg in 2012, decreasing to 19.89 in 2015 and increasing again to 26.81 Gg in 2017.

Table 2.29: Total Greenhouse Gas Emissions from the Waste Sector (Gg CO2 eq)

Greenhouse Gas	2012	2015	2017
	Gg CO_2 eq	Gg CO_2 eq	Gg CO_2 eq
CO2	0.054	0.057	0.072
CH4	16.365	13.017	17.023
N2O	6.310	6.818	9.718
TOTAL	22.73	19.89	26.81

Emissions from Solid Waste: The results of the estimated solid waste disposal in Gigagrams (Gg) are shown in Table 2.30 and Table 2.31. Table 2.30 shows the results using the earlier waste generation rates, while Table 2.31 shows the results using the waste generation rate of 1.07 kg/capita/day for 1994 to 2009, then 0.72 kg/capita/day for 2012 to 2017. It can be seen that the total municipal solid waste disposed was 0.38 in 2012, decreasing to 0.26 in 2015 and 0.27 in 2017. However, using the revised (and lower) waste generation rates, the results ranged from to 0.18 Gg in 2012 down to 0.15 in 2017.

Table 2.30: Estimate of Total MSW and Waste Disposed for 2012, 2015, 2017 (previous rates)

YEAR	TOTAL MSWD (Gg)	TOTAL TO SWD (Gg)
2012	0.38402	0.17503
2015	0.26518	0.12994
2017	0.27927	0.14522

Note: Estimates based on previous inventory waste generation rates

Table 2.31: Estimate of Total MSW and Waste Disposed for 2012, 2015, 2017 (current rates)

YEAR	TOTAL MSWD (Gg)	TOTAL TO SWD (Gg)
2012	0.17503	0.17503
2015	0.12994	0.12994
2017	0.14522	0.14522

Note: Estimates recalculated using new waste generation rates

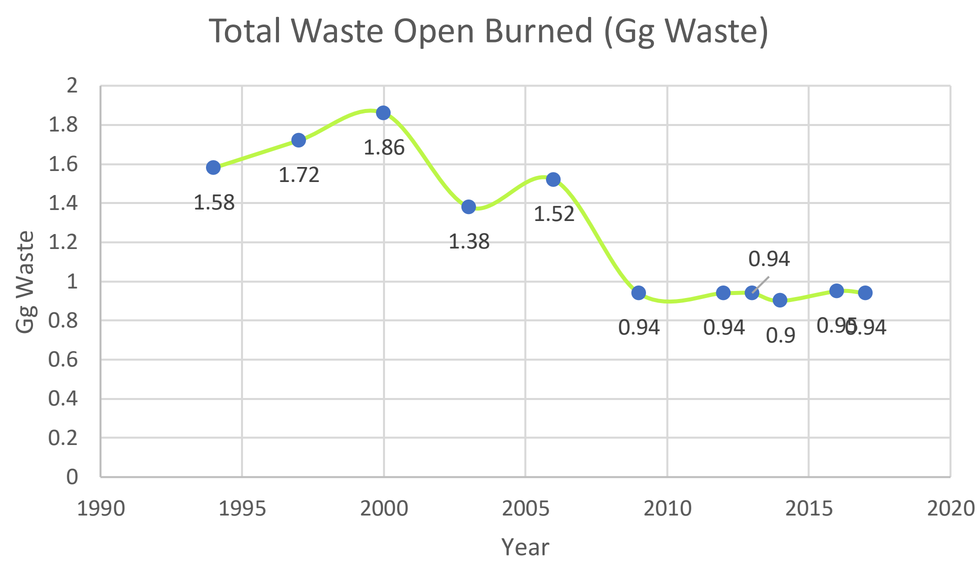
Table 2.32 shows methane emissions from solid waste disposal as well as methane, carbon dioxide and nitrous oxides from open burning. As can be seen, the overall trend is for methane from waste disposal to increase because of increasing population. The improved treatment of waste has not totally cancelled the methane emissions as the population increases. However, there is a notable decrease in GHG emissions as a result of decreased open burning. In 1994, methane emissions were estimated at 0.216 Gg CO2eq and for 2017 was 0.128 Gg CO2 eq. However, methane emissions from open burning for the same period has decreased as a result of improved waste treatment and a decrease in open burning of waste by municipalities. The same applies for nitrous oxides and carbon dioxide.

Table 2.32: Waste Emissions from Past and Current Inventories

GHG (Gg CO2eq)	YEAR								
	1994	1997	2000	2003	2006	2009	2012	2015	2017
CH4 Methane from Solid Waste Disposal									
CH4	0	0.007	0.011	0.014	0.016	0.019	0.023	0.023	0.054
Greenhouse gas from Open Burning of Waste									
CO2	0.0953	0.1039	0.1125	0.0832	0.092	0.049	0.054	0.0568	0.0716
CH4	0.216	0.235	0.254	0.188	0.207	0.110	0.122	0.128	0.128
N2O	0.061	0.066	0.072	0.053	0.059	0.031	0.035	0.036	0.036

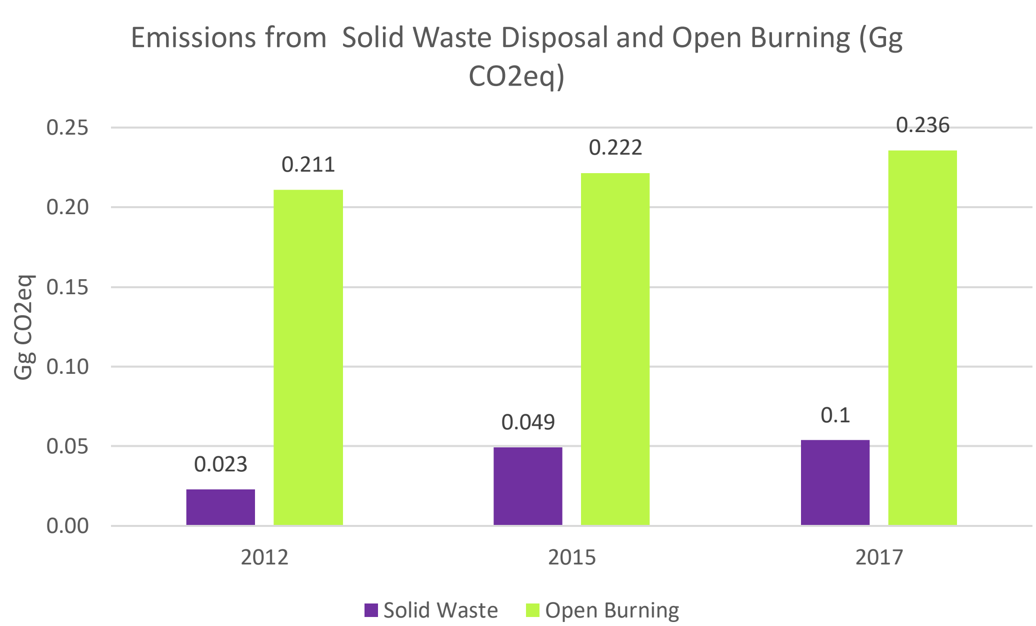
During the period 1994 to 2009, all municipalities practiced open burning of waste at the municipal dumps as a means of waste control. Efforts to stop the practice of open burning at the municipal level was first initiated with the closure of both of the two Belize City dump sites, and more effectively in 2012, with the opening and operation of the National Sanitary Landfill, which then served most large municipalities in the Western Corridor. Figure 2.34 below is a graphical representation of how the GHG emissions from open burning of solid waste were higher in the years when this was the standard practice across the nation. Since the establishment of the national landfill, and major reduction of open burning, the overall volume of waste open burned has decreased significantly. However, emissions of GHGs have only decreased slightly because it is being offset by increases in the population generating more waste, and the fact that there are still many village communities which still practice open burning.

Figure 2.34: Total Solid Waste Open Burned over the period 1994 – 2017



Greenhouse gases emitted as a result of solid waste disposal and open burning of solid waste between the period 2012 to 2017 is shown in Figure 2.35 below.

Figure 2.35: Emissions from Solid Waste Disposal and Open Burning (Gg CO2eq)

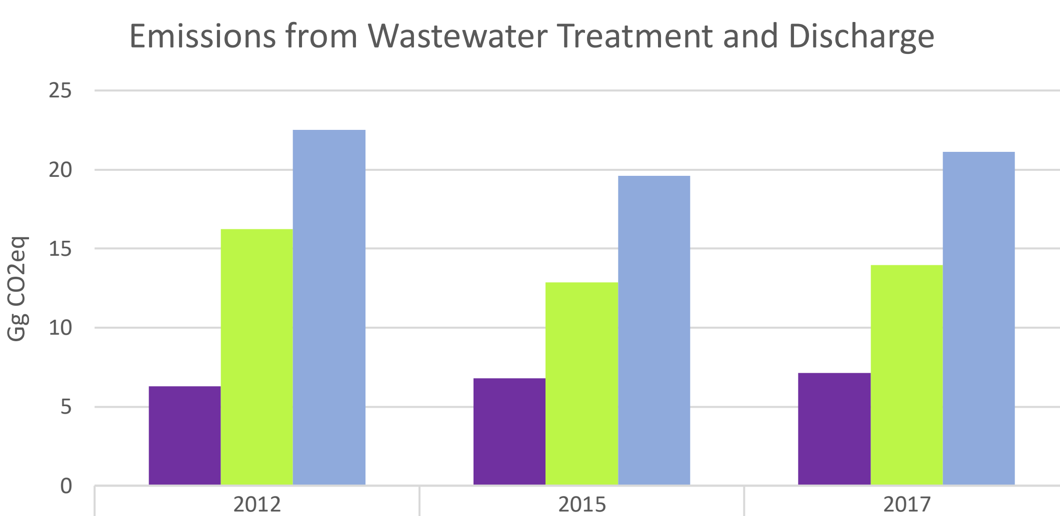


Emissions from Liquid Waste: This sector is comprised of domestic wastewater treatment and discharge and industrial wastewater treatment and discharge. However, the liquid waste sector has great limitations in terms of data availability. Domestic wastewater data is available from BWSL, but the proportion of the population being served by the domestic treatment system is not updated. Only sections of Belmopan, Belize City and San Pedro Town are connected to a wastewater collection and treatment system.

In the industrial sector, there is no formal registration or estimation of liquid waste generated within the industrial sector (including both large industry like banana, and smaller ones like shrimp). Some data is available from the citrus and sugar industries. These data used in the calculations were derived from annual product generation, and converted to tonnes. Similarly, the projected effluent in terms of M^3 per tonne of product is calculated based on published production information.

Even with the limited data available about this source of greenhouse gas emissions, the total emissions from the waste sector increased significantly with the input of the wastewater sector data. The results are shown in Figure 2.36.

Figure 2.36: Emissions from Wastewater Treatment and Discharge, 2012, 2015, 2017 (Gg CO2eq)



	2012	2015	2017
N2O	6.275	6.782	7.142
CH4	16.220	12.839	13.974
Total	22.495	19.622	21.116

Emissions from Waste-Water treatment and Discharge: Since wastewater is a significant source of greenhouse gas emissions, the total emissions from the waste sector increased significantly with the input of the wastewater sub-sector data. The estimates of emissions resulting from waste-water treatment and discharge are shown in Figure 2.44 above. Methane emissions (in CO_2 equivalents) are estimated at 16.22, 12.84 and 13.97 Gg CO2 eq for the years 2012, 2015 and 2017, respectively.

j. Analysis of Results

The Waste sector inventory has been facilitated by the recent solid waste studies, including waste characterization and waste composition studies commissioned by the Solid Waste Management Authority. These studies have led to availability of improved quality of data that renders previously used data on the municipal composition and generation rates of solid waste obsolete. Nonetheless, a national average has not yet been decided.

The results indicate that there is a significant improvement in solid waste data management that is useful for inventory exercises. Additional studies are required if waste generation data are to be applied by region (western corridor, northern and southern corridors), or for each town and city. This practice would be more acceptable and have greater accuracy. If this strategy is established, and datasets are properly archived and managed, it would greatly facilitate future inventory exercises in the solid waste sector.

In terms of the open burning of waste, the only study available is that done by the Statistical Institute of Belize (SIB) as part of the national census. Other studies done are not comprehensive. The SIB effort might be broadened in scope to obtain more data and analysis of the issues around open burning of waste which is still prevalent at the community and household level.

The Industrial solid waste sub-sector is the least studied of the sector, and therefore requires more attention.

Wastewater data displays many gaps. The Department of the Environment maintains an inventory of industries, but the wastewater output is not recorded. This source of data is important because it is noted that the waste-water sector is increasingly becoming of greater significance in greenhouse gas emissions.

2.6 Recalculations: Trends in GHG Emissions since 1994 with and without AFOLU

The software used to estimate Greenhouse Gas emissions has been changed since the first national inventory. The 1996 IPCC tool was used in Belize for the first through to the third national inventory of greenhouse gases emissions and removals. However, all previous inventory results were recalculated using the 2006 software. During this period from 1994 to 2017, some of the source categories have been redefined by the IPCC, but some new or corrected or more accurate data have been obtained for a few sub-categories. In a few instances, additional sources of emissions are now accounted for when there was no data previously available. These changes have probably contributed to the irregular patterns in the level of emissions resulting from the calculations for the earlier years. The overview of total emissions and removals of all sectors can be seen in Table 2.33 below.

Table 2.33: Belize's Recalculated Net Greenhouse Gas Emissions and Removals, 1994-2017 (Gg CO2 eq)

Sectors /sub-sectors	1994	1997	2000	2003	2006	2009	2012	2015	2017
Total National Emissions and Removals (with FOLU)	-6,612.97	-7,193.83	-7,718.26	-11,744.38	-11,202.62	-9,833.79	-7,179.14	-5,260.07	-5,826.79
Total National Emissions (without FOLU removals)	180.96	128.54	158.77	151.77	188.98	255.26	832.19	1,107.46	1,194.71
1 - Energy	NE	NE	NE	NE	NE	NE	538.0705586	781.8082484	786.364153
1.A - Fuel Combustion Activities	NE	NE	NE	NE	NE	NE	538.071	781.808	786.364
2 - Industrial Processes and Product Use	0.669	2.960	6.363	10.572	15.399	22.825	31.429	42.504	43.688
2.A - Mineral Industry	NE	NE	NE	NE	NE	NE	1.525	1.649	0.488
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NE	NE	NE	NE	NE	0	9.29E-08	9.16E-08
2.F - Product Uses as Subsitutes for Ozone Depleting Substances	0.669	2.960	6.363	10.572	15.399	22.825	29.90	40.86	43.20
2.H - Other	NE	NE	NE	NE	NE	NE	3.747E-12	1.116E-06	6.525E-07
3 - Agriculture, Forestry, and Other Land Use	-6,614.01	-7,197.20	-7,725.07	-11,755.29	-11,218.40	-9,868.83	-7,771.37	-6,104.27	-6,683.66
3.A - Livestock	74.51	50.33	72.36	75.33	98.392	121.63	131.65	138.85	177.27
3.B - Land	-6,777.53	-7,307.69	-7,837.85	-11,885.21	-11,391.360	-10,089.05	-8,011.33	-6,344.00	-6,987.00
3.C - Aggregate Sources and non-CO2 emissions sources on land - *FOLU*	48.034	48.034	43.123	15.541	27.934	29.556	31.280	31.175	44.446
3.C - Aggregate Sources and non-CO2 emissions sources on land - *Agriculture*	57.372	26.801	36.478	49.992	46.879	62.844	75.387	93.224	116.129
3.D - Other	-16.398	-14.678	-39.181	-10.944	-0.241	6.197	1.643	-23.522	-34.500
4 - Waste	0.372	0.412	0.450	0.338	0.374	12.211	22.729	19.892	26.813
4.A - Solid Waste Disposal	0	0.007	0.011	0.014	0.016	0.019	0.023	0.049	0.054
4.B - Biological Treatment of Solid Waste	NO	NO	NO	NO	NO	5.407	0	0	5.407
4.C - Incineration and Open Burning of Waste	0.372	0.405	0.439	0.325	0.357	0.190	0.211	0.222	0.236
4.D - Wastewater Treatment and Discharge	NE	NE	NE	NE	NE	6.594	22.495	19.622	21.116
International Bunkers	NE	NE	NE	NE	NE	NE	40.369	39.800	71.240
1.A.3.a.i - International Aviation	NE	NE	NE	NE	NE	NE	40.369	39.8	71.24

The net GHG emissions and removals for the same period, estimated with and without the FOLU removals, are presented graphically in Figure 2.37 and Figure 2.38 below.

In 1994 when Belize prepared and submitted its initial national greenhouse gas inventory to the UNFCCC the estimated population stood at 201,677 persons, with a growth rate of 2.03 % per annum, and population density of 8.78 persons per square kilometer. These parameters had changed to 332,960 people in 2012 with a growth rate of 2.32 % and population density of 16.66 persons/km^2; then to a population estimate of 375,769 in 2017. That year the growth rate was determined to be 2.00 % with a population density of 16.31 persons/km^2. During this period, Belize experienced some economic growth, which was largely driven by agriculture and tourism. It is possible that these areas of economic development have influenced the trend displayed in the country's greenhouse gas emissions. The two sectors contributing significantly to the GHG emissions continue to be AFOLU and Energy.

With Belize being a largely service oriented country with an expanding tourism industry, Belize is able to offer residents and visitors terrestrial and marine experiences. This has probably helped to stimulate growth in the transport sector in the expansion in the public and private sector vehicle fleet, the local maritime ferries, and the local aviation fleet. This has resulted in continuing increases in emissions from the Transport sub-sector even while the emissions from energy generation are not increasing as rapidly even with a increased energy demand by the growing population. The mitigation effect in the Energy sector is produced by the increasing utilization of renewable energy sources in the energy generation mix.

Within the AFOLU sector, land conversion from forested land to other uses (croplands and grasslands) displayed the greatest influence on sector emissions; this is most likely due to the continued expansion in agriculture, in the most recent cases to grassland (pastures) and cropland at the cost of the natural forests. It is noted that not all of this change is man-caused, since natural phenomena like hurricanes and insect infestation have been the precursor of the change and forest disturbance. Hurricane impact across the mid-western section of the country and the pine bark beetle infestation has left their mark on the broadleaf and pine forests respectively.

Figure 2.37: Trend of Belize's Net Emissions and Removals Including Forestry and Other Land Uses (Gg C02 eq)

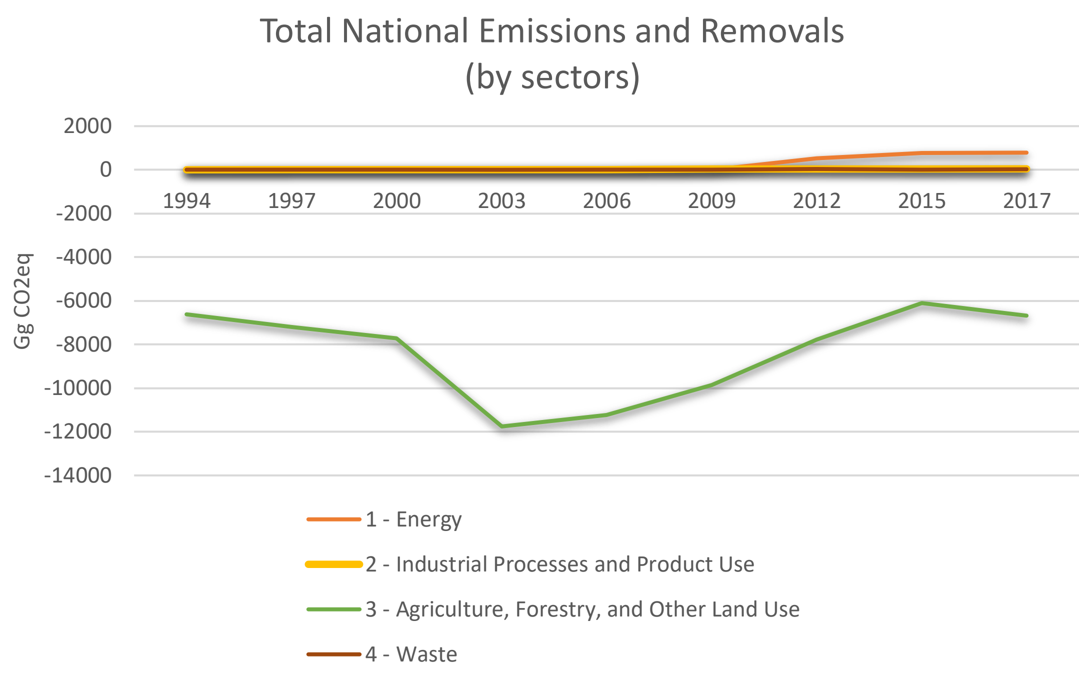
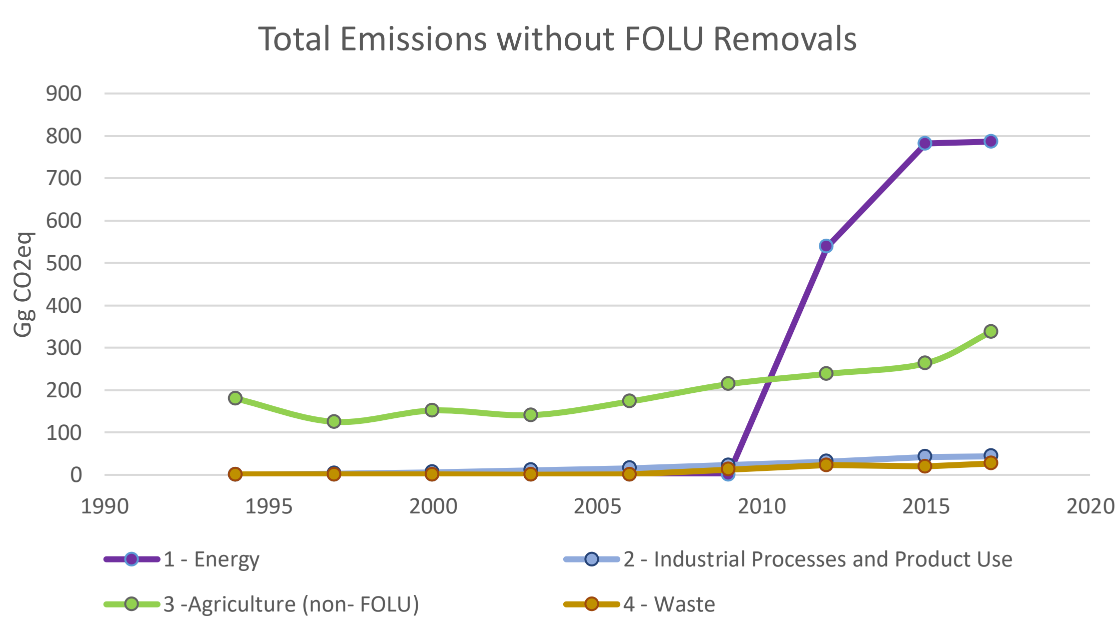


Figure 2.38: Trend of Belize's Net Emissions and Removals excluding Forestry and Other Land Uses (Gg C02 eq)



The observed increases in the emission trends in the **Energy sector** corresponded to some increases in the imports of petroleum fuels since 2012. This was because of increases in the consumption of petroleum fuels for electricity generation, and in the transport sub-sector. Local aviation has also expanded, as has the vehicular and sea-going fleets. Both public transportation and numbers of privately owned vehicles continue to increase. Charter boats and commuter ferries are also on the increase as the tourism industry grows. Biomass usage for industrial and domestic energy production continued to increase as an alternate to petroleum products, thus somewhat tempering the impact of emissions from this sector. Biomass is primarily used in the generation of energy for the sugar industry, and additional conversions are sold to the national grid. There was an increase in the use of this fuel late in the study period due to another company, Santander Sugar Energy Ltd., coming on stream and producing electricity for the national grid. The increase of biomass also increased the greenhouse gases emissions from this source, but this is largely recycled by the additional biomass being cultivated. Solar powered energy is increasing for domestic application, but also for applications like street lighting, and public service buildings.

The **Industrial sector** continues to display slow growth. The trends in GHG emissions displayed by the IPPU sector were the result of increased refrigerants use with the large number of new buildings constructed, along with the noticeable growth in the number of air-conditioning service facilities for vehicles. The tourism industry probably contributed to the use of refrigerants in both accommodations and transportation. Further, there was a general decrease in production and application of lime in the agriculture sectors, and slow growth in the production of beer, spirits, and bread. Beer, spirits, and bread are primarily for local consumption, so are probably apace with population growth. During the study period, there were a few road improvement projects underway in the municipalities, but these were mostly completed by building reinforced concrete roads. The cement was imported, so no discernible levels of GHG emissions could be attributed to this particular activity. However, there was some highway rehabilitation using asphalt. Road paving activities using asphalt appeared to fluctuate somewhat which levels of emissions in 2017 being lower that in 2015. The construction industry was busy across the study period with the building of private homes, expansion of resorts on the cayes, some public building construction like school and office buildings, etc. Many of these were being equipped with air-conditioning.

The most noticeable trend in **the Agriculture, Forest, and Other Land Use sector** is continuing increases by all the gases in all the sub-sectors. While the national forests continued to remove CO_2, this function is diminishing as the process of deforestation and forest conversion continued. It is also noted that the current inventory revealed that the greatest causes of GHG emissions in this sector were due to land conversions to grasslands and croplands. Enteric fermentation emissions from the agriculture sub-sector increased as the livestock populations increased, although some of the emissions in this sector were from land preparation for crop cultivation.

The emissions within the **Waste Sector** show some small changes over the study period, this being due to the fact that some data for waste water disposal and treatment was accessed and introduced to the estimates. This sector also displayed some fluctuations in emissions across the study period with some decline in 2015, but increasing again in 2017. The level of GHG emissions was almost flat across the three reference years, this most likely due to the construction of the managed landfill at mile 23 on the George Price Highway. The improved management of solid waste resulting from the construction and use of the managed landfill and the waste transfer station infrastructure, reinforced by law enforcement has resulted in great reduction in open burning of solid wastes. Greenhouse Gas emissions from this sector has been reduced compared to the period between 1997 and 2007 even with the inclusion of wastewater emissions. Future inventories of this sector may demonstrate that the Methane emissions from waste-water treatment have more impact on national emissions as the data collection improves.

3. KEY CATEGORY ANALYSIS

Key Source Category analyses enable inventory planners to identify the sector activities requiring

additional attention to address gaps in data, or to improve the data where that data was determined to be unreliable of inaccurate. These analyses also enable decision makers at national level to determine where investments can be made to mitigate the GHG emissions through the development and implementation of mitigation actions. At the same time, a series of such analyses can demonstrate whether or what effect the remedial action is having on the particular activity. The following analyses were generated for Belize's fourth national greenhouse inventory of emissions and removals.

Using Approach 1 Level Assessment, the following tables display the Key Category Analyses for the three reference years. The top four sources of GHG emissions and removals are the same and fall into the same order for the three reference years. According to the analyses, the key categories account for 95% of cumulative net emissions and removals for 2012, 2015, and 2017 were:

+ Removals from Forestland (CO_2)

- Land Converted to Cropland (CO_2)

- Land Converted to Grassland (CO_2)

- Road Transportation (CO_2)

Of the emitting activities, the highest would be (1) CO_2 from land converted to cropland, followed by (2) CO_2 from land converted to grassland, (3) CH_4 emissions from Enteric Fermentation (Livestock), (4) N_2O emissions *from Direct Emissions from Managed Soils*, and (5) *CO_2 from Gaseous Fuels consumed for electricity* in the most recent reference year, 2017.

Table 3.1: Key Category Analysis - 2012

IPCC Category code	IPCC Category	Greenhouse gas	2012 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
3.B.1.a and 3.B.1.b	Forest land Remaining Forest land and Land Converted to Forest land	CO2	-13250.304	13250.304	0.671244646	0.671244646
3.B.2.b and 3.B.2.a	Land Converted to Cropland and Cropland Remaining Cropland	CO2	3651.007	3651.007	0.184955674	0.85620032
3.B.3.b	Land Converted to Grassland	CO2	1797.166	1797.166	0.091042293	0.947242613
1.A.3.b	Road Transportation	CO2	480.1830836	480.1830836	0.024325504	0.971568117
3.B.4.a.i	Wetlands remaining Wetlands	CO2	-198.339	198.339	0.010047618	0.981615735
3.A.1	Enteric Fermentation	CH4	122.227707	122.227707	0.00619191	0.987807645
3.C.4	Direct N2O Emissions from managed soils	N2O	51.32808107	51.32808107	0.00260022	0.990407865
3.C.1	Emissions from biomass burning	CH4	31.8261325	31.8261325	0.001612274	0.992020139
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	29.90411243	29.90411243	0.001514907	0.993535045
4.D	Wastewater Treatment and Discharge	CH4	16.2200749	16.2200749	0.00082169	0.994356735
1.A.1	Energy Industries - Liquid Fuels	CO2	14.27394591	14.27394591	0.000723101	0.995079836
1.A.1	Energy Industries - Gaseous Fuels	CO2	13.58167536	13.58167536	0.000688032	0.995767868
3.B.5.a	Settlements Remaining Settlements	CO2	-10.859	10.859	0.000550104	0.996317972
1.A.3.a	Civil Aviation	CO2	9.2933869	9.2933869	0.000470792	0.996788764
3.A.2	Manure Management	CH4	7.66789821	7.66789821	0.000388447	0.99717721
3.C.1	Emissions from biomass burning	N2O	7.189374896	7.189374896	0.000364205	0.997541415
1.A.3.b	Road Transportation	N2O	7.086654693	7.086654693	0.000359002	0.997900417
3.C.6	Indirect N2O Emissions from manure management	N2O	7.01365585	7.01365585	0.000355303	0.99825572
4.D	Wastewater Treatment and Discharge	N2O	6.275343888	6.275343888	0.000317901	0.998573622
1.A.1	Energy Industries - Biomass	N2O	5.129104256	5.129104256	0.000259834	0.998833456
3.C.3	Urea application	CO2	4.47029	4.47029	0.00022646	0.999059916
1.A.4	Other Sectors - Biomass	CH4	4.422079116	4.422079116	0.000224017	0.999283933
3.C.7	Rice cultivations	CH4	3.89844	3.89844	0.00019749	0.999481423
1.A.1	Energy Industries - Biomass	CH4	2.605915872	2.605915872	0.000132013	0.999613436
3.A.2	Manure Management	N2O	1.753413963	1.753413963	8.88259E-05	0.999702262
3.D.1	Harvested Wood Products	CO2	1.642982312	1.642982312	8.32315E-05	0.999785493
2.A.2	Lime production	CO2	1.52482	1.52482	7.72456E-05	0.999862739
3.C.2	Liming	CO2	0.940463333	0.940463333	4.76428E-05	0.999910382
1.A.4	Other Sectors - Biomass	N2O	0.870377477	0.870377477	4.40923E-05	0.999954474
1.A.3.b	Road Transportation	CH4	0.480063705	0.480063705	2.43195E-05	0.999978793
4.C	Incineration and Open Burning of Waste	CH4	0.122357416	0.122357416	6.19848E-06	0.999984992
1.A.3.a	Civil Aviation	N2O	0.082312855	0.082312855	4.16987E-06	0.999989162
4.C	Incineration and Open Burning of Waste	CO2	0.054112957	0.054112957	2.7413E-06	0.999991903
3.B.2.a	Cropland Remaining Cropland	CO2	0.040333333	0.040333333	2.04324E-06	0.999993946
1.A.1	Energy Industries - Liquid Fuels	N2O	0.035837359	0.035837359	1.81548E-06	0.999995762
4.C	Incineration and Open Burning of Waste	N2O	0.034596223	0.034596223	1.7526E-06	0.999997514
4.A	Solid Waste Disposal	CH4	0.022943022	0.022943022	1.16227E-06	0.999998677
1.A.1	Energy Industries - Liquid Fuels	CH4	0.01213846	0.01213846	6.1492E-07	0.999999292
1.A.1	Energy Industries - Gaseous Fuels	N2O	0.007505026	0.007505026	3.80196E-07	0.999999672
1.A.1	Energy Industries - Gaseous Fuels	CH4	0.00508405	0.00508405	2.57552E-07	0.999999929
1.A.3.a	Civil Aviation	CH4	0.001394008	0.001394008	7.06188E-08	1
2.H	Other	CO2	3.7465E-12	3.7465E-12	1.89793E-16	1
Total			-7179.101308	19739.90269	1	

Table 3.2: Key Category Analysis - 2015

IPCC Category code	IPCC Category	Greenhouse gas	2015 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
3.B.1.a and 3.B.1.b	Forest land Remaining Forest land and Land Converted to Forest land	CO2	-12289.9200	12289.9200	0.6315	0.6315
3.B.2.b and 3.B.2.a	Land Converted to Cropland and Cropland Remaining Cropland	CO2	4391.9980	4391.9980	0.2257	0.8572
3.B.3.b	Land Converted to Grassland	CO2	1593.8530	1593.8530	0.0819	0.9391
1.A.3.b	Road Transportation	CO2	663.5535	663.5535	0.0341	0.9732
3.A.1	Enteric Fermentation	CH4	128.4281	128.4281	0.0066	0.9798
1.A.1	Energy Industries - Gaseous Fuels	CO2	54.9299	54.9299	0.0028	0.9826
3.C.4	Direct N2O Emissions from managed soils	N2O	54.4208	54.4208	0.0028	0.9854
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	40.8554	40.8554	0.0021	0.9875
3.B5.a	Settlements Remaining Settlements	CO2	-40.6120	40.6120	0.0021	0.9896
3.C.1	Emissions from biomass burning	CH4	36.5531	36.5531	0.0019	0.9914
1.A.1	Energy Industries - Liquid Fuels	CO2	25.2859	25.2859	0.0013	0.9927
3.D.1	Harvested Wood Products	CO2	-23.5217	23.5217	0.0012	0.9940
1.A.1	Energy Industries - Biomass	N2O	15.5796	15.5796	0.0008	0.9948
3.C.3	Urea application	CO2	12.9176	12.9176	0.0007	0.9954
4.D	Wastewater Treatment and Discharge	CH4	12.8395	12.8395	0.0007	0.9961
1.A.3.a	Civil Aviation	CO2	11.8979	11.8979	0.0006	0.9967
1.A.3.b	Road Transportation	N2O	10.0071	10.0071	0.0005	0.9972
3.A.2	Manure Management	CH4	8.4491	8.4491	0.0004	0.9976
1.A.1	Energy Industries - Biomass	CH4	7.9154	7.9154	0.0004	0.9980
3.C.6	Indirect N2O Emissions from manure management	N2O	7.9016	7.9016	0.0004	0.9984
3.C.1	Emissions from biomass burning	N2O	7.4137	7.4137	0.0004	0.9988
4.D	Wastewater Treatment and Discharge	N2O	6.7821	6.7821	0.0003	0.9992
1.A.4	Other Sectors - Biomass	CH4	4.9916	4.9916	0.0003	0.9994
3.C.7	Rice cultivations	CH4	4.1769	4.1769	0.0002	0.9996
3.A.2	Manure Management	N2O	1.9754	1.9754	0.0001	0.9998
2.A.2	Lime production	CO2	1.6486	1.6486	0.0001	0.9998
3.C.2	Liming	CO2	1.0154	1.0154	0.0001	0.9999
1.A.4	Other Sectors - Biomass	N2O	0.9825	0.9825	0.0001	0.9999
1.A.3.b	Road Transportation	CH4	0.6779	0.6779	0.0000	1.0000
4.C	Incineration and Open Burning of Waste	CH4	0.1284	0.1284	0.0000	1.0000
1.A.3.a	Civil Aviation	N2O	0.1054	0.1054	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	N2O	0.0637	0.0637	0.0000	1.0000
4.C	Incineration and Open Burning of Waste	CO2	0.0568	0.0568	0.0000	1.0000
4.A	Solid Waste Disposal	CH4	0.0492	0.0492	0.0000	1.0000
4.C	Incineration and Open Burning of Waste	N2O	0.0363	0.0363	0.0000	1.0000
1.A.1	Energy Industries - Gaseous Fuels	N2O	0.0304	0.0304	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	CH4	0.0216	0.0216	0.0000	1.0000
1.A.1	Energy Industries - Gaseous Fuels	CH4	0.0206	0.0206	0.0000	1.0000
1.A.3.a	Civil Aviation	CH4	0.0018	0.0018	0.0000	1.0000
2.H	Other	CO2	0.0000	0.0000	0.0000	1.0000
2.D	Non-Energy Products from Fuels and Solvent Use	CO2	0.0000	0.0000	0.0000	1.0000
Total				19461.6172		1

Table 3.3: Key Category Analysis – 2017

IPCC Category code	IPCC Category	Greenhouse gas	2017 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
3.B.1.a and 3.B.1.b	Forest land Remaining Forest land and Land Converted to Forest land	CO2	-10935.2310	10935.231	0.678	0.678
3.B.2.b and 3.B.2.a	Land Converted to Cropland and Cropland Remaining Cropland	CO2	2717.1000	2717.100	0.168	0.846
3.B.3.b	Land Converted to Grassland	CO2	1239.3980	1239.398	0.077	0.923
1.A.3.b	Road Transportation	CO2	648.1923	648.192	0.040	0.963
3.A.1	Enteric Fermentation	CH4	162.6423	162.642	0.010	0.974
3.C.4	Direct N2O Emissions from managed soils	N2O	70.4302	70.430	0.004	0.978
1.A.1	Energy Industries - Gaseous Fuels	CO2	66.9460	66.946	0.004	0.982
3.C.1	Emissions from biomass burning	CH4	48.4294	48.429	0.003	0.985
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	43.1993	43.199	0.003	0.988
3.D.1	Harvested Wood Products	CO2	-34.4997	34.500	0.002	0.990
1.A.1	Energy Industries - Liquid Fuels	CO2	31.0530	31.053	0.002	0.992
4.D	Wastewater Treatment and Discharge	CH4	13.9736	13.974	0.001	0.993
1.A.3.a	Civil Aviation	CO2	12.7762	12.776	0.001	0.994
3.C.3	Urea application	CO2	12.3285	12.329	0.001	0.994
3.C.6	Indirect N2O Emissions from manure management	N2O	11.7772	11.777	0.001	0.995
3.C.1	Emissions from biomass burning	N2O	11.7691	11.769	0.001	0.996
3.A.2	Manure Management	CH4	11.6818	11.682	0.001	0.996
1.A.3.b	Road Transportation	N2O	9.6751	9.675	0.001	0.997
3.B.5.a	Settlements Remaining Settlements	CO2	-7.7680	7.768	0.000	0.998
4.D	Wastewater Treatment and Discharge	N2O	7.1424	7.142	0.000	0.998
1.A.1	Energy Industries - Biomass	N2O	6.9593	6.959	0.000	0.998
3.C.7	Rice cultivations	CH4	5.5414	5.541	0.000	0.999
1.A.4	Other Sectors - Biomass	CH4	5.2568	5.257	0.000	0.999
1.A.1	Energy Industries - Biomass	CH4	3.5358	3.536	0.000	0.999
3.A.2	Manure Management	N2O	2.9443	2.944	0.000	0.999
4.B	Biological Treatment of Solid Waste	CH4	2.8676	2.868	0.000	1.000
4.B	Biological Treatment of Solid Waste	N2O	2.5398	2.540	0.000	1.000
1.A.4	Other Sectors - Biomass	N2O	1.0347	1.035	0.000	1.000
1.A.3.b	Road Transportation	CH4	0.6554	0.655	0.000	1.000
2.A.2	Lime production	CO2	0.4883	0.488	0.000	1.000
3.C.2	Liming	CO2	0.2986	0.299	0.000	1.000
4.C	Incineration and Open Burning of Waste	CH4	0.1278	0.128	0.000	1.000
1.A.3.a	Civil Aviation	N2O	0.1108	0.111	0.000	1.000
1.A.1	Energy Industries - Liquid Fuels	N2O	0.0783	0.078	0.000	1.000
4.C	Incineration and Open Burning of Waste	CO2	0.0716	0.072	0.000	1.000
4.A	Solid Waste Disposal	CH4	0.0537	0.054	0.000	1.000
1.A.1	Energy Industries - Gaseous Fuels	N2O	0.0370	0.037	0.000	1.000
4.C	Incineration and Open Burning of Waste	N2O	0.0361	0.036	0.000	1.000
1.A.1	Energy Industries - Liquid Fuels	CH4	0.0265	0.027	0.000	1.000
1.A.1	Energy Industries - Gaseous Fuels	CH4	0.0251	0.025	0.000	1.000
1.A.3.a	Civil Aviation	CH4	0.0019	0.002	0.000	1.000
					16128.70	1

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4. UNCERTAINTY ASSESSMENT

Uncertainties were introduced to the calculations from the activity data and through the emissions factors. Uncertainty trend assessments were conducted for the reference years 2015 and 2017 using the capabilities of the IPCC inventory tool. Uncertainty was measured and the sector with the largest contribution to inventory and trend uncertainty was within fuel combustion activities in the Energy sector.

Uncertainty measurements were assessed for the periods between 2012 and the other reference years 2015 and 2017, as emissions for all sectors and gases were done for these years, being a more representative comparison than an earlier base year with fewer analyzed sectors and gases. The tables are presented below.

For reference year 2015, the uncertainty in the total inventory was 17.19%, and trend uncertainty was 15.66%. For year 2017, total inventory uncertainty was 26.87% and trend uncertainty was 6.72%.

Table 4.1: Uncertainty Assessment for 2015, base year 2012

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	ED Uncertainty (%)	EF Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	14.274	25.286	5.000	6.136	7.915	0.018	0.017	0.012	0.106	0.087	0.019
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	0.012	0.022	5.000	50.000	50.249	0.000	0.000	0.000	0.001	0.000	0.000
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	0.036	0.064	5.000	228.000	228.055	0.000	0.000	0.000	0.010	0.000	0.000
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CO2	13.582	54.930	5.000	3.922	6.354	0.056	0.032	0.027	0.124	0.189	0.051
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CH4	0.005	0.021	5.000	200.000	200.062	0.000	0.000	0.000	0.002	0.000	0.000
1.A.1.a.i - Electricity Generation - Gaseous Fuels	N2O	0.008	0.030	5.000	200.000	200.062	0.000	0.000	0.000	0.003	0.000	0.000
1.A.1.a.i - Electricity Generation - Biomass	CO2	413.637	1256.42	5.000	18.694	19.351	271.473	0.759	0.613	14.198	4.333	220.355
1.A.1.a.i - Electricity Generation - Biomass	CH4	2.606	7.915	5.000	65.000	65.192	0.122	0.005	0.004	0.310	0.027	0.097
1.A.1.a.i - Electricity Generation - Biomass	N2O	5.129	15.580	5.000	300.000	300.042	10.035	0.009	0.008	2.820	0.054	7.953
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CO2	40.008	39.869	5.000	4.171	6.511	0.031	0.033	0.019	0.140	0.137	0.038
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH4	0.006	0.006	5.000	100.000	100.125	0.000	0.000	0.000	0.001	0.000	0.000
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N2O	0.354	0.353	5.000	150.000	150.083	0.001	0.000	0.000	0.044	0.001	0.002
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO2	9.293	11.898	5.000	4.171	6.511	0.003	0.009	0.006	0.038	0.041	0.003
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.001	0.002	5.000	100.000	100.125	1.47E-08	1.36E-06	8.70E-07	1.36E-04	6.15E-06	1.85E-08
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	0.082	0.105	5.000	150.000	150.083	1.149E-04	8.029E-05	5.140E-05	1.204E-02	3.634E-04	1.452E-04
1.A.3.b - Road Transportation - Liquid Fuels	CO2	480.183	663.553	5.000	3.068	5.866	6.959	0.493	0.324	1.514	2.288	7.528
1.A.3.b - Road Transportation - Liquid Fuels	CH4	0.480	0.678	5.000	150.000	150.083	0.005	0.000	0.000	0.075	0.002	0.006
1.A.3.b - Road Transportation - Liquid Fuels	N2O	7.087	10.007	5.000	200.000	200.062	1.841	0.007	0.005	1.474	0.035	2.173
1.A.4.b - Residential - Biomass	CO2	78.615	88.739	5.000	20.000	20.616	1.537	0.071	0.043	1.418	0.306	2.104

1.A.4.b - Residential - Biomass	CH4	4.422	4.992	5.000	250.000	250.050	0.715	0.004	0.002	0.997	0.017	0.994
1.A.4.b - Residential - Biomass	N2O	0.870	0.982	5.000	250.000	250.050	0.028	0.001	0.000	0.196	0.003	0.038
2.A - Mineral Industry												
2.A.2 - Lime production	CO2	1.525	1.649	5.000	8.000	9.434	0.000	0.001	0.001	0.011	0.006	0.000
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	CO2	0.000	0.000	10.000	50.000	50.990	0.000	0.000	0.000	0.000	0.000	0.000
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2FCF3	18.463	23.306	5.000	0.000	5.000	0.006	0.018	0.011	0.000	0.080	0.006
2.F.1.b - Mobile Air Conditioning	CH2FCF3	11.441	17.549	5.000	0.000	5.000	0.004	0.013	0.009	0.000	0.061	0.004
2.H - Other												
2.H.2 - Food and Beverages Industry	CO2	0.000	0.000	0.000	20.000	20.000	2.29E-16	5.44E-10	5.44E-10	1.09E-08	0.00E+00	1.19E-16
3.A - Livestock												
3.A.1.a.i - Dairy Cows	CH4	5.862	5.549	10.000	15.000	18.028	0.005	0.005	0.003	0.071	0.038	0.007
3.A.1.a.ii - Other Cattle	CH4	111.505	117.600	4.000	20.000	20.396	2.642	0.097	0.057	1.931	0.324	3.834
3.A.1.b - Buffalo	CH4	0.276	0.442	5.000	10.000	11.180	0.000	0.000	0.000	0.003	0.002	0.000
3.A.1.c - Sheep	CH4	1.523	1.596	10.000	20.000	22.361	0.001	0.001	0.001	0.026	0.011	0.001
3.A.1.d - Goats	CH4	0.086	0.082	5.000	15.000	15.811	0.000	0.000	0.000	0.001	0.000	0.000
3.A.1.f - Horses	CH4	2.354	2.448	15.000	10.000	18.028	0.001	0.002	0.001	0.020	0.025	0.001
3.A.1.g - Mules and Asses	CH4	0.144	0.165	14.000	15.000	20.518	5.27E-06	1.31E-04	8.05E-05	0.002	0.002	6.40E-06
3.A.1.h - Swine	CH4	0.479	0.546	5.000	15.000	15.811	3.42E-05	4.34E-04	2.66E-04	0.007	0.002	4.60E-05
3.A.2.i - Poultry	N2O	1.753	1.975	6.000	15.000	16.155	0.000	0.002	0.001	0.024	0.008	0.001
3.A.2.j - Other (please specify)	N2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.A.2.a.i - Dairy cows	CH4	0.163	0.154	10.000	15.000	18.028	0.000	0.000	0.000	0.002	0.001	0.000
3.A.2.a.ii - Other cattle	CH4	1.991	2.100	5.000	20.000	20.616	0.001	0.002	0.001	0.034	0.007	0.001
3.A.2.b - Buffalo	CH4	0.004	0.005	5.000	15.000	15.811	0.000	0.000	0.000	0.000	0.000	0.000
3.A.2.c - Sheep	CH4	0.061	0.064	5.000	20.000	20.616	7.95E-07	5.25E-05	3.11E-05	1.05E-03	2.20E-04	1.15E-06
3.A.2.d - Goats	CH4	0.004	0.004	5.000	20.000	20.616	2.53E-09	3.09E-06	1.76E-06	6.17E-05	1.24E-05	3.97E-09
3.A.2.e - Camels	CH4	0.000	0.000	0.000	0.000	0.000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.A.2.f - Horses	CH4	0.286	0.298	15.000	20.000	25.000	2.55E-05	2.46E-04	1.45E-04	4.92E-03	3.08E-03	3.37E-05
3.A.2.g - Mules and Asses	CH4	0.017	0.020	15.000	30.000	33.541	2.03E-07	1.57E-05	9.66E-06	4.71E-04	2.05E-04	2.64E-07
3.A.2.h - Swine	CH4	0.958	1.092	5.000	20.000	20.616	2.33E-04	8.69E-04	5.32E-04	1.74E-02	3.76E-03	3.16E-04
3.A.2.i - Poultry	CH4	4.184	4.713	10.000	15.000	18.028	3.32E-03	3.77E-03	2.30E-03	5.65E-02	3.25E-02	4.25E-03
3.B - Land												

3.B.1.a - Forest land Remaining Forest land	CO2	-6586.6	-5943.3	0.000	0.000	0.000	0.000	5.048	2.899	0.000	0.000	0.000
3.B.2.a - Cropland Remaining Cropland	CO2	0.040	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.B.2.b.i - Forest Land converted to Cropland	CO2	2107.78	2686.10	0.000	0.000	0.000	0.000	2.071	1.310	0.000	0.000	0.000
3.B.2.b.ii - Grassland converted to Cropland	CO2	29.664	14.847	0.000	0.000	0.000	0.000	0.018	0.007	0.000	0.000	0.000
3.B.3.b.i - Forest Land converted to Grassland	CO2	1057.28	2265.55	0.000	0.000	0.000	0.000	1.484	1.105	0.000	0.000	0.000
3.B.3.b.ii - Cropland converted to Grassland	CO2	7.831	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
3.C - Aggregate sources and non-CO2 emissions sources on land												
3.C.1.a - Biomass burning in forest lands	CH4	0.871	1.210	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
3.C.1.a - Biomass burning in forest lands	N2O	0.378	0.525	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.C.1.b - Biomass burning in croplands	CH4	6.486	11.057	0.000	0.000	0.000	0.000	0.008	0.005	0.000	0.000	0.000
3.C.2 - Liming	CO2	0.940	1.015	7.000	10.000	12.207	0.000	0.001	0.000	0.008	0.005	0.000
3.C.3 - Urea application	CO2	4.470	12.918	10.000	10.000	14.142	0.015	0.008	0.006	0.079	0.089	0.014
3.C.4 - Direct N2O Emissions from managed soils	N2O	51.328	54.421	0.000	0.000	0.000	0.000	0.045	0.027	0.000	0.000	0.000
3.C.6 - Indirect N2O Emissions from manure management	N2O	7.014	7.902	0.000	0.000	0.000	0.000	0.006	0.004	0.000	0.000	0.000
3.C.7 - Rice cultivations	CH4	3.898	4.177	5.000	20.000	20.616	0.003	0.003	0.002	0.068	0.014	0.005
3.D - Other												
3.D.1 - Harvested Wood Products	CO2	1.643	-23.522	0.000	0.000	0.000	0.000	0.011	0.011	0.000	0.000	0.000
4.A - Solid Waste Disposal												
4.A - Solid Waste Disposal	CH4	0.023	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.C - Incineration and Open Burning of Waste												
4.C.2 - Open Burning of Waste	CO2	0.054	0.057	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.C.2 - Open Burning of Waste	CH4	0.122	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.C.2 - Open Burning of Waste	N2O	0.035	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewaster Treatment and Discharge	CH4	4.079	4.287	0.000	0.000	0.000	0.000	0.004	0.002	0.000	0.000	0.000
4.D.1 - Domestic Wastewaster Treatment and Discharge	N2O	6.275	6.782	0.000	0.000	0.000	0.000	0.006	0.003	0.000	0.000	0.000
4.D.2 - Industrial Wastewater Treatment and Discharge	CH4	12.141	8.552	0.000	0.000	0.000	0.000	0.008	0.004	0.000	0.000	0.000
TOTAL	Sum	-2050.5	1475.64		Sum		295.506			Sum		245.240
NOTE: Tier 1 EFs were used for Subcategory 3B				Uncertainty in total inventory:			17.190			Trend Uncertainty		15.660

Table 4.2: Uncertainty Assessment for 2017, base year 2012

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 eq)	Year T emissions or removals (Gg CO2 eq)	AD Uncertainty (%)	EF Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	14.274	31.053	5	6.136	7.915	0.2041	0.013	0.015	0.082	0.107	0.018
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	0.012	0.027	5	50.000	50.249	6.00E-06	1.14E-05	1.29E-05	5.68E-04	9.15E-05	3.31E-07
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	0.036	0.078	5	228.000	228.055	1.08E-03	3.36E-05	3.82E-05	7.65E-03	2.70E-04	5.86E-05
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CO2	13.582	66.946	5	3.922	6.354	0.6114	0.031	0.033	0.121	0.231	0.068
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CH4	0.005	0.025	5	200.000	200.062	8.49E-05	1.16E-05	1.22E-05	2.31E-03	8.64E-05	5.36E-06
1.A.1.a.i - Electricity Generation - Gaseous Fuels	N2O	0.008	0.037	5	200.000	200.062	1.85E-04	1.71E-05	1.80E-05	3.41E-03	1.28E-04	1.17E-05
1.A.1.a.i - Electricity Generation - Biomass	CO2	413.637	561.235	5	18.694	19.351	398.5160	0.221	0.274	4.125	1.935	20.759
1.A.1.a.i - Electricity Generation - Biomass	CH4	2.606	3.536	5	64.550	64.743	0.1771	0.001	0.002	0.090	0.012	0.008
1.A.1.a.i - Electricity Generation - Biomass	N2O	5.129	6.959	5	300.000	300.042	14.7310	0.003	0.003	0.819	0.024	0.672
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CO2	40.008	71.248	5	4.171	6.511	0.7271	0.030	0.035	0.123	0.246	0.076
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH4	0.006	0.011	5	100.000	100.125	3.87E-06	4.44E-06	5.21E-06	4.44E-04	3.69E-05	1.98E-07
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N2O	0.354	0.631	5	150.000	150.083	0.0303	0.000	0.000	0.039	0.002	0.002
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO2	9.293	12.776	5	4.171	6.511	0.0234	0.005	0.006	0.021	0.044	0.002
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.001	0.002	5	100.000	100.125	1.19E-07	7.35E-07	9.15E-07	7.35E-05	6.47E-06	5.44E-09
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	0.082	0.111	5	150.000	150.083	9.34E-04	4.34E-05	5.40E-05	6.51E-03	3.82E-04	4.25E-05
1.A.3.b - Road Transportation - Liquid Fuels	CO2	480.183	648.192	5	3.068	5.866	48.8521	0.255	0.316	0.781	2.235	5.607
1.A.3.b - Road Transportation - Liquid Fuels	CH4	0.480	0.655	5	150.000	150.083	0.0327	0.000	0.000	0.039	0.002	0.001
1.A.3.b - Road Transportation - Liquid Fuels	N2O	7.087	9.675	5	200.000	200.062	12.6585	0.004	0.005	0.760	0.033	0.579
1.A.4.b - Residential - Biomass	CO2	78.615	93.454	5	20.000	20.616	12.5407	0.035	0.046	0.708	0.322	0.606
1.A.4.b - Residential - Biomass	CH4	4.422	5.257	5	250.000	250.050	5.8376	0.002	0.003	0.498	0.018	0.248
1.A.4.b - Residential - Biomass	N2O	0.870	1.035	5	250.000	250.050	0.2261	0.000	0.001	0.098	0.004	0.010
2.A - Mineral Industry												

2.A.2 - Lime production	CO2	1.525	0.488	5	8.000	9.434	0.0001	4.08E-05	2.38E-04	3.27E-04	1.68E-03	2.94E-06
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	CO2	0.000	0.000	5	50.000	50.249	0.0000	4.47E-11	4.47E-11	2.23E-09	3.16E-10	5.09E-18
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2FCF3	18.463	0.000	5	0.000	5.000	0.0000	0.002	0	0	0	0
2.F.1.b - Mobile Air Conditioning	CH2FCF3	11.441	0.000	5	0.000	5.000	0.0000	0.001	0	0	0	0
2.H - Other												
2.H.2 - Food and Beverages Industry	CO2	0.000	0.000	5	20.000	20.616	0.0000	3.18E-10	3.18E-10	6.36E-09	2.25E-09	4.56E-17
3.A - Livestock												
3.A.1.a.i - Dairy Cows	CH4	5.862	9.163	5	20.000	20.616	0.1206	3.7E-03	4.5E-03	7.4E-02	3.2E-02	6.5E-03
3.A.1.a.ii - Other Cattle	CH4	111.505	148.328	3	30.000	30.150	67.5688	5.8E-02	7.2E-02	1.7E+00	3.1E-01	3.1E+00
3.A.1.b - Buffalo	CH4	0.276	0.553	4	30.000	30.265	0.0009	2.3E-04	2.7E-04	7.0E-03	1.5E-03	5.2E-05
3.A.1.c - Sheep	CH4	1.523	1.201	5	20.000	20.616	0.0021	3.9E-04	5.9E-04	7.8E-03	4.1E-03	7.8E-05
3.A.1.d - Goats	CH4	0.086	0.026	10	22.000	24.166	0.0000	1.4E-06	1.2E-05	3.0E-05	1.8E-04	3.2E-08
3.A.1.f - Horses	CH4	2.354	2.497	10	30.000	31.623	0.0211	9.1E-04	1.2E-03	2.7E-02	1.7E-02	1.0E-03
3.A.1.g - Mules and Asses	CH4	0.144	0.190	10	30.000	31.623	0.0001	7.4E-05	9.2E-05	2.2E-03	1.3E-03	6.6E-06
3.A.1.h - Swine	CH4	0.479	0.686	8	20.000	21.541	0.0007	0.000	0.000	0.005	0.004	4.41E-05
3.A.2.i - Poultry	N2O	1.753	2.944	10	10.000	14.142	0.0059	0.001	0.001	0.012	0.020	0.001
3.A.2.j - Other (please specify)	N2O	0.000	0.000	0	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000
3.A.2.a.i - Dairy cows	CH4	0.163	0.255	10	20.000	22.361	0.0001	0.000	0.000	0.002	0.002	7.33E-06
3.A.2.a.ii - Other cattle	CH4	1.991	2.649	5	20.000	20.616	0.0101	0.001	0.001	0.021	0.009	0.001
3.A.2.b - Buffalo	CH4	0.004	0.006	3	30.000	30.150	0.0000	2.13E-06	2.70E-06	6.40E-05	1.15E-05	4.23E-09
3.A.2.c - Sheep	CH4	0.061	0.048	3	20.000	20.224	0.0000	1.55E-05	2.34E-05	3.11E-04	9.94E-05	1.06E-07
3.A.2.d - Goats	CH4	0.004	0.001	6	4.000	7.211	0.0000	5.95E-08	5.50E-07	2.38E-07	4.67E-06	2.18E-11
3.A.2.e - Camels	CH4	0.000	0.000	0	0.000	0.000	0.0000	0	0	0	0	0
3.A.2.f - Horses	CH4	0.286	0.304	5	20.000	20.616	0.0001	1.11E-04	1.48E-04	2.22E-03	1.05E-03	6.03E-06
3.A.2.g - Mules and Asses	CH4	0.017	0.023	15	12.000	19.209	0.0000	8.87E-06	1.11E-05	1.06E-04	2.35E-04	6.67E-08
3.A.2.h - Swine	CH4	0.958	1.372	10	20.000	22.361	0.0032	0.001	0.001	0.011	0.009	0.000
3.A.2.i - Poultry	CH4	4.184	7.025	15	15.000	21.213	0.0750	0.003	0.003	0.043	0.073	0.007
3.B - Land												

3.B.1.a - Forest land Remaining Forest land	CO2	-6586.527	-4846.558	1	1.000	1.414	158.7210	1.464	2.364	1.464	3.343	13.319
3.B.2.a - Cropland Remaining Cropland	CO2	0.040	0.135	5	2.000	5.385	0.0000	6.06E-05	6.58E-05	1.21E-04	4.65E-04	2.31E-07
3.B.2.b.i - Forest Land converted to Cropland	CO2	2107.779	1281.191	0	0.000	0.000	0.0000	0.356	0.625	0	0	0
3.B.2.b.ii - Grassland converted to Cropland	CO2	29.664	14.847	0	0.000	0.000	0.0000	0.003	0.007	0	0	0
3.B.3.b.i - Forest Land converted to Grassland	CO2	1057.279	1208.266	0	0.000	0.000	0.0000	0.455	0.589	0	0	0
3.B.3.b.ii - Cropland converted to Grassland	CO2	7.831	-1.062	0	0.000	0.000	0.0000	0.002	0.001	0	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land												
3.C.1.a - Biomass burning in forest lands	CH4	0.871	4.816	3	1.000	3.162	0.0008	0.002	0.002	0.002	0.010	0.000
3.C.1.a - Biomass burning in forest lands	N2O	0.378	2.091	3	0.000	3.000	0.0001	0.001	0.001	0.000	0.004	0.000
3.C.1.b - Biomass burning in croplands	CH4	6.486	8.845	0	0.000	0.000	0.0000	0.003	0.004	0.000	0.000	0.000
3.C.2 - Liming	CO2	0.940	0.299	3	8.000	8.544	2.20E-05	2.39104E-05	1.46E-04	0.000	0.001	0.000
3.C.3 - Urea application	CO2	4.470	12.329	10	15.000	18.028	0.1669	0.005	0.006	0.082	0.085	0.014
3.C.4 - Direct N2O Emissions from managed soils	N2O	51.328	70.430	0	0.000	0.000	0.0000	0.028	0.034	0.000	0.000	0.000
3.C.6 - Indirect N2O Emissions from manure management	N2O	7.014	11.777	0	0.000	0.000	0.0000	0.005	0.006	0.000	0.000	0.000
3.C.7 - Rice cultivations	CH4	3.898	5.541	3	8.000	8.544	0.0076	0.002	0.003	0.018	0.011	0.000
3.D - Other												
3.D.1 - Harvested Wood Products	CO2	1.643	-34.500	0	0	0	0	0.017	0.017	0	0	0
4.A - Solid Waste Disposal												
4.A - Solid Waste Disposal	CH4	0.023	0.054	0	0	0	0	2.32E-05	2.62E-05	0	0	0
4.B - Biological Treatment of Solid Waste												
4.B - Biological Treatment of Solid Waste	CH4	0.000	2.868	0	0	0	0	0.0014	0.0014	0	0	0
4.B - Biological Treatment of Solid Waste	N2O	0.000	2.540	0	0	0	0	0.0012	0.0012	0	0	0
4.C - Incineration and Open Burning of Waste												
4.C.1 - Waste Incineration	CO2	0.000	0.015	0	0	0	0	7.4E-06	7.4E-06	0	0	0
4.C.2 - Open Burning of Waste	CO2	0.054	0.057	0	0	0	0	2.1E-05	2.8E-05	0	0	0
4.C.2 - Open Burning of Waste	CH4	0.122	0.128	0	0	0	0	4.7E-05	6.2E-05	0	0	0
4.C.2 - Open Burning of Waste	N2O	0.035	0.036	0	0	0	0	1.3E-05	1.8E-05	0	0	0
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewaster Treatment and Discharge	CH4	4.079	4.931	0	0	0	0	0.002	0.002	0	0	0
4.D.1 - Domestic Wastewaster Treatment and Discharge	N2O	6.275	7.142	0	0	0	0	0.003	0.003	0	0	0
4.D.2 - Industrial Wastewater Treatment and Discharge	CH4	12.141	9.043	0	0	0	0	0.003	0.004	0	0	0
Total	Sum	-2050.4	-544.040	Sum:			721.876			Sum		45.120
NOTE: Tier 1 EFs were used for Subcategory 3B				Uncertainty in total inventory:			26.868		Trend uncertainty			6.717

5. GAPS AND LIMITATIONS

5.1. ENERGY

Detailed recording of the consumption of the different fuel types is not done; i.e. gasoline and diesel consumption is not separately available for road or marine transport. Road transport comprises included public and private transportation including all types of vehicles ranging from motorcycles, such as cars, motorcycles, light and heavy duty pickups, trucks buses. Heavy duty equipment used in construction or industry is not accounted for.

Marine transport includes private boats, water taxis, and fishing boats among others but again, there is not detail of the boat inventory. Greater detail would allow more accurate and complete estimation of the emissions using higher Tiers of calculations.

Fugitive emissions from the limited oil and gas activities in the country were not accounted for due to data unavailability. For a more complete account of the Energy sector, this subcategory will require more information for the subsequent inventory.

5.2. IPPU

Accurate and reliable local (nationally collected, archived, and managed) data and information continues to be a constraint for this sector. For example, even accurate and reliable data on flour and asphalt imports prove practically impossible to extract in country.

5.3. AFOLU

Continuous monitoring of deforestation is lacking. Data gathering mechanisms and data management is important to provide accurate and reliable data and information for the formulation of strategies to ameliorate the impacts of climate change, and to create adequate adaptation responses.

The availability of reliable data in the agriculture and forest sectors and its retrieval in a user-friendly condition continues to be a challenge. It appears that some of the public institutions that are mandated to maintain a database with relevance to the sector are inadequately resourced. Institutional coordination is also lacking as it is evident that there are overlaps and gaps in the type of data that these institutions should be compiling and managing. One example is the Livestock sector; the BLPA collect statistics on cattle but not the other livestock... eg. sheep, pigs, goats etc...

Avoiding deforestation, alone, in Belize has the potential to contribute to more than 1 million tons in CO2 emission reductions every year. Reversing the trend and adding forest regeneration to these estimates would increase this number even more. Afforestation/reforestation initiatives aiming to replant 50% of the loss in forest cover during 1989-2012 (249,727 ha), would require the regeneration of 124,863.5 ha of forest land, which could generate about 16 million tCO2e reductions every year.

Round wood volumes to be used in the inventory had to be sourced from FAO website, since the national authority was unable to provide same. At the same time this date might not have been reliable due to the relatively high level of illegal extraction of timber from national lands, as well as the generally unrecorded removals from land being converted to other use.

The basic data collection is carried out by country correspondents in the Member States.

5.4. WASTE

The waste sector inventory has been facilitated by the recent solid waste studies, which determined waste characterization and waste composition. No baseline national average for waste generation rate has been adopted in Belize as yet. This could then be periodically updated based on annually population estimates. Complete data on open burning of waste is not available. Questions remain about the quality of the data on Industrial solid waste.

Waste water data is the least available of all waste sector data. Although there is an inventory of industries, the volume of waste water being produced is not recorded. Domestic and commercial wastewater data is incomplete, and the population being served by the domestic treatment system is not kept up-to-date.

In the industrial sector, there is no formal reporting of the generation of liquid waste such from shrimp culture and other smaller industries. To compound the fact that the data is not readily available, what is available is not in user-friendly format, but had to be calculated from based on the volumes of the relevant commodity such as beer and alcohol.

6. IMPROVEMENT PLAN

The peer review of the past inventory conducted in 2018 produced some recommendations for improvement of the current and future GHG inventories.

A number of recommendations have also been made by the consultants for each sector of the inventory. These were made based on the quality and/or availability of activity data. Collectively these would contribute to the formulation of a GHG improvement plan. However, the NCCO has already put in place a structure for GHG inventory improvement, and this was utilized during the current exercise.

Institutional Arrangements:

The NCCO has created an Inventory management structure, described earlier in this report, that enables coordination of the participation of key stakeholders such various government departments and other institutions. The structure establishes the roles and responsibilities of these stakeholders through a system of sector leads with support groups for data collection and management.

Quality Assurance/Quality Control:

The close supervision and monitoring maintained by the NCCO, Mitigation Officer, enabled greater quality assurance and control over this exercise. Data review and validation were done at the sector level using the established inventory management structure, and draft reports were periodically reviewed by technicians and professionals from within and outside government departments.

Key Category Analysis:

For a few of the sectors, such as IPPU and Waste, activity data is limited because the country is not highly industrialized, making Key Category Analysis at that level unnecessary. The Energy and AFOLU sectors are relatively larger displaying greater diversification in composition, so Key Category Analyses may be conducted for these sectors.

Uncertainty Analysis:

Uncertainly analysis was conducted for the sectors.

National Inventory Improvement Plan:

An outline a GHG Inventory Plan was one of the outputs of the peer review. Since then a draft Improvement Plan has been initiated by the Belize National Climate Change office. It is expected that some information coming out of the current inventory exercise will further inform this process.

Archiving System:

The NCCO has initiated the development of a database in which all the data and information collected is being archived. This includes raw data, and copies of the completed worksheets. This builds on work began with the third national GHG inventory. Technical assistance has been accessed for the development of the database to archive GHG data and information.

Recalculations:

Recalculations of previous inventories were done, where possible, using the old data retrieved from the archives, but with the application of the 2006 software. Where new data has become available, such has been used.

TACCC Principles (Transparency, Accuracy, Completeness, Consistency, and Comparability): Guided effort was expended to ensure these principles were adhered to for all sectors throughout the entire exercise. Sources were properly cited, and the validation process also contributed to meeting these objectives.

Additional efforts for GHG inventory specific to the sectors are described below.

ENERGY

A survey can be conducted to try to develop separation (obtain greater detail) of the type of fuel (diesel or gasoline) used within the road transport sub-sector which presently cannot be measured properly. Neither can the amount or type of fuel be used in marine transportation be determined. The same type of survey could be done for marine transportation. Fuel consumed by the fishing fleet, mostly small skiffs powered by outboard engines, is also un-estimated. These surveys could be done in advance of the GHG inventory so the data/information would be available for the upcoming exercise. The Transport sub-sector is a significant source of GHG emissions in Belize within the Energy sector. The survey would also inform whether mitigation measures would positively impact the sub-sector.

IPPU

Local data on asphalt imports for road paving was either not available or accessible. The Customs Department should be able to provide this data. The Customs Department is also the potential source of data related to the industries such as beer and wine because of the taxes levied on the product, but the reporting mechanism appears to be weak. Other small industries seem to be emerging, such as paper recycling, and these would have to be assessed to determine if they are contributing to GHG emissions in Belize.

AFOLU

The major recommendation would be to ensure that more reliable information be collected for the sector to get a more realistic figure of the emissions as for this exercise, some data still needs verification.

The available Land Use data should be revaluated, particularly the categories for cropland. Annual and perennial crops need to be clearly defined, including agroforestry systems such as cocoa, coconuts and fruit trees. There appears to be discrepancies (in perennials) between the official data from the Ministry of Agriculture and that of the Statistical Institute of Belize. It is also recommended to incorporate the emissions from aquaculture especially related to waste water and use of urea and dolomite.

WASTE

Although the Waste sector inventory has been improved due to waste characterization and composition data derived from recent solid waste studies, no national average waste generation rate has yet been established.

The data about the number of connections to the waste (water) treatment systems need to be updated. Tier 2 and Tier 3 levels of estimated might be possible if waste generation data was available at municipal and village levels for the entire country. Surveys about industrial waste water discharge and treatment needs to be conducted in order that this sub-sector could be better addressed in future inventories, possibly at higher levels of calculations with the input of greater detail.

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8. ANNEX

Annex I: AFOLU RESOURCE PERSONNEL

Name	Job Position	Role in the NIR	Contact Information
Ministry of Agriculture, Fisheries, Forestry, Sustainable Development, the Environment, Climate Change and Solid Waste Management Authority			
Dr. Percival Cho	Chief Executive Officer	Provide data on forest emission factors. Data validation and expert judgment Coordination among Departments and other national institutions Approval of final report	Address: Market Square - Belmopan City, Belize. Tel: +(501) 822-2548, +(501) 822-2819 Email: ceo@environment.gov.bz Webpage: http://doe.gov.bz
Forest Department – MAFFESDI			
Wilber Sabido	Chief Forest Officer	Quality Assurance and verification of data analysis (FOLU) Policy guidance	Address: St. Lorem ipsum, Vestibulum auctor. Belmopan City, Belize. Tel: (501)-322-2222 Email: cfo@forest.gov.bz Webpage: http://forest.gov.bz
German Lopez	Sustainable Forest Management Programme Manager	Data collection, Forest Emission Factors Expert in Grassland Ecosystem country wide.	Email: brh@forest.gov.bz
Edgar Correa	Geospatial Monitoring Unit, Lead	Technical Lead, Activity Data Data collection- CE Assessment Field Validation Country Wide field knowledge and experience of land use GHG emission and removals estimations Data analysis Documentation	Email: edgarcorrea21@gmail.com
Florencia Guerra	Sustainable Forest Management Programme, Officer	Technical Lead, Forest Emission Factors Data collection- CE Assessment Documentation	Email: florysguerra@yahoo.com
Jorge Nabet	Geospatial Monitoring Unit, Forester	Data collection- CE Assessment	Email: nabetjorge@yahoo.com

		Vast knowledge of land use experience in northern part of Belize.	
Alex Escanlante	Geospatial Monitoring Unit, Forester	Data collection- CE Assessment Country wide knowledge and experience of land use types.	Email: alex_forestry@yahoo.com
Koren Sanchez	Geospatial Monitoring Unit, Forester	Data collection- CE Assessment Knowledge of land use types in Central and South of Belize.	Email: pa.central@forest.gov.bz
Lewis Usher	Forester	Advisor during collect earth assessment. Experience Forester of 29 years working country wide in the field and lead expert in establishment of permanent sample plots.	Email: usher_forestry@yahoo.com
Mr. Marcelo Windsor	Deputy Chief Forest Officer	Advisor during collect earth assessment. Vast knowledge of Forest dynamics in the country and knowledge of land use activities. Has been working with the Forest Department for 36 years.	dcfo@forest.gov.bz
National Climate Change Office- MAFFESDI			
Lennox Gladden	Chief Climate Change Officer	UNFCCC Focal Point Inter-ministerial policy coordination for mainstreaming climate change Oversight of REDD+ CU	Address: Market Square - Belmopan City, Belize. Tel: +(501) 828-8962 Email: cco.cc@environment.gov.bz
Brittany Meighan	Climate Change Officer Mitigation	National GHG inventory coordinator Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: mitigation.cc@environment.gov.bz
REDD+ Coordination Unit - MAFFESDI			

Eduardo Reyes	REDD+ coordinator	QC Data collection- CE Assessment Coordination Policy Advisor Data analysis Documentation	Email: geotermia58@yahoo.com
Edalmi Grijalva	Technician	Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: edalmi.redd@environment.gov.bz
Mercedes Carcamo	Technician	Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: mercedes.redd@environment.gov.bz
Luis Balan	Technician	Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: luis.redd@environment.gov.bz
Kareem Reynolds	Technician	Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: kareem.redd@environment.gov.bz
Summeet Betancourt	Technician	Data collection- CE Assessment GHG emission and removals estimations Data analysis Documentation	Email: sumeet.redd@environment.gov.bz
Timothy Mesh	Social Expert	Data collection- CE Assessment Data analysis Documentation	Email: social.redd@environment.gov.bz
International Support			
Marcial Arias	GIS technical Expert	Trainer and CE Assessment lead. QC Data collection- CE Assessment Documentation	Institution: Ministerio de Ambiente de Panamá, Unidad de Cambio Climático Address: Sede Principal Edif.804 Apartado Ancón-República de Panamá, Calle Broberg, Panamá Email: marias@miambiente.gob.pa Webpage: https://miambiente.gob.pa/
Milena Niño	GHG Inventory Officer	Trainer on CE Assessment	Institution: Coalition for Rainforest Nations [CfRN] Address: 52 Vanderbilt Avenue Suite #1401. New York, NY 10017

		QA Data collection- CE Assessment Trainer on GHG Inventories and IPCC requirements Adaptation of calculation tool to Belize circumstances GHG emission and removals estimations Data analysis Documentation	Email: milena@cfrn.org Webpage: www.rainforestcoalition.org
Javier Fernandez	GHG Inventory Officer	Trainer on CE Assessment QA Data collection- CE Assessment Trainer on GHG Inventories and IPCC requirements Adaptation of calculation tool to Belize circumstances GHG emission and removals estimations Data analysis Documentation	Institution: Coalition for Rainforest Nations [CfRN] Address: 52 Vanderbilt Avenue Suite #1401. New York, NY 10017 Email: javier@cfrn.org Webpage: www.rainforestcoalition.org
Eloise Guide	GHG Inventory Officer	QC of GHG inventory Report and Calculation tool	Institution: Coalition for Rainforest Nations [CfRN] Address: 52 Vanderbilt Avenue Suite #1401. New York, NY 10017 Email: eloise@cfrn.org Webpage: www.rainforestcoalition.org
Jongikhaya Witi	GHG Inventory Reviewer – RRR+ Independent Panel	QA of GHG inventory Report and Calculation tool	Institution: Coalition for Rainforest Nations [CfRN] Address: 52 Vanderbilt Avenue Suite #1401. New York, NY 10017 Email: witija@gmail.com Webpage: www.rainforestcoalition.org
Alfonso Sanchez-Paus	Land Monitoring Expert	Data collection- CE Assessment	Institution: Food and Agriculture Organization Address: Headquarters, Viale delle Terme di Caracalla 00153 Rome, Italy Email: sanchez.paus.pro@gmail.com Webpage: http://www.fao.org
Department of Agriculture, Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration			
Dr. Victoriano Pascual	Climate Change Focal Point, Department of Agriculture	Quality Assurance of Agriculture Data	Email: dir.wmcc@agriculture.gov.bz

Annex 2a: Agriculture Crop Production in millions of pounds and acreages - 2000 to 2017

PRODUCTS	2000	2001	2002	2003	2004	2005	2006	2007	2008
BLACK BEANS									
Mechanized[1]	1.65	0.18	0.35	0.67	0.92	0.47	0.47	0.81	0.44
Acres	1995	120	650	954	969	747	771	1,077	442
Yield (lb)[2]	825	1500	539	701	951	626	605	756	1000
Milpa	0.37	1.06	2.93	1.91	1.26	2.49	2.47	2.12	2.03
Acres	418	1217	3825	2522	1579	2771	2704	2284	2182
Yield (lbs)	889	871	767	758	797	898	898	898	930
Total Production	2.02	1.24	3.28	2.58	2.18	2.96	2.93	2.94	2.47
Total Acres	2413	1337	4475	3476	2548	3518	3475	3361	2624
R.K. BEANS									
Milpa	0.71	0.45	0.69	0.51	1.26	0.23	0.53	0.53	0.41
Acres	1157	890	1517	715	1643	282	785	709	513
Yield (lb)	615	509	454	720	766	809	672	748	799
Mechanized:	10.2	12.34	4.25	9.15	5.37	7.39	5.15	5.72	5.12
Acres	12310	16166	10065	11075	9786	9745	8315	8097	9464
Yield (lbs)	828	764	422	826	549	759	620	707	541
Total production	10.91	12.79	4.94	9.67	6.63	7.62	5.68	6.25	5.53
total acres	13467	17056	11582	11790	11429	10027	9100	8806	9977
COWPEA									
Production (lbs)	6.30	7.2	8.23	6.90	5.95	5.05	4.91	5.44	6.76
Acres	5143	5993	6933	4798	5898	5091	5320	5790	6842

Yield (lb)	1225	1201	1186	1439	1009	992	922	939	988
OTHER BEANS									
Production			0.83	0.68	0.15	1.14	0.69	0.91	1.08
Acres			1052	830	430	1391	1113	1176	1105
CORN Yellow									
Milpa:	13.36	6.80	11.19	10.99	7.57	11.08	9.41	9.09	7.99
Acres	10050	4900	7764	6114	5081	6939	5601	5473	4691
Yield (lb)	1329	1387	1441	1798	1490	1596	1679	1660	1703
Mechanized:	56.57	74.19	62.42	67.48	59.58	65.30	53.20	75.38	57.29
Acres	24969	25268	27571	25453	26335	22352	20402	28037	24263
Yield (lb)	2266	2936	2264	2651	2262	2921	2608	2689	2361
Mech. Irrigation									
Acres harvested									
total production	69.93	80.99	73.61	78.47	67.15	76.38	62.61	84,47	65.27
total acres	35019	30168	35335	31567	31416	29291	26003	33510	28954
WHITE CORN									
Milpa:				2.21	8.19	16.72	13.94	12.84	12.52
Acres				1566	5112	10476	8253	7634	7051
Yield (lb)				1412	1601	1596	1689	1682	1774
Mechanized:				3.38	2.6	11.05	4.92	3.05	3.9
Acres				1688	3026	4777	2433	1517	2869
Yield (lb)				2000	858	2313	2023	2014	1359
total production				5.59	10.78	27.77	18.86	15.89	16.41
total acres				3254	8138	15253	10686	9151	9920
RICE									

Milpa:	6.04	2.29	4.16	4.15	1.25	1.69	1.35	1.31	1.17
Acres	3500	1376	3212	1627	748	853	738	1005	791
Yield (lb)	1725	1663	1296	2552	1672	1979	1828	1306	1478
Mechanized	15.67	24.43	13.78	15.96	14.41	25.18	21.64	5.15	4.95
Acres	5453	8559	7031	7973	5398	6383	5757	2063	2382
Yield (lb)	2874	2855	1960	2002	2669	3945	3758	2499	2078
Mech. Irrigated			6,200,000	8,000,000	7,360,000	12,281,500	3,150,000	32,720,000	19,850,950
Acres			1,550	1,600	1,600	2,100	700	6,104	5,200
Yield (lb)			4,000	5,000	4,600	5,848	4,500	5,360	3,817
Total production	21.71	26.72	24.14	28.11	23.02	39.15	26.14	39.19	25.97
Total acres	8953	9935	11793	11200	7746	9336	7195	9172	8373
SORGHUM									
Production (lbs)	13.90	18.54	26.65	20.18	17.95	14.90	10.1	15.11	23.57
Acres	4928	5525	9785	5977	9016	7886	5463	7116	13325
Yield (lb)	2821	2400	2724	3376	1991	1890	1848	2124	1769
SOYBEANS									
Production (lbs)	1.09	1.16	2.06	3.52	0.7	0.75	1.35	0.83	0.054,
Acres	609	730	2088	2602	600	300	750	486	45
Yield (lb)	1795	1524	986	1351	1167	2500	1800	1710	1200
PRODUCTS	2009	2010	2011	2012	2013	2014	2015	2016	2017 (P)
BLACK BEANS									
Mechanized	0.72	0.93	0.68	1.72	0.24	0.422	1.09	1.26	2.59
Acres	1312	994	700	1607	398	795	1202	1993	2983

Yield (lb)	552	931	972	1,070	612	532	906	630	867
Milpa	2.19	2.96	3.34	5.25	4.26	4.81	5.55	0.43	1.06
Acres	2226	3135	3317	4724	3855	4147	7021	448	1300
Yield	985	946	1007	1112	1106	1159	790	960	818
Total Production	2.92	3.89	4.02	6.97	4.51	5.23	6.64	1.69	3.65
Total Acres	3538	4129	4017	6331	4253	4942	8223	2441	4283
R.K. BEANS									
Milpa:	0.47	0.68	1.18	1.31	0.94	0.85	0.46	0.44	0.49
Acres	430	796	1300	1513	1176	875	385	498	577
Yield (lb)	1091	858	905	867	803	976	1193	883	
Mechanized:	5.40	13.89	6.99	12.01	11.54	9.49	20.78	9.24	11,.05
Acres	9,134	16650	11400	12869	19594	16010	23759	16207	16140
Yield (lbs)	592	834	613	933	589	593	875	570	685
Total production	5.87	14.57	8.17	13.32	12.48	10.34	21.24	9.68	11.54
total acres	9564	17446	12700	14382	20770	16885	24144	16705	16717
COWPEA									
Production	8.1	5.90	7.02	5.99	6.45	4.48	5.96	9.08	3.68
Acres	6645	5187	5950	6666	6142	5308	5585	7250	3822
Yield (lb)	1219	1138	1180	900	1050	844	1067	1252	963
OTHER BEANS									
Production	1.62	1.28	0.77	3.53	2.03	0.58	1.18	0.74	0.99
Acres	2134	1457	1794	3861	2543	774	1757	1462	1864
CORN Yellow									
Milpa:	10.99	10.24	9.52	5.60	7.81	5.11	4.94	1.33	3,48
Acres	8042	7163	6206	4146	6065	5463	5101	1306	2276
Yield (lb)	1367	1,429	1535	1352	1287	935	968	1021	1530
Mechanized:	88.31	89.02	99.87	114.88	139.14	140.27	106.12	135.69	182.16

Acres	29768	26513	27924	29021	38199	35492	32984	49408	39012
Yield (lb)	2967	3358	3576	3958	3642	3952	3217	2746	4669
Mech.Irrig							3.85		
Acres harvested							700		
total production	99.3	99.25	109.39	120.48	146.94	145.37	114.91	137.03	185.64
total acres	37810	33676	34130	33167	44264	40955	38785	50714	41288
WHITE CORN									
Milpa:	14.23	15.57	15.31	8.82	8.89	4.03	5.11	0.71	5,29
Acres	9625	11130	9354	6237	6123	4109	5212	714	3790
Yield (lb)	1478	1399	1637	1414	1452	981	981		1397
Mechanized:	12.88	13.16	13.53	10.64	2.73	3.09	7.19	7.24	6.45
Acres	8302	4189	4563	3416	1249	1683	5782	3138	3436
Yield (lb)	1551	3140	2966	3114	2186	1834	1244	2306	1878
total production	27.10	28.72	28.85	19.45	11,.62	7.12	12.30	7.95	11.75
total acres	17927	15319	13917	9653	7372	5792	10994	3852	7226
RICE									
Milpa	1.50	2.82	1.74	0.39	0.4	0.43	0.39	0.22	0.31
Acres	1004	1873	1122	219	259	285	326	123	162
Yield (lb)	1498	1506	1555	1779	1528	1519	1220	1817	1920
Mechanized	13.48	17.94	18.32	15.85	31.42	10.07	4.55	14.79	14.16
Acres	4137	5052	5081	4626	8022	3157	2123	4213	3950
Yield (lb)	3258	3552	3606	3425	3917	3189	2141	3510	3584
Mech. Irrigated	30.47	24.48	22	10.92	13.39	25.35	22.97	20.71	26.87
Acres	6170	4456	4800	1850	1415	5231	4924	4045	5700
Yield (lb)	4938	5494	4583	5903	9460	4845	4666	5120	4714

Total production	45.45	45.25	42.07	27.16	45.21	35.85	27.92	35.72	41.34
Total acres	11311	11381	11003	6695	9696	8673	7373	8381	9812
SORGHUM									
Production (lbs)	20.56	43.91	22	34.91	42.99	20.05	23.35	21.15	22.24
Acres	13194	15092	12783	16063	15137	9529	11857	8514	10813
Yield (lb)	1558	2909	1721	2174	2840	2103	1970	2484	
SOYBEANS									
Production (lbs)	1.29	2.90	1.31	2.33	9.28	8.55	11.24	17.15	28.74
Acres	750	1668	842	1513	6479	7520	9407	10388	17598
Yield (lb)	1720	1,740	1560	1541	1433	1137	1195	1651	
PRODUCTS	2000	2001	2002	2003	2004	2005	2006	2007	2008
SUGAR									
Sugarcane tonnes	1,089,128	1,011,214	1,150,656	1,073,247	1,149,475	929,392	1,173,468	1,200,050	980,114
Acres	57,332	57,332	59,500	57,322	61,000	62,134	58,087	60,000	65,000
Yield (Tons/acre)									
ORANGE									
Production (90 lb Boxes)	5,589,702	5,734,330	4,122,594	4,046,295	4,946,717	6,264,847	4,930,957	5,221,204	5,661,295
Acres			30,418	31,724	31,724	30,400	33,002	39,361	39,361
Yield									
GRAPEFRUIT									
Production (80 lb Boxes)	1,391,414	1,460,574	1,230,942	1,078,137	1,478,788	1,527,802	1,686,567	1,504,894	1,440,893
Acres	8,497	5,630	4,812	4,645	4,645	7,600	5,456	6,769	6,769

Yield	164	21,600							
BANANA (Exports) bxs		3,072,567	2,660,109	4,351,359	4,767,598	4,769,053	4,879,781	4,193,725	
Production boxes)	3,625,615	2,607,913	2,368,531	4,043,000	4,346,153	4,037,016	3,838,650	3,416,776	3,750,593
Acres	4,752	5,512	6,087	6,161	6,136	6,294	6,387	6,021	6,280
Yield	778	20,120	1,113						
APPLE BANANA									
Production (Bunches)			5,700	20,840	73,988	7,226	149,450	3,725	6,775
Acres			19	58	43	20	51	32	40
Yield (Bunches/acre)			300	359	1,721	361	2,930	116	172
MANGOES									
Production (lbs)	2,596,000	113,000	2,431,000	2,651,000	1,240,500	4,673,000	2,454,000	1,340,000	1,243,000
Acres	748	340	613	653	231	597	249	147	65
Yield (lb)	3,471	332	3,966	4,060	5,370	7,827	9,855	9,116	19,123
PAPAYA									
Production (lbs)	12,317,999	11,872,722	23,783,560	31,200,010	60,989,421	58,240,463	73,368,900	70,964,944	59,476,829
Acres	443	441	739	608	1,044	1,352			1,057
Yield (lb)	27,806	24,301	32,173	51,316	58,419	43,077			56,269
PEANUTS									
Production (lb)	253,920	263,300	306,950	181,400	169,380	249,200	225,314	215,155	218,750
Acres	204	207	237	154	142	218	135	176	242
Yield (lb)	1,247	1,272	1,295	1,178	1,193	1,143	1,665	1,225	906
PINEAPPLE									

Production (lbs)	4,853,600	4,472,000	4,208,727	3,655,287	4,759,880	4,963,188	3,162,150	5,017,044	2,101,950
Acres	435	375	490	271	410	341	188	302	177
Yield (lb)	11,158	11,925	8,589	13,488	11,609	14,555	16,820	16,613	11,875
PLANTAIN									
Production (Bunches)	1,626,227	1,158,189	879,770	611,420	813,135	416,650	770,634	147,331	358,891
Acres	1,798	2,007	1,852	1,551	1,791	999	735	454	513
Yield (Bunches)	904	577	475	394	454	417	1,048	325	700
WATERMELON									
Production (lbs)	3,840,000	4,500,994	4,564,760	3,793,026	3,355,365	2,832,500	4,402,500	2,551,600	2,551,117
Acres	179	187	229	240	192	163	248	175	193
Yield (lb)	21,513	24,069	19,977	15,804	17,476	17,377	17,752	14,581	13,218
COCONUT									
Production (Nuts)	2,226,800	2,012,000	3,746,522	3,075,843	2,055,500	3,519,600	1,124,400	841,840	561,900
Acres	541	550	1,075	1,133	853	693	572	491	404
Yield (Nuts)	4,116	3,658				5,079	1,966	1,715	1,391
COCOA									
Production (lbs)	65,211	65,536	56,131	91,200	87,369	47,827	94,925	54,773	110,515
Acres	1,514	202		40	534	80	158	76	259
Yield (lb)	43	324			164	598	601	721	427
CANTELOUPE									
Production (lbs)	474,400	697,500	799,300	564,700	434,440	617,100	872,800	638,350	508,833
Acres	50	68	86	61	50	56	76	47	43

Yield (lb)	9,488	9,838	9,294	9,257	8,689	11,020	11,484	13,698	11,833
ANNATO									
Production (lbs)	21,500	28,500	21,300	41,300	30,800	49,800	79,000	83,400	108,200
Acres	31	33	27	53	38	44	60	63	68
Yield (lb)	694	864	789	779	811	1,132	1,317	1,324	1,591
COFFEE									
Production (lbs)	4,000	503,750	500,000	502,800	510,000	120,000	210,000	100,000	
Acres	8	102	100	105	102	30	100	110	
Yield (lb)	500	4,939	5,000	4,789	5,000	4,000	2,100	909	
AVOCADO									
Production (lbs)	857,195	20,000	410,000	396,400	225,750	168,000	70,000	65,250	26,000
Acres	182	5	73	70	31	31	13	15	4
Yield (lb)	4,723	4,000	5,616	5,663	7,282	5,419	5,385	4,350	6,500
CASHEW									
Production (lbs)	1,588,000	2,546,000	300,500	240,800	316,250	325,920	323,440	298,430	262,250
Acres	794	1,530	1,976	1,964	2,300	2,365	2,336	2,145	1,747
Yield (lb)	2,000	1,664	152	123		138	138	139	150
SOURSOP									
Production (lbs)	13,500	29,640	22,800	22,025	24,575	8,145	20,495	26,820	30,325
Acres	30	48	42	43	33	16	36	53	36
Yield (lb)	450	618	543	512	745	509	569	506	842

PRODUCTS	2009	2010	2011	2012	2013	2014	2015	2016	2017 (P)
SUGAR									
Sugarcane	917.728	1.122.765	843.786	1.070.128	1.078.015	1.214.125	1.186.154	1.478.401	1.670.432

Acres	60.000	60.000	60.000	60.000	60.000	67.000	74.000	83.892	92.000
Yield (lbs)									
ORANGE									
	5.519.62	3.851.429	4.447.49	5.805.948	4.051.659	4.158.869	3.963.779	3.247.752	3.200.843
Acres	37.786		39.330	39.000	40.162	40.162	37.948	33.978	32.443
Yield									
GRAPEFRUIT									
	1.124.23	1.389.753	673.043	880.489	678.147	576.234	722.104	370.964	186.106
Acres	6.665		7.687	7.600	6.944	6.944	5.834	6.102	5.379
Yield									
BANANA	4.505.63	5.118.896							
Production	3.751.69	4.287.510	4.084.70	5.716.254	5.446.813	5.661.558	5.447.976	3.892.151	4.693.842
Acres	6.524	6.528	6.633	6.971	6.700	7.162	10.117	6.107	6.107
Yield									
APPLE BANANA									
	13.600	1.400	15.200	28.495	19.970	5.700	23.000	23.000	4.800
Acres	19	7	32	60	21	17	40	40	24
Yield	716	200	475	475	951	335	575		
MANGOES									
Production	129.000		542.000		288.000	66.150	300.000	100.000	115.000
Acres	33				29	18	30	10	12
Yield (lb)	3.909				9.931	3.675	10.000	10.000	
PAPAYA									
Production	54,349.2	58,925.36	53,743.7	36,316,050	47,986,270	61,046.22	25,026.16	7,500,030	3,179,520
Acres	674		1.379	750	613	600			
Yield (lb)	80.637		38.973	48.421					
PEANUTS									
Production	139.650	299.000	279.700	308.600	299.950	240.459	348.950	315.400	276.600
Acres	109	246	280	265	254	217	321	329	310
Yield (lb)	1.281	1.215	999	1.165	1.181	1.108	1.089	959	892
PINEAPPLE									
Production	2.594.50	5.085.500	3.245.50	2.618.050	2.859.875	3.070.375	8.329.675	3.138.500	4.152.154
Acres	145	284	234	214	171	258	612	185	519
Yield (lb)	17,893	17,907	13,870	12,234	16,724	11,901	13,611	16,965	8,000
PLANTAIN									
Production	470.261	154.647	180.620	168.319	144.466	199.200	282.086	282.025	297.934
Acres	427	423	442	450	394	575	785	774	765
Yield	1.101	366	409	374	367	346	359	364	389
WATERMELON									
Production	4.335.25	2.843.274	2.216.40	2.362.800	2.145.923	3.018.050	2.944.024	7.545.968	9.091.565
Acres	189	181	122	138	136	181	191	365	426
Yield (lb)	22.938	15.709	18.167	17.122	15.779	16.674	15.401	20.674	21.357
COCONUT									
Production	735,700	8,023,680	6,146,00	7,680,680	1,041,000	9,043,400	18,548,46	24,135,00	25,077,60
Acres	573	796	615	620	548	956	1.533	2.028	2.322
Yield (Nuts)	1.284	10.080	9.993	12.388	1.900	9.460	12.099	11.901	10.800
COCOA									
Production	86,115	57,629	57,671	150,000	145,000	165,850	158,365	186,554	537,590
Acres	300	300	500	500	1.587	1.750	1.692		1.013
Yield (lb)	287	192	115	300			94		
CANTELOUPE									
Production	638.200	726.375	601.428	632.944	643.156	326.050	461.210	2.227.550	1.636.205
Acres	50	70	59	58	60	33	59	164	204

Yield (lb)	12.764	10.377	10.194	10.913	10.719	9.880	7.791	13.583	8.021
ANNATO									
Production	78.200	55.000	35.000	35.000	95.000	2.800	55.525	12.038	
Acres	38	29	35	35	35	2	20	5	
Yield (lb)	2.058	1.897	1.000	1.000	2.714	1.400	2.776	2.408	
COFFEE									
Production									
Acres			60	40					
Yield (lb)									
AVOCADO									
Production	1.500		54.000			18.600	21.000	1.250	2.000
Acres	0.5		5.4			4	6	3	4
Yield (lb)	3.000					4.650	3.500	417	500
CASHEW									
Production	238.050	238.050	165.000			3.430	51.797		
Acres	1.725	1.725	1.375			10	4		
Yield (lb)	138	138	120			343			
SOURSOP									
Production	11.375		2.200			102.080	272.812	160.650	195.000
Acres	22		3			12	4	5	15
Yield (lb)	517		733			8.507	64.191	32.130	13.000

Source: MOA, SIB

[1]: Total production in millions of pounds

[2]: Yield per acre

Crop Residue Management

Annex 2.b: Major Crop Production in pounds

Crop	2009	2012	2015	2017
Rice	14,981,500	27,917,000	35,721,000	41,339,000
Corn	25,218,095	127,209,000	144,978,000	197,391,000
Beans	2,661,860	21,239,000	9,680,000	11,541,000
Peanuts	139,650	308,600	348.950	276,600
Soybeans	1,290,000	2,330,903	11,240,300	28740490
Cowpeas	8,097,700	5,997,000	5,958,800	3.681,200
Sugarcane (long tons)	917,728	1,190,000	1,467,000	1,647,000

Source: Min of Agriculture, 2019

Annex 3a: Livestock Production for 2000-2017

Annex 3: Livestock Production for 2000-2017									
LIVESTOCK	2000	2001	2002	2003	2004	2005	2006	2007	2008
CATTLE									
Dairy Population (Heads):		2,064	3,560	3,550	N/A	5,202	7,728	3,914	3,592
Beef Population (Heads):	63,655	56,345	53,389	54,250	N/A	63,038	67,611	72,826	81,328
Heads Slaughtered:	7,235	8,729	9,076	10,880	13,020	7,904	8,252	7,926	8,401
MILK									
Production (lbs)	3,079,415	5,580,268	7,422,148	7,584,352	7,974,867	8,347,339	6,644,628	5,965,514	6,437,593
HONEY									
Production	171,745	95,815	104,500	117,343	83,466	69,164	107,084	106,325	63,315
No. of Hives	1,842	1,363	1,241	1,460	533		1,511	1,752	1,692
PIGS									
Pig Population (Heads):		18,039	22,820	21,224	N/A	15,387	14,533	12,403	13,146
Heads Slaughtered:	14,712	17,225	17,905	19,003	14,325	19,612	21,330	20,536	19,602
Liveweight (lbs)	2,780,568	3,607,602	3,581,000	3,800,600	2,865,000	3,922,330	4,266,000	4,107,200	3,920,400
SHEEP									
Sheep Population (Heads):		4,053	6,409	6,265	N/A	5,842	7,770	9,645	9,911
Heads Slaughtered:			992	1,137	1,316	1,326	1,253	1,171	1,494
Liveweight (lbs)			74,400	85,275	98,700	99,469	93,975	87,825	112,050
Dress weight (lbs)			37,200	40,950	49,350	59,681	56,385	52,695	67,230
BROILERS									

No. of Birds (Slaughtered)	5,416,550	7,795,364	9,210,235	8,168,432	8,588,379	8,491,463	8,242,504	8,455,917	8,329,011
Liveweight (lbs)	24,337,489	37,897,115	40,365,958	38,595,615	39,502,923	38,927,204	37,584,341	37,468,249	35,348,891
Dress weight (lbs)	19,007,060	29,965,666	30,800,751	30,048,504	30,740,883	30,488,884	29,880,350	29,473,121	27,767,402
LAYERS									
Eggs (Doz)	2,004,619	2,263,463	2,153,322	2,664,928	2,851,257	2,405,968	2,640,152	2,949,537	3,373,885
TURKEY									
No. of Turkey (Slaughtered)	N/A	28,180	32,371	26,780	25,107	23,298	29,434	24,310	28,939
Liveweight (lbs)	282,575	368,696	558,050	429,284	403,989	401,568	444,902	441,535	473,985
Dress weight (lbs)		281,800	396,990	353,511	317,449	321,643	355,095	366,049	288,431
LIVESTOCK	2009	2010	2011	2012	2013	2014	2015	2016	2017 (P)
CATTLE									
Dairy Population (Heads):	3,877	3,500				4,243			98,727
Beef Population (Heads):	91,129	95,000				97,770			36,676
Heads Slaughtered:	7,961	7,414	7,861	8,157	9,052	7,588	7,834	7,093	7,268
Liveweight (lbs)	7,164,900	6,672,960	7,074,900	7,341,300	8,146,800	6,829,200	7,050,960	6,383,664	6,540,912
Dress weight (lbs)	3,582,450	3,336,480	3,537,450	3,670,650	4,073,400	3,414,600	3,525,480	3,191,832	3,270,456
MILK									
Production (lbs)	8,276,859	7,330,679	8,697,623	11,872,766	11,027,564	10,281,394	12,570,433	12,062,440	14,366,366
HONEY									
Production	130,345	89,203	130,495	102,835	100,100	64,380	97,931	73,160	83,107
No. of Hives	1,379	2,430	984	650	851	784			2,910
Yield (lbs/Hive)									
PIGS									
Pig Population (Heads):	17,038	20,000							18,708

Heads Slaughtered:	21,953	22,415	21,704	25,881	24,655	25,233	30,038	30,993	32,674
Liveweight (lbs)	4,390,600	4,482,930	4,340,800	5,176,200	4,931,000	5,046,660	6,007,600	6,198,500	6,534,760
SHEEP									
Sheep Population (Heads):	13,018	14,500							11,434
Heads Slaughtered:	886	1,341	1,401	1,735	2,096	1,396	2,398	2,528	2,199
Liveweight (lbs)	66,450	100,575	105,075	130,125	157,200	104,664	179,844	189,588	164,892
Dress weight (lbs)	39,870	60,345	63,045	78,075	94,320	62,798	107,906	113,753	98,935
POULTRY									
Broiler Population									
No. of Birds (Slaughtered)	8,428,611	8,589,552	8,816,623	8,964,840	9,953,565	10,690,338	11,211,590	11,669,210	11,869,579
Liveweight (lbs)	36,909,285	38,052,455	39,438,212	39,714,623	44,255,514	48,634,832	50,817,120	53,064,713	53,927,570
Dress weight (lbs)	28,577,082	30,112,764	30,578,971	31,549,691	35,312,284	38,578,868	40,773,787	41,719,106	43,310,912
LAYERS									
Eggs (Doz)	3,427,440	4,033,692	3,533,962	2,742,949	3,573,489	4,089,287	4,229,782	5,778,705	4,806,281
Eggs	41,129,280	48,404,304	42,407,544	32,915,388	42,881,868	49,071,444	50,757,384	69,344,460	57,675,372
TURKEY									
No. of Turkey (Slaughtered)	40,748	24,485	23,632	7,369	44,277	37,658	10,367	31,770	50,414
Liveweight (lbs)	606,073	453,233	363,347	126,477	641,170	625,491	167,522	496,712	839,346
Dress weight (lbs)	486,099	364,740	297,707	103,777	507,936	492,008	135,764	409,503	698,660

Source: Ministry of Agriculture

Annex 3.b: Livestock Production (heads) based on Min of Agric and BLPA data.

Species	2009	2012	2015	2017
Beef	91,129	94,817	100,000	126,129
Dairy	3,877	3,582	3,670	3,676
Swine	17,038	22,800	25,992	32,674
Sheep	13,018	14,500	15,200	11,434
Goat	750	820	780	244
Buffalo	85	126	360	565
Horses	5,931	6,227	6,476	6,605
Poultry**	12,140,498	9,960,934	11,221,957	16,726,274

Source: Min of Agric and BLPA data *estimated based on FAO data
** includes Broilers, Layers and Turkeys

Annex 3.c: Livestock Data (number of heads) for Recalculations

Source	1994	1997	2000	2003	2006	2009
Dairy Cows	1,882	2,539	2,360	3,550	7,728	3,877
Other Cattle	51,097	34,269	50,087	54,250	67,611	91,129
Buffalo	1,970	150	230	60	75	85
Sheep	2,688	2,525	3,000	6,265	7,770	13,018
Goats*	32	130	140	620	720	750
Horses	4,527	4,980	5,478	4,902	5,392	5,931
Mules and Asses**	4,400	4,400	4,400	490	540	595
Swine	24,224	23,248	18,000	21,224	14,533	17,038
Poultry	5,516,766	4,789,280	6,275,322	869,857	1,855,606	1,984,358

*Source: Min of Agric and BLPA; *Data for 1997 and 2000 FAO sourced; **Data for ‘94, ‘97, 2000 FAO data sourced*

Annex 3.d: Total Nitrogen Fertilizers in kgs

Fertilizer Type	2009	2012	2015	2017
Urea	9,105,733	15,353,877	15,915,111	10,875,721
Ammonium Sulphate	334,136	1,817,174	2,380,651	8,112,983
Ammonium Sulphate solution	na	na	405222	na
Ammonium Nitrate	696,577	2,738,853	3,062,553	4,409,307
Diammonium phosphate	7,695,840	10,381,369	14,547,035	12,785,790
Nitrogenous Fertilizer	370095	6 470	na	na
NPK Fertilizers	1902602	18,807,924	29,600,932	42,268,400
Fertilizer Mixes	1,812,897	941	695,838	648,604
Monoammonium phosphate	254	2,000	111,977	65,263
Ammonium carbonate	2131	na	na	na

Source: FAO

Annex 3.e: Fertilizer consumption (Kg/Ha of arable land)

Date	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kg/ha	367.73	382.37	78.66	81	89.26	60.87	49.76	121.44	58.01	234.71	140.04	176.47	170.56	431.64	466.25

Source: World Bank