NATIONAL INVENTORY REPORT 1994 - 2022: GREENHOUSE GAS SOURCES AND SINKS IN BELIZE

BELIZE'S SUBMISSION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

2024

Ministry of Sustainable Development, Climate Change and Disaster Management

National Climate Change Office of Belize

FOREWORD

Climate change is a critical, cross-sectoral challenge that significantly impacts Belize's long-term development. The nation is already experiencing the effects of climate change, including rising temperatures, prolonged droughts, and ocean acidification. Belize's geographical location further exacerbates these impacts due to its reliance on climate-sensitive sectors, putting the country at heightened risk for economic crises, such as declines in agricultural productivity, increased costs for natural disaster recovery, and a rise in health conditions like vector-borne diseases and heat stress.

Belize’s greenhouse gas emissions represent a miniscule fraction of global emissions, highlighting the country’s minimal contribution to climate change despite its vulnerability to its impacts. According to the IPCC Sixth Assessment Report (AR6), global net anthropogenic greenhouse gas emissions reached 59 ± 6.6 GtCO2eq in 2019, marking a 12% increase since 2010 and a 54% rise since 1990. In contrast, Belize’s emissions account for less than 0.01% of the global total. This stark disparity underscores the disproportionate climate risks faced by small nations like Belize, which contribute negligibly to global emissions yet are among the most susceptible to climate change effects.

Despite Belize's less than one percent contribution to global greenhouse gas (GHG) emissions, the country remains steadfast in its commitment to reducing emissions in alignment with the Paris Agreement's goal of limiting global temperature rise to below 1.5° to 2°C above pre-industrial levels. Belize is actively pursuing its potential in renewable energy and energy efficiency with the intent to decrease fossil fuel consumption while promoting sustainable development. Although Belize's GHG emissions are relatively low, its international commitments and the opportunities that arise from addressing climate change necessitate the integration of climate considerations into national development plans.

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Suggested reference for Belize's National Inventory Document (NID): Belize's Fifth National Inventory Document, Ministry of Sustainable Development and Climate Change

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ACRONYMS AND ABBREVIATIONS

AD	Activity Data	Dm	Dry Matter
AFOLU	Agriculture, Forestry, and Other Land Use	DNA	Designated National Authority
AGB	Above-Ground Biomass	DOE	Department of the Environment
AGM	Annual General Meeting	DOM	Dead Organic Matter
API	Annual Production Index	EECA	Energy Efficiency and Conservation Authority
AR5	IPCC Fifth Assessment Report	EF	Emission factor
BEL	Belize Electricity Limited	EFDB	Emission Factor Database
BFD	Belize Forest Department	EPA	Environmental Protection Agency
BGB	Below-Ground Biomass	ES	Executive summary
BNCCC	Belize National Climate Change Committee	EU	European Union
BNE	Belize Natural Energy	FAO	Food and Agriculture Organization (of the United Nations)
BOD	Biological Oxygen Demand	FCPF	Forest Carbon Partnership Facility
BTR	Biennial transparency report	FD	Forest Department
BUR	Biennial Update Report	FNC	Fourth National Communication
BWSL	Belize Water Service Limited	FOLU	Forest and Other Land Use
C	Confidential (notation key)	FP	Focal Point
CaCO3	Calcium Carbonate	FREL	Forest Reference Emission Levels
CaMg(CO3)2	Calcium Magnesium Carbonate (Dolomite)	FRL	Forest Reference Levels
CaO	Calcium Oxide	GEF	Global Environment Facility
CBD	Convention on Biological Diversity	Gg	Gigagrammes
CBIT-GSP	Capacity-building Initiative for Transparency and Global Support Programme	GHG	Greenhouse gas
CCCCC	Caribbean Community Climate Change Centre	GHGI	Greenhouse Gas Inventory
CDM	Clean Development Mechanism	GoB	Government of Belize
CFCs	Chlorofluorocarbons	GPG	Good Practice(s) Guidance
CFE	Comisión Federal de Electricidad	GSMU	Geospatial Monitoring Unit
CfRN	Coalition for Rainforest Nations	GWP	Global warming potentials
CH_4	Methane	GWPs	Global Warming Potentials
CHP	Combined Heat and Power	Ha	Hectare
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement	HCFC	Hydrochlorofluorocarbons
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement	HFC	Hydrofluorocarbons
CNTMP	Comprehensive National Transportation Master Plan	HPMP	Hydrochlorofluorocarbons Phase-out Management Plan
CO	Carbon monoxide	HWP	Harvested Wood Products
CO_2 eq	Carbon dioxide equivalent	IE	Included elsewhere (notation key)
CO_2	Carbon dioxide	IEF	Implied Emission Factor
COP	Conference of the Parties	IFCs	International Finance Cooperations
CR	CORINAIR (key notation)	IIP	Inventory Improvement Plan
CRT	Common Reporting Tables	INC	Initial National Communication
CS	Country Specific emission factors	IPCC NGGIP	Intergovernmental Panel on Climate Change National Gas Inventory Programme
D	Default value for emission factors	IPCC TFI	Intergovernmental Panel on Climate Change Taskforce on National Gas Inventories
Dm	Dry Matter	IPCC	Intergovernmental Panel on Climate Change

DNA	Designated National Authority	IPPU	Industrial processes and product use (sector)
DOE	Department of the Environment	KCA	Key Category Analysis
DOM	Dead Organic Matter	Kha	kilo hectares (1000 hectares)
EECA	Energy Efficiency and Conservation Authority	KML	Keyhole Markup Language
EF	Emission factor	kt	Kilotonne or gigagram
EFDB	Emission Factor Database	Kts	kilotonnes
EPA	Environmental Protection Agency	L	Level
ES	Executive summary	LIC	Land Information Center
EU	European Union	LPG	Liquid Petroleum Gas
FAO	Food and Agriculture Organization (of the United Nations)	LUA	Land Use Assessment (app)
FCPF	Forest Carbon Partnership Facility	LULUCF	Land use, land-use change and forestry (sector)
FD	Forest Department	M	Model
FNC	Fourth National Communication	m3	cubic meter
FOLU	Forest and Other Land Use	MAFFESDI	Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable
FP	Focal Point	MCF	Methane Conversion Factor
FREL	Forest Reference Emission Levels	MDGs	Millennium Development Goals
FRL	Forest Reference Levels	MLP	Managed Lands Proxy
GEF	Global Environment Facility	MMS	Manure Management System
Gg	Gigagrammes	MNRA	Ministry of Natural Resources and Agriculture
GHG	Greenhouse gas	MPG	Modalities, procedures and guidelines for the transparency framework of the Paris Agreement
GHGI	Greenhouse Gas Inventory	MRV	Monitoring, reporting and verification
GoB	Government of Belize	MSDCC	Ministry of Sustainable Development and Climate Change
GPG	Good Practice(s) Guidance	MSDCCDR	Ministry of Sustainable Development, Climate Change & Disaster Risk Management
GSMU	Geospatial Monitoring Unit	MSW	Municipal Solid Waste
GWP	Global warming potentials	MT	Method
GWPs	Global Warming Potentials	Mt	Metric tons
Ha	Hectare	MW	Megawatt
HCFC	Hydrochlorofluorocarbons	N2O	Nitrous oxide
HFC	Hydrofluorocarbons	NA	Not Applicable (notation key)
HPMP	Hydrochlorofluorocarbons Phase-out Management Plan	NA1	Non-Annex One
HWP	Harvested Wood Products	NASA	National Aeronautics and Space Administration
IE	Included elsewhere (notation key)	NC	National Communication
IEF	Implied Emission Factor	NCCC	National Climate Change Committee
IFCs	International Finance Cooperations	NCCO	National Climate Change Office
IIP	Inventory Improvement Plan	NDC	National Determined Contributions
INC	Initial National Communication	NE	Not Estimated (notation key)
IPCC NGGIP	Intergovernmental Panel on Climate Change National Gas Inventory Programme	NEMO	National Emergency Management Organization
IPCC TFI	Intergovernmental Panel on Climate Change Taskforce on National Gas Inventories	NF3	Nitrogen Trifluoride
IPCC	Intergovernmental Panel on Climate Change	NFP	National Focal Point
IPPU	Industrial processes and product use (sector)	NICFI	Norway's International Climate and Forest Initiative
KCA	Key Category Analysis	NICH	National Institute of Culture and History

Kha	kilo hectares (1000 hectares)	NID	National Inventory Document
KML	Keyhole Markup Language	NIR	National Inventory Report
kt	Kilotonne or gigagram	NMS	National Meteorological Service
Kts	kilotonnes	NMVOC	Non-Methane Volatile Organic Compound(s)
L	Level	NO	Not Occurring (notation key)
LIC	Land Information Center	NO2	Nitrogen Dioxide
LPG	Liquid Petroleum Gas	NOx	Nitrogen Oxides
LUA	Land Use Assessment (app)	NTFP	Non-Timber Forest Products
LULUCF	Land use, land-use change and forestry (sector)	ODS	Ozone-Depleting Substances
M	Model	ODU	Oxidized During Use (ODU) factor
m3	cubic meter	OPAL	Online Permitting and Licensing
MAFFESDI	Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable	PAs	Protected Areas
MCF	Methane Conversion Factor	PFC	Perfluorinated Compounds
MDGs	Millennium Development Goals	PFC	Perfluorocarbons
MLP	Managed Lands Proxy	PMU	Project Management Unit
MMS	Manure Management System	PS	Plant Specific
MNRA	Ministry of Natural Resources and Agriculture	PSPs	Permanent Sample Plots
MPG	Modalities, procedures and guidelines for the transparency framework of the Paris Agreement	PUC	Public Utilities Commission
MRV	Monitoring, reporting and verification	QA/QC	Quality Assurance and Quality Control
MSDCC	Ministry of Sustainable Development and Climate Change	R+CU	REDD+ Coordination Unit
MSDCCDR	Ministry of Sustainable Development, Climate Change & Disaster Risk Management	RAC	(Not provided in your original list - please clarify or provide a meaning if needed)
MSW	Municipal Solid Waste	REDD+	Reducing Emissions from Deforestation and Forest Degradation
MT	Method	RedINGEI	Latin American Network of National Greenhouse Gas Inventories (Red Latinoamericana de Inventarios Nacionales de Gases de Efecto Invernadero)
Mt	Metric tons	SD	Sustainable Development Goals
MW	Megawatt	SF6	Sulfur Hexafluoride
N2O	Nitrous oxide	SFM	Sustainable Forest Management
NA	Not Applicable (notation key)	SIB	Statistical Institute of Belize
NA1	Non-Annex One	SNC	Second National Communication
NASA	National Aeronautics and Space Administration	SO	Sustainable Objective
NC	National Communication	SO2	Sulphur Dioxide
NCCC	National Climate Change Committee	SOC	Soil Organic Carbon
NCCO	National Climate Change Office	SOx	Sulfur Oxides
NDC	Nationally Determined Contributions	SWDS	Solid Waste Disposal Systems
NDC	National Determined Contributions		
NE	Not Estimated (notation key)		

EXECUTIVE SUMMARY

ES.1 Key Points

Belize's greenhouse gas inventory demonstrates the country's unique position as a net carbon sink, while highlighting growing emission challenges in specific sectors. The ***country's net greenhouse gas (GHG) emissions and removals (including Land Use, Land Use Change and Forestry (LULUCF))*** were **-2191.48kt CO2 eq in 2022**, showcasing its vital role in global carbon sequestration. Despite Belize's relatively small global emissions footprint, the country remains committed to reducing emissions in alignment with the Paris Agreement's temperature goals.

The sectoral breakdown reveals important trends (Figure ES 1):

- Waste sector (55% of total emissions): Improved data capture and population growth have led to better understanding of this sector's impact.
- Energy sector (26% of total emissions): Growing transportation and tourism activities are driving increased emissions.
- Agriculture sector: (12% of total emissions): Growing livestock and rice cultivation activities generate most emissions.
- IPPU sector: (7% of total emissions): Small scale industry contributing the least to overall emissions.
- LULUCF sector: Demonstrates exceptional carbon sink capacity with -5023.47 kt CO2 eq removals.

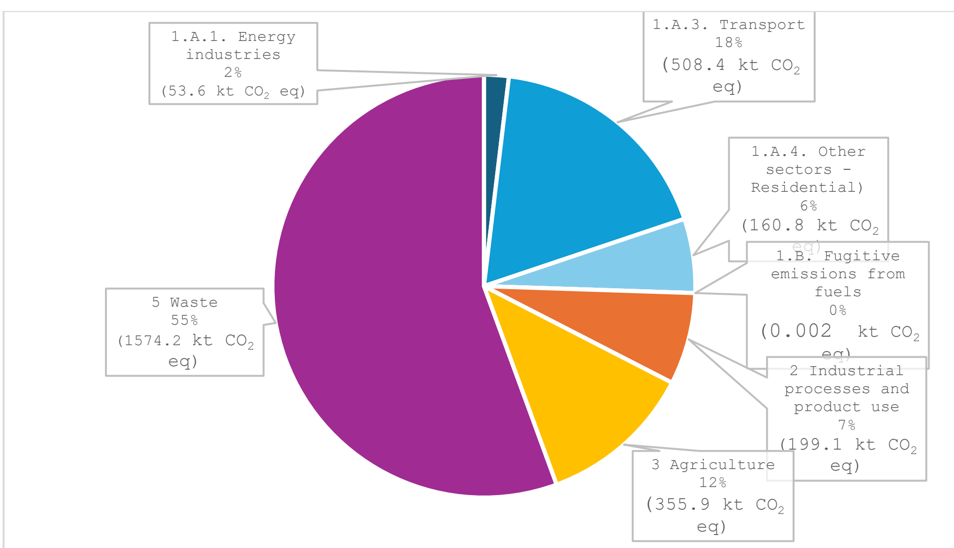

Figure ES 1 Breakdown of Belize's Emissions by Sector (2022)

ES. 2 Background information on GHG inventories and climate change

Belize's National Greenhouse Gas Inventory Report (NIR) is part of its first Biennial Transparency Report (BTR) to be submitted in December 2024, covering emissions and removals from 1994 to 2022. This inventory was prepared by the National Climate Change Office (NCCO) under the Ministry of Sustainable Development and Climate Change with support from technical experts across the reporting sectors (Energy, IPPU, AFOLU and Waste).

Belize, located in Central America and bordered by Mexico, Guatemala, and the Caribbean Sea, experiences unique climate impacts, including active hurricane seasons, wildfires, prolonged rainy periods, and rising sea levels. Despite Belize's vulnerability, the country maintains its focus on national environmental protection and global environmental stewardship having been engaged in international climate action since 1992 after its accession to the United Nations Framework Convention on Climate Change (UNFCCC) followed by subsequent ratification of the Kyoto Protocol in 2013 and the Paris Agreement in 2016.

The NCCO, operating under the Ministry of Sustainable Development and Climate Change, coordinates national climate initiatives and reporting obligations to ensure strong governmental support and partnerships for impactful climate action. The NCCO is also the secretariat to the Belize National Climate Change Council (BNCCC). The BNCCC reviews and approves national documents before submission to Belize's Cabinet. A draft Climate Change and Carbon Market Initiative Bill is under revision that will formalize the institutional arrangements including to facilitate carbon trading.

ES. 3 Overview of National GHG Emissions and Removals (1994 – 2022)

The country maintains its status as a net carbon sink, with total net emissions of **-2191.48 kt CO2 eq in 2022**. Figure ES 2 illustrates a steady increase in emissions from 2006 to 2019, followed by a decline in 2020 due to the pandemic. A further reduction in emissions is seen between 2021 and 2022, but sectoral emissions remain consistent with some fluctuations.

The **Energy sector** emissions are primarily driven by growing transportation and energy production demands. **The Industrial Processes and Product Use (IPPU) sector**, although the smallest, shows steady growth attributed to the expanding tourism industry and rising demand for refrigeration and air conditioning systems.

The **Agriculture sector** has demonstrated consistent growth in emissions led by livestock emissions from enteric fermentation. The Waste sector has shown substantial increases over the time series driven by population rise and improved accounting of domestic and industrial wastewater emissions. Finally, the **Land Use, Land Use Change and Forestry (LULUCF) sector** reports a significant net removal of -5023.47 kt CO2 eq in 2022, highlighting Belize's forest management and great carbon sink potential.

Throughout the time series, natural events have also significantly influenced emission patterns. In 2011 (see Figure ES 3), large-scale wildfire outbreaks increased country emissions substantially to 10,457,484.37 tCO2eq due to Hurricane Richard in the previous year. Similarly, Hurricane Earl in 2016 generated additional emissions of 114,062.03 tCO2eq through forest damage and increased fuel loads on the forest floor.

Methane (CH4) has emerged as the dominant greenhouse gas (led by high waste sector emissions), accounting for 67% of emissions (1898.33 kt CO2 eq) in 2022, while carbon dioxide (CO2) represents 25% (702.89 kt CO2 eq) of total emissions (primarily resulting from the energy sector). Nitrous oxide (N2O) and hydrofluorocarbons (HFCs) form the remainder.

This comprehensive analysis demonstrates Belize's commitment and achievements in managing its greenhouse gas emissions and identifies areas for further improvement to uphold its NDCs.

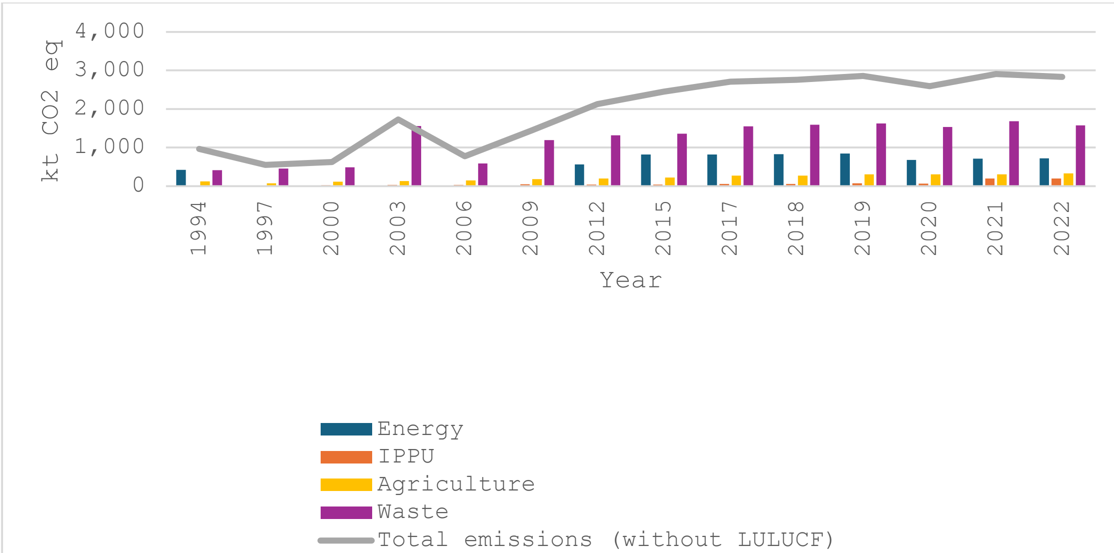

Figure ES 2 Belize's inventory: total GHGs by sector (kt CO2 eq), 1994-2022

Figure ES 3 Figure showing Belize's inventory: total net GHG by sector (kt CO2 eq), 1994 -2022

ES. 4 Key Category Analysis

The key category analysis highlights the most significant sources of GHG emissions and removals, focusing on both their current levels and trends over time.

This assessment was conducted using both trend assessment for 2022 and level assessment for the period 2012-2022, following Approach 1 as outlined in the IPCC guidelines.

Table ES 1 presents the key categories.

Table ES 1 Key categories in 2022.

IPCC category code	IPCC Category	Greenhouse gas	KC according to Level and/or Trend
3.B.1.a	Forest land Remaining Forest land	CO2	L, T
3.B.2.b	Land Converted to Cropland	CO2	L, T
3.B.3.b	Land Converted to Grassland	CO2	L, T
4.D	Wastewater Treatment and Discharge	CH4	L, T
3.B.5.b	Land Converted to Settlements	CO2	L, T
1.A.3.b	Road Transportation - Liquid Fuels	CO2	L
3.A.1	Enteric Fermentation	CH4	L, T
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	T

By identifying and analyzing these key categories, Belize can prioritize actions to improve data quality, enhance mitigation strategies, and effectively manage its GHG inventory.

ES. 5 Inventory Improvements

Belize continues to identify areas to enhance its data quality and reporting accuracy. An Inventory Improvement Plan was drafted to address both ongoing issues from previous reports and new challenges that have been identified, with specific timelines and responsibilities assigned to relevant agencies with priority levels. Key areas for improvements include:

1. Addressing data gaps
2. Improving data consistency
3. Enhancing data collection and standardize protocols
4. Increasing technical capacity
5. Establishing a centralized database

A detailed summary of improvements can be found in Section 8.4 on Belize's National Inventory Improvement Plan.

1 **Chapter 1**: NATIONAL CIRCUMSTANCES, INSTITUTIONAL ARRANGEMENTS AND CROSS-CUTTING INFORMATION

1.1 Background information on GHG inventories and climate change

1.2 Climate change

Climate change is a critical, cross-sectoral challenge that significantly impacts Belize's long-term development. The nation is already experiencing the effects of climate change, including rising temperatures, prolonged droughts, and ocean acidification. Belize's geographical location further exacerbates these impacts due to its reliance on climate-sensitive sectors, putting the country at heightened risk for economic crises, such as declines in agricultural productivity, increased costs for natural disaster recovery, and a rise in health conditions like vector-borne diseases and heat stress.

Following its ratification of the Kyoto Protocol and the Paris Agreement in 2013 and 2016, respectively, Belize has submitted its first Biennial Transparency Report (BTR1). This report addresses GHG emissions and removals for the period 1994 - 2022, incorporating recalculations. BTR will update the most recent GHG inventory, document progress towards nationally determined contributions, and outline other mitigation actions along with their impacts.

Through the submission of in previous national communications to the United Nations Framework Convention on Climate Change (UNFCCC), Belize has been enhancing its national capacity. The development of the BTR1 is expected to further institutionalize the GHG inventory process within the Government of Belize (GOB), coordinated by the National Climate Change Office in collaboration with key ministries and departments. This institutionalization aims to ensure the continuity and sustainability of future reporting processes.

1.3 National greenhouse gas inventories

Under the Enhanced Transparency Framework of the Paris Agreement, Article 13 decision 18/CMA.1, Belize is required to submit biennial transparency reports (BTR) every two years, including a national inventory report (NIR) of anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs). Belize's first and second GHG inventories covered the sectors of Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land Use Change and Forestry, and Waste. These inventories provided estimates for the base year 1994 and subsequent years 1997 and 2000. The third national GHG inventory aimed to capture new sources and sinks due to development activities, initially planning to estimate emissions for the years 2003, 2006, and 2009. This was followed by submissions of Belize’s

First Biennial Update Report (BUR1) in 2020, and its Fourth National Communications in 2022. Most recently, Belize has submitted its first Biennial Transparency Report (BTR) in 2022, bringing the national greenhouse gas inventory up to the reporting year 2022.

The figure below shows the series of greenhouse gas submissions by Belize since ratification of the UNFCCC to date.

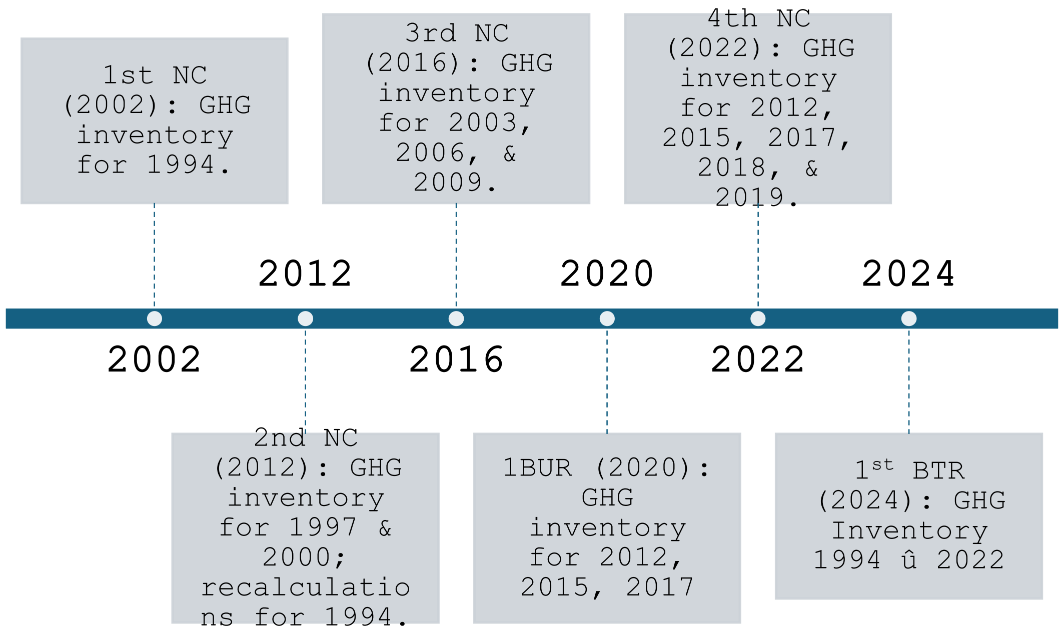

Figure 1-1 Greenhouse gas Inventory submissions by Belize

Belize has been building national capacity through participation in the preparation of greenhouse gas inventories and continues to build towards institutionalizing the greenhouse inventory process (data collection, analysis, and report preparation) within the Government of Belize.

1.4 National circumstances and institutional arrangements

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 1-2.

1.5 National entity or national focal point

The Belize Ministry of Sustainable Development and Climate Change (MSDCC), 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 Transparency 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. As an aid to the coordination, the Belize National Climate Change Committee and its two subcommittees who provide technical guidance for final decision making. These subcommittees are the Technical Sub-Committee, which provides technical guidance on adaption and mitigation efforts, and the Climate Finance Sub-Committee, which provides oversight of the delivery of climate change financing and areas of economic expansion.

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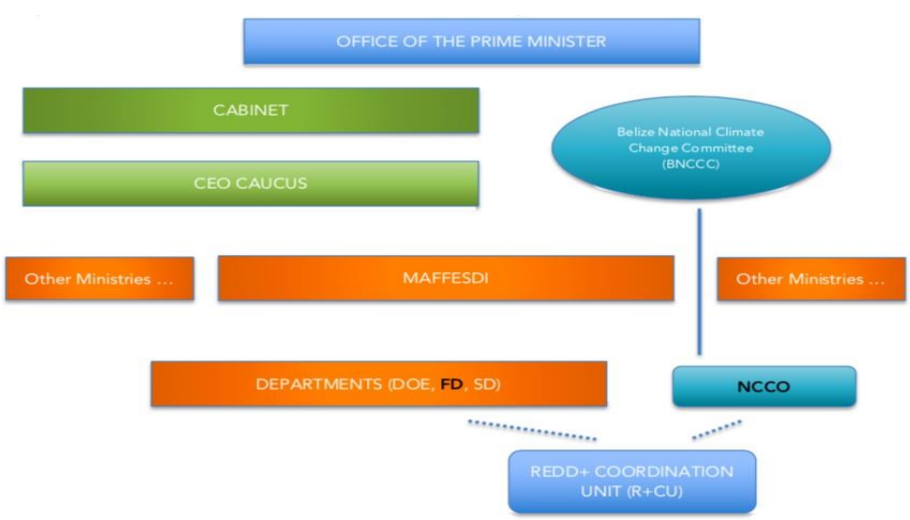

Figure 1-2 Belize institutional framework for the preparation of the GHG inventory

1.6 Inventory preparation process

The Belize Ministry of Sustainable Development and Climate Change (MSDCC) 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 Transparency Reports, and National Greenhouse Gas Inventory Reports.

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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 details 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 1-3 below outline 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.

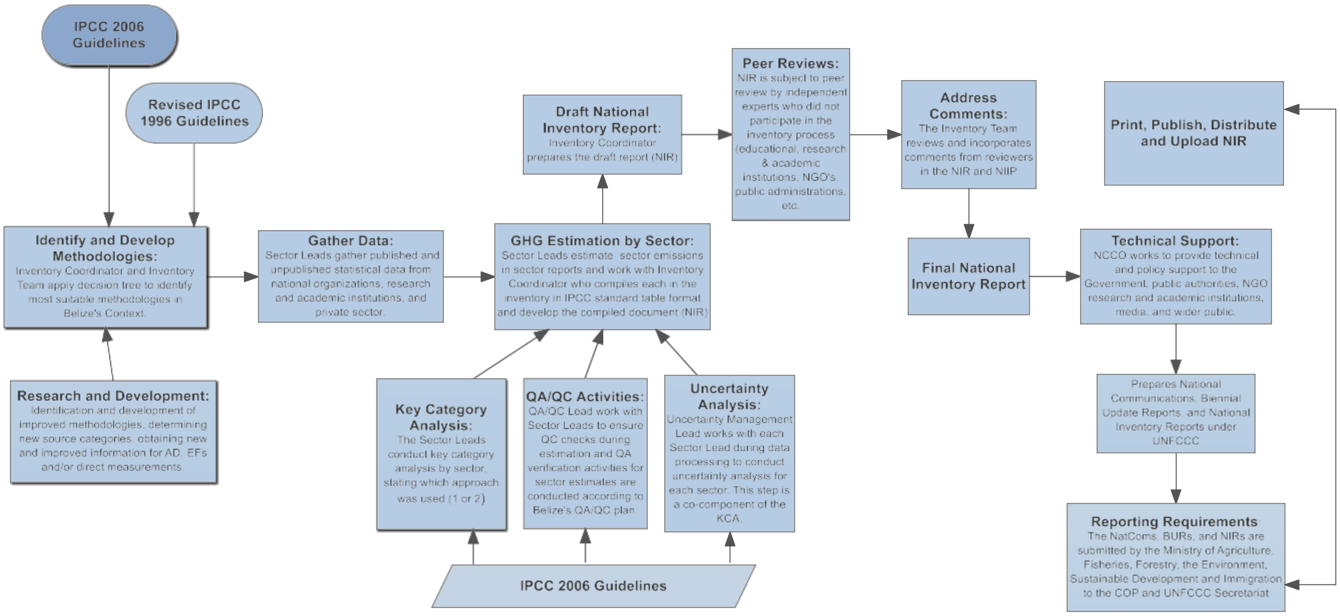

Figure 1-3 Inventory Process in Belize

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. Kenrick Williams	The Ministry of Sustainable Development and Climate Change	UNFCCC Focal Point/ Chief Executive Officer
2	Mrs. Edalmi Pinelo	National Climate Change Office	UNFCCC Focal Point/ Chief Climate Change Officer
3	Ms. Kamil Salazar Ms. Ide Sosa	National Climate Change Office	BTR Coordinator, Compiler & Generalist
4	Melvin Xis	National Climate Change Office	QA/QC Lead
5	Mr. Geon Hanson	Energy Unit, Ministry of Public Utilities, Energy, Logistics & E-Governance	Lead, Energy Sector
6	Ms. Areli Sutherland	Energy Unit, Ministry of Public Utilities, Energy, Logistics & E-Governance	Alternate Lead, Energy Sector
7	Mr. Clifford Martinez	Agriculture Department, Ministry of Agriculture, Food Security, and Enterprise	Lead, Agriculture Sector
8	Mr. Alfonso Bautista	Agriculture Department, Ministry of Agriculture, Food Security, and Enterprise	Alternate Lead & Statistician, Agriculture Sector
9	Ms. Indera Montero	Department of the Environment, The Ministry of Sustainable Development and Climate Change	Lead, IPPU Sector
10	Ms. Kristy Vernon	Department of the Environment, The Ministry of Sustainable Development and Climate Change	Alternate Lead, IPPU Sector
11	Mr. Kenneth Williams	Belize Solid Waste Management Authority, The Ministry of Sustainable Development and Climate Change	Lead, Waste Sector
12	Mr. Luis Balan, Ms. Mercedes Carcamo, Ms. Karlene Williams	Forest Department, The Ministry of Sustainable Development and Climate Change	Lead, Land Use & Land Use Change Sector
13	Mr. Edgar Correa	Forest Department, The Ministry of Sustainable Development and Climate Change	REDD+ Lead, Land Use & Land Use Change Sector Lead.

Source: National Climate Change Office

Greenhouse Gas Inventory Cycle

Belize's GHG Inventory Cycle is segregated into six phases based on the 2006 IPCC guidelines and the Consultative Group of Experts 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 1-4 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.

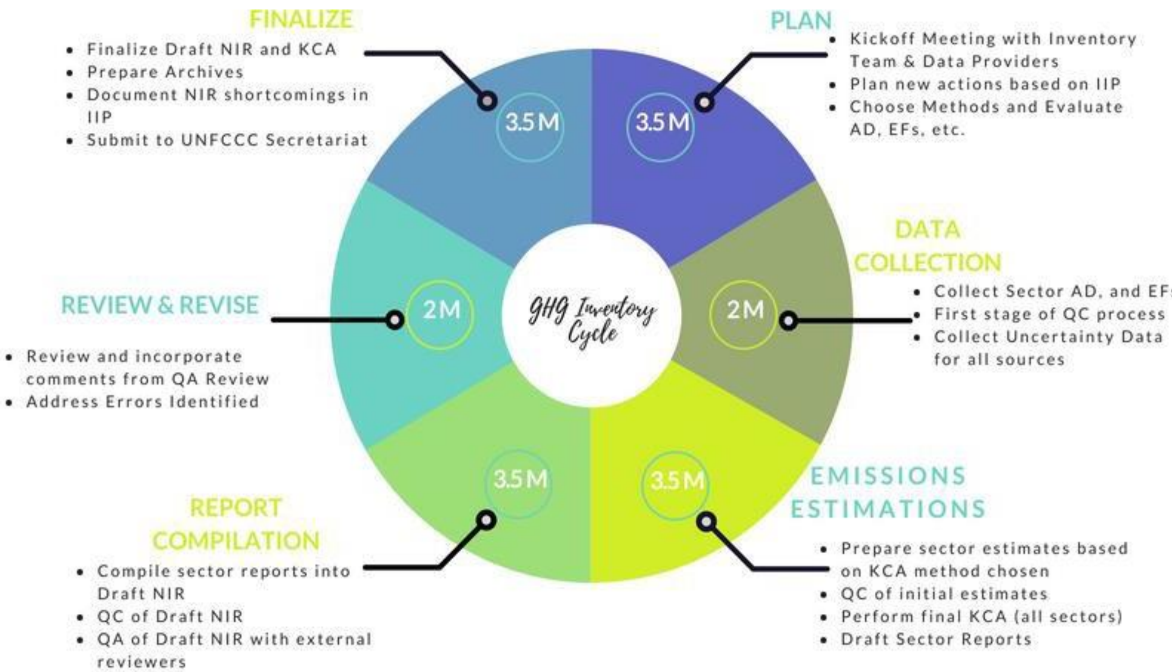

Figure 1-4 Belize's GHG Inventory Cycle

Source: NCCO-Belize's GHGI Institutional Arrangements

Data acquisition, Data management and Archiving

The GHG Inventory exercise is now executed by an inventory team led by the Ministry of Sustainable Development and Climate Change 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/ 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 functions as the liaison between the Inventory Sector Leads.

The NCCO established 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 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 1994-2022, (c) manuals and protocols, (f) literature reviewed, (g) completed QA/QC templates and protocols (when available), and (h) all reports and documentation.

1.7 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.

1.8 Gases included in the inventory

Gas emissions to be estimated and reported on include Carbon dioxide (CO2), Methane (CH4), and Nitrous Oxide (N2O).

1.9 Reporting years

Reporting years for Belize's National Inventory Report are 1994 – 2022.

1.10Recalculations

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. 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. For various years, activity data was also unable to be retrieved to make estimates of a complete time series. The most reliable activity data in the energy sector is available from 2012-2022.

For the IPPU Sector, recalculations were done for F-gases, however lime production data as early as 1994 - 2000 was very limited, therefore reliable estimations were only made for 2003- 2022.

For the Waste sector, recalculation was challenging due to different methods of determining waste generation rates were used by different studies, rendering older data incompatible. This was, however, still possible for solid waste disposal and domestic wastewater with the introduction of long-term population data disaggregated by city/municipality, which made provided updated activity data for the entire time series. Open Burning and Incineration were not included in this inventory due to data retrieval constraints, however further investigation will be prioritized for the subsequent inventory.

For the Agriculture sector, recalculations for all subcategories were possible with the exception of burning in croplands (sugarcane), which was previously included. The data recovery process was met with time constraints; however, this recovery remains a priority for the next inventory cycle.

Lastly, for the LULUCF sector, the 1994-2022 time series includes: (a) no 1994-1999 recalculations were done due to time constraints, however this remains a priority for the following inventory cycle, and (b) 2000-2022 new annual estimates were done based on reassessment of the LULUCF sector using advanced spatial and ground truthing analyses.

1.11 Description of methodologies, methods and data sources

Data for all sectors were collected by each GHG sector lead from their relevant stakeholders in their sectors. Specific information on data sources and methods are described in each sector chapter of this report.

The Tier 1 approach for calculations was used for most of the sectors including Energy, IPPU, and Waste and Agriculture 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, 2 and 3 were utilized for the Forest and Land Use sector due to the data that was available or developed through the REDD+ 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 Inventory Report 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.

Table 1-2 Summary report for methods applied to Belize inventory

Code	GHG source and sink categories	CO_2		CH_4		N_2O		HFC		PFC		SF_6		NF_3	
		Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
1.	Energy														
1.A.	Fuel combustion														
1.A.1.	Energy industries	T1	D	T1	D	T1	D								
1.A.2.	Manufacturing industries and construction	T1	D	T1	D	T1	D								
1.A.3.	Transport	T1	D	T1	D	T1	D								
1.A.4.	Other sectors	T1	D	T1	D	T1	D								
1.A.5.	Other (please specify)	T1	D	T1	D	T1	D								
1.B.	Fugitive emissions from fuels														
1.B.1.	Solid fuels	T1	D	T1	D	T1	D								
1.B.2.	Oil and natural gas and other emissions from energy production	T1	D	T1	D	T1	D								
1.C.	CO_2 transport and storage	T1	D												
2.	Industrial processes and product use														
2.A.	Mineral industry	T1	D												
2.B.	Chemical industry	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
2.C.	Metal industry	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
2.D.	Non-energy products from fuels and solvent use	T1	D	T1	D	T1	D								
2.E.	Electronic industry					T1	D	T1	D	T1	D	T1	D	T1	D
2.F.	Product uses as substitutes for ODS							T1	D	T1	D	T1	D	T1	D
2.G.	Other product manufacture and use	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
2.H.	Other (please specify)	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
3.	Agriculture														
3.A.	Enteric fermentation			T1	D										
3.B.	Manure management			T1	D	T1	D								
3.C.	Rice cultivation			T1	D										
3.D.	Agricultural soils			T1	D	T1	D								
3.E.	Prescribed burning of savannahs			T1	D	T1	D								
3.F.	Field burning of agricultural residues			T1	D	T1	D								
3.G.	Liming	T1	D												
3.H.	Urea application	T1	D												
3.I.	Other carbon-containing fertilizers	T1	D												
3.J.	Other (please specify)	T1	D	T1	D	T1	D								
4.	Land use, land-use change and forestry														

Code	GHG source and sink categories	CO_2		CH_4		N_2O		HFC		PFC		SF_6		NF_3	
		Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
4.A.	Forest land	T2, T3	CS	T1	D	T1	D								
4.B.	Cropland	T1	D	T1	D	T1	D								
4.C.	Grassland	T2	CS	T1	D	T1	D								
4.D.	Wetlands	T1	D												
4.E.	Settlements	T1	D												
4.F.	Other land	T1	D												
4.G.	Harvested wood products	T1	D												
4.H.	Other (please specify)	NO													
5.	Waste														
5.A.	Solid waste disposal			T1	D										
5.B.	Biological treatment of solid waste			T1	D	T1	D								
5.C.	Incineration and open burning of waste	T1	D	T1	D	T1	D								
5.D.	Wastewater treatment and discharge			T1	D	T1	D								
5.E.	Other (please specify)	T1	D	T1	D	T1	D								
6.	Other (please specify)														
	Memo items														
1.D.1.	International bunkers														
1.D.1.a.	Aviation	T1	D	T1	D	T1	D								
1.D.1.b.	Navigation	T1	D	T1	D	T1	D								
1.D.2.	Multilateral operations	T1	D	T1	D	T1	D								
1.D.3.	CO_2 emissions from biomass	T1	D												
1.D.4.	CO_2 captured	T1	D												
5.F.1.	Long-term storage of C in waste disposal sites	T1	D												
	Indirect N_2O					T1	D								
	Indirect CO_2	T1	D												

Notes: Use the following notation keys to specify the method applied: D = IPCC default; T1 = IPCC tier 1; T1a, T1b, T1c = IPCC tier 1a, tier 1b and tier 1c, respectively; T2 = IPCC tier 2; T3 = IPCC tier 3; CR = CORINAIR; CS = country-specific; M = model; RA = reference approach; OTH = other.

1.12 Description of key categories

The key category analysis (KCA) was conducted using both trend assessment for 2022 and level assessment for the period 2012-2022, following Approach 1 as outlined in the IPCC guidelines. The level assessment with 2012 as the base year was chosen because the most accurate emissions data from all sectors, particularly the energy sector, were complete starting in 2012. This serves as a fair trend comparison.

The key category analysis identifies the most significant sources of greenhouse gas (GHG) emissions and removals within a country's inventory. This analysis is crucial for prioritizing efforts to improve data quality and implement effective mitigation strategies. The categories are assessed based on their contribution to the total emissions and their trends over time, following the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC).

The key category analysis highlights the most significant sources of GHG emissions and removals, focusing on both their current levels and trends over time.

For instance, forest land remaining forest land (3.B.1.a) plays a crucial role in carbon sequestration, while land-use changes such as conversion to cropland (3.B.2.b) and grassland (3.B.3.b) can lead to substantial CO2 emissions.

Methane emissions from wastewater treatment (4.D) and enteric fermentation (3.A.1) are critical due to their high global warming potential. Road transportation (1.A.3.b) remains a major source of CO2 emissions from an upward trending road transport emissions. Lastly, the increasing use of refrigeration and air conditioning (2.F.1) highlights the growing trend of HFC and PFC emissions.

By identifying and analyzing these key categories, Belize can prioritize actions to improve data quality, enhance mitigation strategies, and effectively manage its GHG inventory.

Details of the Key Categories Analyses are provided in Annex I.

Table 1-3 Summary of 2022 key categories analysis approach 1, Level and Trend Assessment

IPCC category code	IPCC Category	Greenhouse gas	KC according to Level and/or Trend?
3.B.1.a	Forest land Remaining Forest land	CO2	L, T
3.B.2.b	Land Converted to Cropland	CO2	L, T
3.B.3.b	Land Converted to Grassland	CO2	L, T
4.D	Wastewater Treatment and Discharge	CH4	L, T
3.B.5.b	Land Converted to Settlements	CO2	L, T
1.A.3.b	Road Transportation - Liquid Fuels	CO2	L
3.A.1	Enteric Fermentation	CH4	L, T
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	T

1.13 QA/QC plan and implementation

This section outlines the quality assurance and quality control (QAQC) procedures implemented in Belize's Greenhouse Gas (GHG) inventory process. While Belize’s QA/QC plan is detailed and thorough, it is important to note that the plan is under partial implementation as the capacity of the national inventory team and its stakeholders continue to progress over time. The challenges in full implementation is owed to the frequent changes in the inventory team of experts, as well as the limited time and capacity of the inventory team between each 2-year inventory cycle. Despite these challenges, significant efforts are made to ensure the accuracy and reliability of the GHG inventory through both general and category-specific QAQC procedures.

The aim of Belize’s QA/QC manual is to convey the actual activities to be undertaken by all persons involved in the development of the GHG inventory. The completion of all QA/QC activities contributes to ensuring that the inventory submitted to the UNFCCC is transparent, accurate, consistent, complete, transparent and timely. Together, these activities aim to improve the quality of the GHG inventory over time and to ensure the sustainability of the system.

General QC Procedures

General QC procedures are routinely applied to all categories by sector experts responsible for each category and to the inventory report as a whole. Additionally, category-specific procedures based on the prioritization identified during the inventory planning process may be carried out.

General QC procedures include generic quality checks related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories. These checks are designed to be applicable to all categories, although they are not necessarily conducted on all inventory input data, parameters, and calculations.

Instead, checks are performed on selected sets of data and processes, with a representative sample of data and calculations from every category being reviewed. The categories focused on in the current review are documented in checklists to ensure full QA/QC of all categories over a multi-year period.

Belize also uses sector-specific data from some major industries, such as the sugar and citrus industries. The general QC procedures are applied to these data, with more in-depth checks included under the category-specific QC (Belize’s QA/QC Manual, 2019).

These checks are to be carried out by sector leads during the acquisition of data, the emissions calculation procedures, and the compilation of the National Communications (NC) and Biennial Transparency Reports (BTR) in accordance with established timelines. This section describes the procedures broadly carried out during the inventory preparation phase.

Annexes II through IV of the plan provide corresponding checklists that each inventory expert in the relevant organization should complete and sign to document the necessary QC checks and their results. Sector experts are responsible for immediate corrections of input data/emissions calculations where errors are found. If an issue cannot be resolved during the current inventory submission, sector experts should include an explanation and recommendations for future work on these issues. Such issues may be incorporated into the Inventory Improvement Plan (IIP). A copy of the completed checklist is sent to the National Climate Change Office (NCCO) and archived by the archiving lead on the Ministry server and cloud.

Sector Experts Conduct QC of Input Data

Sector experts undertake this phase of QC, involving the review of underlying activity data (AD), emission factors (EFs), and other parameters used for emissions calculations. The activities include, but are not limited to:

- Cross-checking descriptions of AD, EFs, and other parameters with category information to ensure proper recording and archiving.
- Ensuring that the time series of input EF, AD, and other parameters are justifiable, with outliers explained by national circumstances.
- Ensuring proper bibliographic information is available and documented in archives for all input parameters.
- Cross-checking a sample of input data with publicly available information to prevent transcription errors.
- Collecting information to enable calculation of parameter-specific uncertainty estimates.
- Comparing sector-level data with previous data and related indicators or national data where AD or EF data are obtained from plant operators.
- Documenting and archiving any QA/QC procedures on input data from national statistics.
- Checking that units are properly labelled for all input data and correctly transcribed and applied in emissions calculation spreadsheets.
- Documenting expert judgement used for parameters, including the expert's affiliation and expertise.
- Identifying recalculations of previous input data, documenting qualitative reasons,

Sector Experts Conduct QC of Calculated Emissions Estimates

Sector experts incorporate underlying AD, EFs, and parameters into inventory calculation spreadsheets/models and/or IPCC software to calculate category-level emissions. The QC activities for calculated emissions estimates include:

- Hand-checking the accuracy of random calculations.
- Ensuring that only basic input data are hardwired in spreadsheets, with all other cells using spreadsheet tools to link and calculate emissions.
- Reviewing time series consistency of emissions calculations for outliers and comparing values within the interval of other Parties.
- Ensuring category-level uncertainty estimates are calculated according to IPCC Guidelines.
- Randomly sampling conversion factors to ensure proper calculation from input data to emissions calculations.
- Assessing the reasonableness of implied emission factors (IEF) compared with previous submissions and IPCC Guidelines.
- Checking the time series of the IEF for explainable large changes.

Where data are provided directly by third parties or used for confidential emissions estimates, the sector expert ensures that the third party has completed necessary QC checklists or that QA/QC procedures meet data quality objectives for the GHG inventory. Aggregation of emissions in spreadsheets to the category level is checked for accuracy.

All completed checklists are sent to the archiving lead.
If sector experts identify issues with calculated estimates, they should correct the data or describe unresolved issues in the GHG inventory report.

Review of Compiled Inventory Report
The technical working group, comprising sector experts and other stakeholders, undertakes random sampling of checks similar to those performed during the initial compilation and calculation of category-level estimates. This includes:

- Aggregating emissions and removals data correctly for summary tables.
- Ensuring all cells in reporting tables are completed with values or notation keys.
- Verifying consistent use and explanations for notation keys.
- Ensuring confidential emissions data are properly aggregated to maintain confidentiality and included in national totals.
- Checking methodological tiers for key categories and explaining deviations in the inventory report.
- Documenting inventory data uncertainty and related assumptions.
- Ensuring the inventory report is balanced and consistent with information on category trends, methods, AD, and EFs used, recalculations, QA/QC procedures, and uncertainty analysis.
- Updating tables, figures, and text to reflect the latest information in the IPCC software.
- Describing observed trends in emissions data.
- Documenting recalculations and their impacts.

- Assessing completeness of categories and planned improvements.

Consistency in units used in the GHG inventory report and IPCC software is verified. Information on constraints, gaps, and capacity-building needs is provided, along with a complete references section and active web links.

Quality Assurance Procedures

Quality Assurance (QA) procedures involve activities outside the actual inventory compilation process, including reviews and audits to assess inventory quality, conformity of procedures, and areas for improvement. QA is conducted periodically by independent experts or expert teams not directly involved in inventory compilation.

Belize prioritizes QA for key categories, issues in the IIP, major recalculations, and issues identified by experts. The QA process includes expert reviews and audits.

Expert Review

Expert peer review ensures the reasonableness of inventory results, assumptions, and methods. Effective peer review involves identifying key independent organizations or research institutions to select appropriate reviewers. Reviews may identify technical problems with methods, AD, and EFs, and suggest improvements. Issues are incorporated into the current inventory process or the IIP for future cycles.

1.14 General uncertainty assessment

Belize's uncertainty assessment for greenhouse gas (GHG) emissions and removals is currently qualitative due to the unavailability of detailed uncertainty data from data providers. Additionally, there are significant discrepancies associated with default emission factors, which further complicate the uncertainty analysis. This limitation will be addressed with greater capacity and time in subsequent inventories.

According to the 2006 IPCC Guidelines, uncertainty refers to the lack of certainty in data and estimates, which can arise from various sources such as measurement errors, estimation methods, and inherent variability in natural systems. The guidelines recommend both quantitative and qualitative approaches to assess uncertainty, aiming to improve the transparency, accuracy, and completeness of GHG inventories.

Developing countries, like Belize, that require flexibility with respect to provision 29, are encouraged to provide a qualitative discussion of uncertainty for key categories. While quantitative estimates are ideal, the current focus is on identifying and discussing the main sources of uncertainty qualitatively. Noting that the key categories are in the LULUCF, Energy and Waste sectors, further investigation to quantify is required.

1.15 Completeness assessment

The national GHG inventory provides a thorough assessment of anthropogenic GHG emissions and removals in Belize. This inventory covers CO2, CH4, N2O and HFCs main (flexibility applied with respect to provision 48). However, emissions for certain categories have not been estimated or have been combined with other categories due to the following reasons:

- Categories that do not occur in Belize
- Lack of data at the category level
- Methodological issues specific to national circumstances

As part of the ongoing inventory improvement process, efforts are continuously made to identify new or improved data sources or methodologies to estimate those categories that are currently "not estimated." More details on the inventory's completeness can be found in table below.

Table 1-4 Belize's GHG inventory sources and sinks not estimated

GHG	Sector	GHG source and sink categories (CRT code)	Explanation or comment
CO_2	Agriculture	3.I Other carbon-containing fertilizers	Capacity constraints to appropriately group the synthetic fertilizers by chemical compound and get an accurate account of quantity actually applied annually.
CH_4	Waste	Incineration	Data and methodological constraints to obtain time series data
	Waste	Open Burning	Data and methodological constraints to obtain this as these activities are not officially recorded
	Agriculture	3.F. Field burning of agricultural residues	Data retrieval from previous inventories has been limited, a reassessment from agriculture activities is necessary and requires more time
N_2O	Waste	Incineration	Data and methodological constraints to obtain time series data
	Waste	Open Burning	Data and methodological constraints to obtain time series data
	Agriculture	3.F. Field burning of agricultural residues	Data retrieval from previous inventories has been limited, a reassessment from agriculture activities is necessary and requires more time

Table 1-5 Belize's GHG inventory sources and sinks included elsewhere

GHG	GHG source and sink categories	Allocation as per 2006 IPCC Guidelines	Allocation used by the country	Explanation or comment
CO_2	Asphalt for Road Paving		Railways (Energy)	Methodological challenge for non-energy use of bitumen

1.16 Metrics

The greenhouse gas emissions are 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 (AR5) were used for all sectors.

Table 1-6 Global Warming Potentials used (AR5)

Trade or common name	Chemical formula	Global warming potential	Global temperature potential
Carbon dioxide	CO_2	1	1
Methane	CH_4	28	4
Nitrous oxide	N_2O	265	234

Trade or common name	Chemical formula	Global warming potential	Global temperature potential
HFC-134a	CH_2FCF_3	1,300	201

Source: IPCC Fifth Assessment Report (AR5)

1.17 Summary of any flexibility applied[1]

The flexibility applied in this inventory submission includes those related to *time series*[2], *uncertainty assessment*[3], *and gases*[4]. Details of each these in Belize's submission are outlined below.

In accordance with the UNFCCC MPGs for the ETF (Annex to decision 18/CMA.1), a consistent annual **time series** starting from 1990 should be reported. Upon consulting with various stakeholders on the availability of historical data, it was determined that data prior to 1994 is not available. Hence, the starting year for the time series that is reported in the NID 2024 is from year 1994 to 2022. Despite the thorough efforts undertaken to enhance the completeness of GHG inventory reporting in this inventory submission for year 1994 to 2022, some gaps in the data in this time series were identified. This remains a point of continuous improvement to ensure complete time series in future reports.

According to the 2006 IPCC Guidelines, uncertainty refers to the lack of certainty in data and estimates, which can arise from various sources such as measurement errors, estimation methods, and inherent variability in natural systems. The guidelines recommend both quantitative and qualitative approaches to assess uncertainty, aiming to improve the transparency, accuracy, and completeness of GHG inventories. Belize's **uncertainty assessment** for greenhouse gas (GHG) emissions and removals is currently lacking due to the unavailability of detailed uncertainty data from data sources. This flexibility is afforded for developing countries like Belize, where although quantitative estimates are ideal, the current focus is on identifying and discussing the main sources of uncertainty qualitatively for key categories in the LULUCF, Energy and Waste sectors in the future inventory.

Additionally, there are significant discrepancies associated with default emission factors, which further complicate the uncertainty analysis. This limitation will be addressed with greater capacity and time in subsequent inventories.

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[1] Countries may elect either to report the information on specific flexibility provisions applied in a separate chapter or to integrate this information into sectoral chapters relevant to where specific flexibility provisions have been applied.

[2] MPG Flexibility provision on **Time series (paras. 57)** indicate that report data covering the reference year/period for the NDC and, in addition, a consistent annual time series from at least 2020 onward (as opposed to reporting a continuous time series from 1990 onwards).

[3] MPG Flexibility provision on **Uncertainty assessment (para. 29)** entails providing qualitative discussion of uncertainty for key categories both latest inventory year/ trend, instead of quantitatively estimating and qualitatively discussing uncertainty for all categories for at least the starting year and the latest reporting year and the trend.

[4] MPG Flexibility provision on **Gases (para. 48)** indicates that report data covering the reference year/period for the NDC and, in addition, a consistent annual time series from at least 2020 onward (as opposed to reporting a continuous time series from 1990 onwards).

As per guidelines, all seven **gases** should be reported, but flexibility is applied in Belize's reporting as four gases (CO_2, CH_4, N_2O and HFCs) are reported. These are the main and most greenhouse gases in the country, and others remain challenging to account for with the information currently available.

2 **Chapter 2:** TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1 Description of the trend in aggregated GHG emissions and removals

Belize's national inventory report includes a time series from 1994 – 2022, including estimates from its initial national communication, second national communication, third national communication, first biennial update report, and its fourth national communication.

In 2022, the most recent year for which data are available for this report, Belize's greenhouse gas (GHG) net emissions and removals (including LULUCF) were **-2191.48 kt CO2 eq**. Represented graphically in Figure 2-1 below, and in detail in Table 2-1 and Table 2-2 below, the energy sector was a major emitter (26% of national emissions), contributing 722.79 **kt CO2 eq in large part from a growing transport sector** (18% of national emissions within the energy sector), and the waste sector added 1574.19 kt CO2 eq (55% of national emissions) reflecting improved capture of data for population with access to managed sewage for domestic wastewater, and overall population growth. Emissions from industrial processes and product use (IPPU) and agriculture were 199.08 kt and 335.93 kt CO2 eq, respectively.

Notably, the land use, land use change and forestry (LULUCF) sector reported a net removal of -5023.47 **kt CO2 eq in 2022**. This substantial removal highlights the crucial role of Belize's high forest cover (63%) land use management practices.

However, emissions excluding LULUCF (as seen in Table 2-2 Summary for the national GHG inventory 2022 by sectors and categories, net emissions), were **2831.99 kt CO2 eq**, underscoring the significant contributions from other sectors, growing transport, tourism, and agricultural activities amidst a growing population.

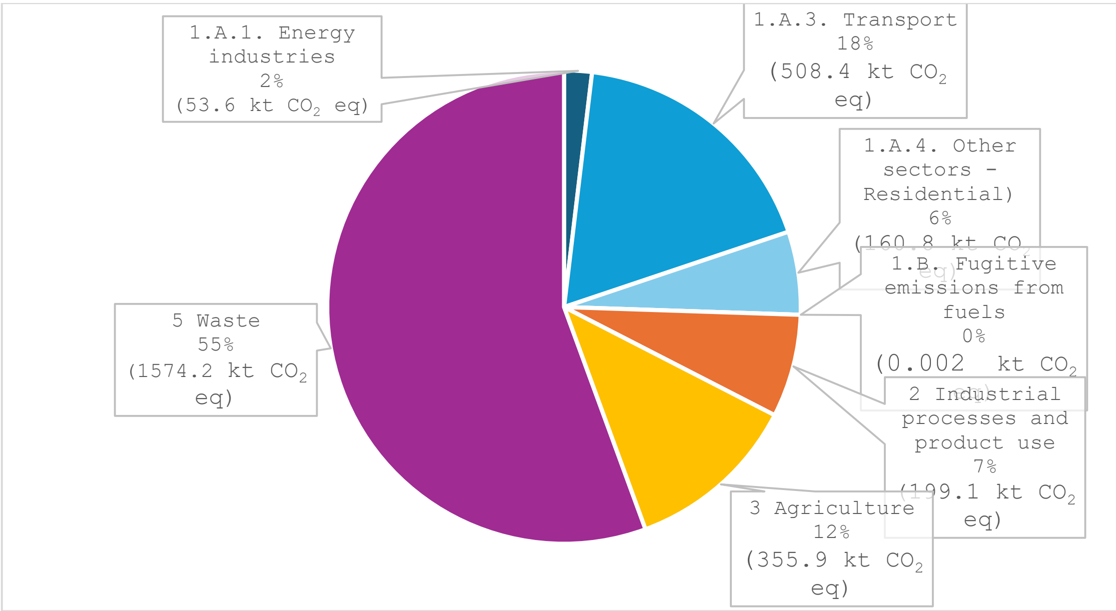


Figure 2-1 Breakdown of Belize's Emissions by Sector (2022)

Table 2-1 Summary for the national GHG inventory 2022 by sectors and categories, emissions and removals

GHG source and sink categories	Net CO_2 (kt)	CH_4 (kt)	N_2O (kt)	HFC (kt CO_2 eq)	PFC (kt CO_2 eq)	Unspecified mix of HFCs and PFCs (kt CO_2 eq)	SF_6 (kt)	NF_3 (kt)	NO_x (kt)	CO (kt)	NMVOC (kt)	SO_X (kt)	Total GHG (kt CO_2 eq)
Total national emissions and removals	-4360.2638	67.79735	0.0770355	197.5624	NO	NO	NE	NE	NE	NE	NE	NE	-2191.48
Energy	696.425662	0.4973393	0.0469417										722.7907031
Fuel combustion	696.4237656	0.49733813	0.046941625										722.788764
Energy industries	44.22151482	0.148000278	0.019851743										53.62623456
Manufacturing industries and construction	NO	NO	NO										
Transport	498.4034508	0.131358352	0.023672572										508.3547163
Other sectors	153.7988	0.2179795	0.00341731										160.8078132
Other	NO	NO	NO										160.8078132
Fugitive emissions from fuels	0.001896718	1.19222E-06	3.387E-08										0.001939076
Solid fuels	NO	NO	NO										
Oil and natural gas and other emissions from energy production	0.001896718	1.19222E-06	3.387E-08										0.001939076
CO_2 transport and storage	NO												
Industrial processes and product use	1.5142401	NO	NO	197.56239	NE	NO	NE	NE					199.0766281
Mineral industry	0.21225												0.21225
Chemical industry	NO	NO	NO	NO									
Metal industry	NO	NO	NO	NO									
Non-energy products from fuels and solvent use	NO	NO	NO										0.669328
Electronic industry													
Product uses as substitutes for ODS													197.562388
Other product manufacture and use	NO	NO	NO	NO									
Other (please specify)	0.6326621	NO	NO										0.6326621
Agriculture	4.94741867	11.078919	0.0300774										335.9253095
Enteric fermentation		10.2764205	NO										287.739774
Manure management		0.52434407	0.005940301										16.25581382

Rice cultivation		0.27815418	NE										7.788317046
Agricultural soils		NE	0.024137083										19.19398592
Prescribed burning of savannahs		NE	NE										
Field burning of agricultural residues		NE	NE										
Liming	0.12452												0.12452
Urea application	4.822898667												4.822898667
Other carbon-containing fertilizers	NE												
Other (please specify)	NO	NO	NO										
Land use, land-use change and forestry	-5,020.4942	1.05	0.04										-5023.47
Forest land	-9671.620567	0.92	0.03										-9638.855
Cropland	2120.41866	NE	NE										2120.41866
Grassland	2021.946667	0.14	0.01										2029.04196
Wetlands	NO	NO	NO										
Settlements	508.761	NO	NO										508.761
Other land	NO	NO	NO										
Harvested wood products	-42.85351												-42.85350609
Other (please specify)	NO	NO	NO										
Waste		56.221094	1.646E-05										1574.19498
Solid waste disposal		0.003756809											0.105190643
Biological treatment of solid waste													
Incineration and open burning of waste	NE	NE	NE										
Wastewater treatment and discharge	0	56.21733671	1.646E-05										1574.08979
Other (please specify)	NO	NO	NO										
Other (please specify)	NO	NO	NO										
Memo items													
International bunkers	72.71696	0.00052225	0.0020344										73.270699
Aviation	72.56135	0.00050755	0.0020302										73.1135644
Navigation	0.15561	0.0000147	0.0000042										0.1571346

Multilateral operations	NO	NO	NO										0
CO_2 emissions from biomass	562.6348209												
CO_2 captured	NO												
Long-term storage of C in waste disposal sites													
Indirect N_2O													
Indirect CO_2													

Table 2-2 Summary for the national GHG inventory 2022 by sectors and categories, net emissions

Code	GHG source and sink categories	CO_2 (kt CO_2 eq)	CH_4 (kt CO_2 eq)	N_2O (kt CO_2 eq)	HFC (kt CO_2 eq)	PFC (kt CO_2 eq)	Unspecified mix of HFCs and PFCs (kt CO_2 eq)	SF_6 (kt CO_2 eq)	NF_3 (kt CO_2 eq)	Total GHG (kt CO_2 eq)
	Total (net emissions)	702.88732	1898.3258	33.212067	197.56239	NE	NO	NE	NE	2831.987621
1	Energy	696.42566	13.925501	12.43954						722.7907031
1.A.	Fuel combustion	696.4237656	13.92546765	12.43953076						722.788764
1.A.1.	Energy industries	44.22151482	4.144007788	5.26071195						53.62623456
1.A.2.	Manufacturing industries and construction	NE	NE	NE						
1.A.3.	Transport	498.4034508	3.678033862	6.273231655						508.3547163
1.A.4.	Other sectors	153.7988	6.103426	0.90558715						160.8078132
1.A.5.	Other	NO	NO	NO						
1.B.	Fugitive emissions from fuels	0.001896718	3.33822E-05	8.97554E-06						0.001939076
1.B.1.	Solid fuels	NO	NO	NO						
1.B.2.	Oil and natural gas and other emissions from energy production	0.001896718	3.33822E-05	8.97554E-06						0.001939076
1.C.	CO_2 transport and storage	NO								
2	Industrial processes and product use	1.5142401	NO	NO	197.56239					199.0766281
2.A.	Mineral industry	0.21225								0.21225
2.B.	Chemical industry	NO	NO	NO						
2.C.	Metal industry	NO	NO	NO						
2.D.	Non-energy products from fuels and solvent use	0.669328	NO	NO						0.669328
2.E.	Electronic industry			NO						
2.F.	Product uses as substitutes for ODS				197.562388					197.562388
2.G.	Other product manufacture and use	NO	NO	NO	NO					
2.H.	Other (please specify)	0.6326621	NO	NO	NO					0.6326621
3	Agriculture	4.9474187	310.20973	20.768166						335.9253095
3.A.	Enteric fermentation		287.739774							287.739774
3.B.	Manure management		14.68163396	1.57417986						16.25581382
3.C.	Rice cultivation		7.788317046							7.788317046
3.D.	Agricultural soils		NO	19.19398592						19.19398592
3.E.	Prescribed burning of savannahs		NE	NE						

3.F.	Field burning of agricultural residues		NE	NE						
3.G.	Liming	0.12452								0.12452
3.H.	Urea application	4.822898667								4.822898667
3.I.	Other carbon-containing fertilizers	NE								
3.J.	Other (please specify)	NO	NO	NO						
4	Land use, land-use change and forestry	-5,063.35	1.05	0.04						-5023.47
4.A.	Forest land	-9638.85	0.92	0.03						-9638.855
4.B.	Cropland	2120.42	NE	NE						2120.41866
4.C.	Grassland	2029.04	0.14	0.01						2029.04196
4.D.	Wetlands	NO	NO	NO						
4.E.	Settlements	508.761	NO	NO						508.761
4.F.	Other land	NO	NO	NO						
4.G.	Harvested wood products	-42.85								-42.8535061
4.H.	Other (please specify)	NO								
5	Waste	NO	1574.1906	0.0043619						1574.19498
5.A.	Solid waste disposal		0.105190643							0.105190643
5.B.	Biological treatment of solid waste		NO	NO						
5.C.	Incineration and open burning of waste	NE	NE	NE						
5.D.	Wastewater treatment and discharge		1574.085428	0.004361912						1574.08979
5.E.	Other (please specify)	NO	NO	NO						
6	Other (please specify)	NO	NO	NO						
	Memo items									
1.D.1.	International bunkers	72.71696	0.014623	0.539116						73.270699
1.D.1.a.	Aviation	72.56135	0.0142114	0.538003						73.1135644
1.D.1.b.	Navigation	0.15561	0.0004116	0.001113						0.1571346
1.D.2.	Multilateral operations	NO	NO	NO						
1.D.3.	CO_2 emissions from biomass	562.6348209								562.6348209
1.D.4.	CO_2 captured	NO								
5.F.1.	Long-term storage of C in waste disposal sites	NO								
	Indirect N_2O									

[redacted]									
	Indirect CO_2								
[redacted]									
Total CO_2 equivalent emissions without LULUCF									2831.987621
Total CO_2 equivalent emissions with LULUCF									-2191.48
Total CO_2 equivalent emissions, including indirect CO_2, without LULUCF									2831.987621
Total CO_2 equivalent emissions, including indirect CO_2, with LULUCF									-2191.48

Throughout the time series where LULUCF is estimated (2000 – 2022), Belize continues to be a net sink with the exception of 2019 and 2020.

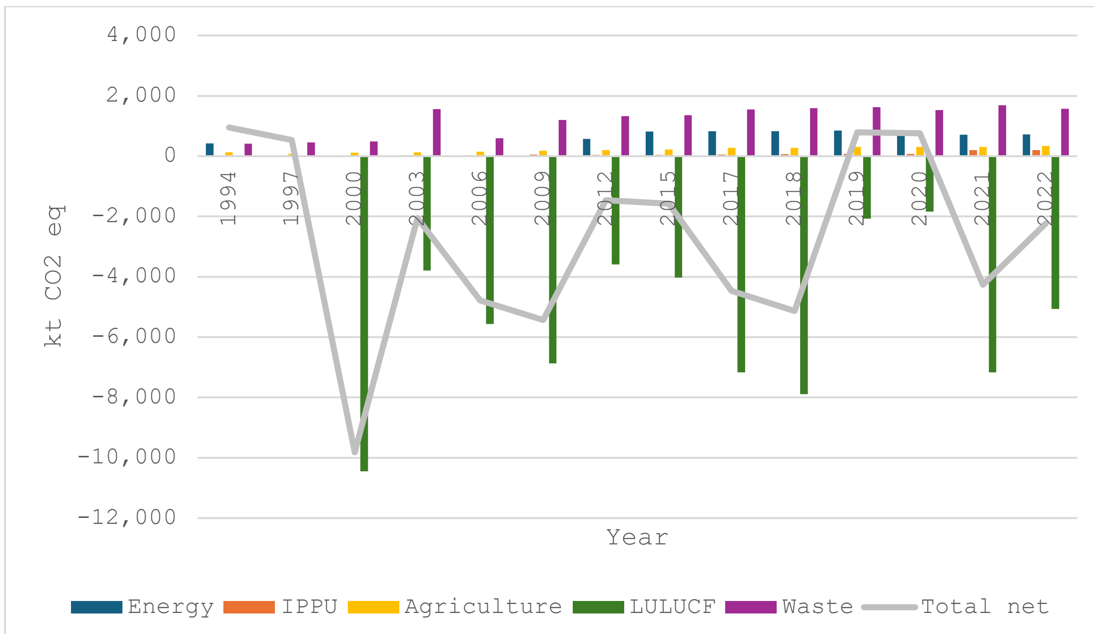


Figure 2-2 Belize's inventory: total net GHG by sector (kt CO2 eq), 1994 -2022

Table 2-3 below outlines Belize’s total national emissions **country's total GHG emissions** (without LULUCF), in kt CO_2 eq. From 1994 to 2022, Belize's GHG emissions have shown a trending increase across the various sectors. The Energy sector experienced a significant Increase in emissions starting around 2012 when the national availability of reliable energy statistics was noted, peaking at 849.91 kt CO2 eq in 2019. The IPPU sector has gradually increased its emissions over the years in large part due to the increasing use of refrigerants as the tourism industry expands, and home and commercial cooling becomes more necessary, reaching a maximum of 199.08 kt CO2 eq in 2022.

Agriculture emissions have also risen steadily, with the highest recorded value of 335.93 kt CO2 eq in 2022. The Waste sector has seen a substantial increase in emissions, peaking at 1682.14 kt CO2 eq in 2021. This is attributed to the greater percentage of the population having access to sewage systems, and greater accounting of industrial wastewater emissions than in previous inventories. Overall, the total emissions (excluding LULUCF) have shown an upward trend, with the highest value of 2905.96 kt CO2 eq across these sectors in 2021. These trends highlight the growing contributions of various sectors to Belize's GHG emissions over the years.

Table 2-3 Belize’s total national emissions country's total GHG emissions (without LULUCF), in kt CO2 eq

Sector	*1994*	*1997*	*2000*	*2003*	*2006*	*2009*	*2012*	*2015*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Energy	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.21	714.80	722.79
IPPU	8.71	17.77	23.71	31.69	36.10	50.77	40.74	43.54	54.15	61.13	73.92	69.27	198.57	199.08
Agriculture	123.15	77.64	115.47	130.46	147.10	183.36	202.16	222.76	273.72	277.06	309.40	309.40	310.46	335.93
Waste	414.26	455.67	490.80	1,561.24	592.30	1,198.13	1,321.16	1,361.93	1,554.09	1,589.81	1,625.13	1,530.28	1,682.14	1,574.19
Total emissions (without LULUCF)	**969.07**	**551.07**	**629.97**	**1,728.29**	**778.39**	**1,434.93**	**2,131.36**	**2,449.21**	**2,705.10**	**2,757.86**	**2,858.37**	**2,593.17**	**2,905.96**	**2,831.99**

Figure 2-3 below shows a summary of total GHG emissions of the country inventory by sector (in kt CO2 eq) for 1994-2022.

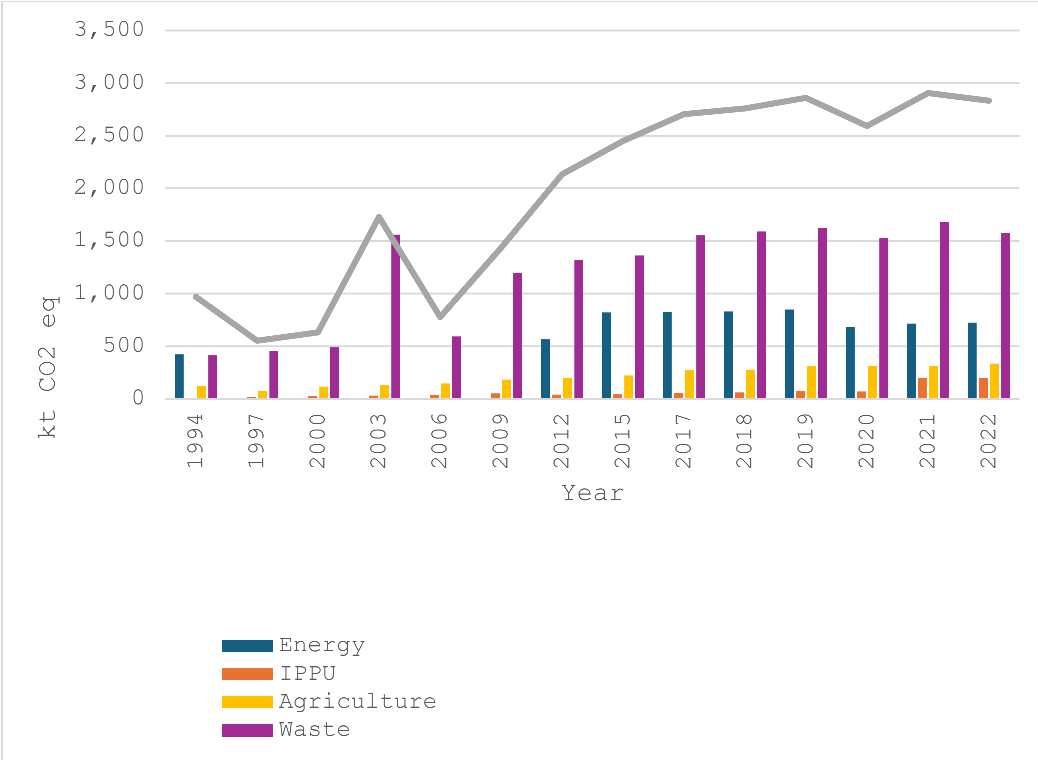


Figure 2-3 Belize's inventory: total GHGs by sector (kt CO2 eq), 1994-2022)

2.2 Description of the trend by greenhouse gas

Belize's GHG emissions profile is unique due to the country's carbon sink status, for this reason, carbon dioxide (CO2) is not the largest contributor to total emissions. It is, however, methane (CH4) accounting for 1898.33 kt CO2 eq or 67% of emissions in 2022 (Figure 2-4). Carbon dioxide (CO_2) emissions were 702.89 kt CO2 eq (25%), nitrous oxide (N_2O) emissions were 33.21 kt CO2 eq (1%), and hydrofluorocarbons (HFCs) contributed 197.56 kt CO2 eq (7%).

Carbon Dioxide (CO_2)

In 2022, carbon dioxide (CO_2) emissions in Belize amounted to 702.89 kt CO2 eq, representing approximately 25% of the total greenhouse gas emissions. The majority of these emissions originated from the energy industries sector, with road transport being a significant contributor. The growing number of vehicles and increased fuel consumption have led to higher CO_2 emissions.

Methane (CH_4)

Methane (CH_4) emissions were the highest among all gases, totaling 1,898.33 kt CO2 eq, which accounts for about 67% of the total emissions. 99% of these emissions resulted from wastewater treatment and discharge. This includes emissions from both domestic sewage systems and industrial wastewater from major productive sectors such as sugar, bananas, beer, rum, citrus, and shrimp industries.

Nitrous Oxide (N_2O)

Nitrous oxide (N_2O) emissions were 33.21 kt CO2 eq, making up roughly 1% of the total emissions. The majority of N_2O emissions stem from agricultural soils, primarily due to direct emissions from the application of synthetic fertilizers, animal manure, and other organic fertilizers. These emissions are driven by microbial processes such as nitrification and denitrification in soils, which are influenced by factors like soil type, climate, and agricultural practices.

Hydrofluorocarbons (HFCs)

Hydrofluorocarbons (HFCs) contributed 197.56 kt CO2 eq to the total emissions, representing about 7% of the total. These emissions are primarily associated with the use of refrigerants in cooling and air conditioning systems. The captured data reflects the quantity of refrigerants used both residentially and commercially.

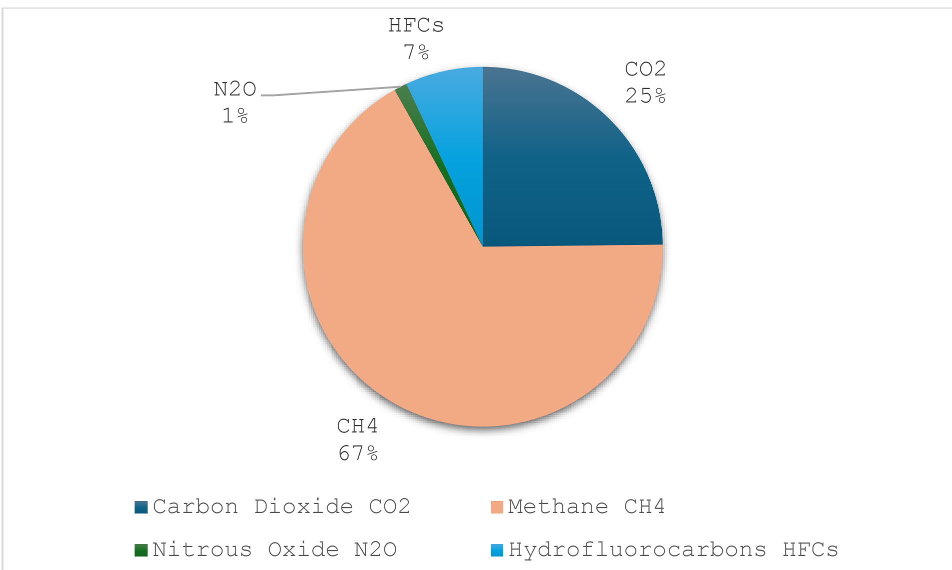


Figure 2-4 Emissions by gas 2022 (without LULUCF)

Table 2-4 Belize inventory: emissions and removals by GHG gas (kt CO2 eq) 1994 - 2022

GHG	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
CO_2: without net CO_2 from LULUCF	425.98	5.08	5.65	29.32	15.36	14.37	554.62	811.43	798.29	804.84	827.28	661.99	688.58	702.89
CO_2: with net CO_2 from LULUCF	409.58	-9.60	-10,440.93	-3,758.33	-5,544.55	-6,854.41	-3,036.82	-3,211.14	-6,370.73	-7,088.18	-1,239.28	-1,171.96	-6,480.44	-4,360.26
CH_4: without CH_4 from LULUCF	517.29	525.76	588.82	1,668.24	728.24	1,368.37	1,509.68	1,560.42	1,806.70	1,877.82	1,935.87	1,839.34	1,988.85	1,898.33
CH_4: with CH_4 from LULUCF	517.29	525.76	588.82	1,668.24	728.24	1,368.37	1,509.68	1,560.42	1,806.70	1,877.82	1,935.87	1,839.34	1,988.85	1,898.33
N_2O: without N_2O from LULUCF	17.09	2.47	11.80	2.98	4.17	4.58	30.35	37.77	49.44	16.51	27.22	23.60	31.24	33.21
N_2O: with N_2O from LULUCF	17.09	2.47	11.80	2.98	4.17	4.58	30.35	37.77	49.44	16.51	27.22	23.60	31.24	33.21
HFC	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
PFC	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NF_3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total (without LULUCF)	**969.07**	**551.07**	**629.97**	**1,728.29**	**778.39**	**1,434.93**	**2,131.36**	**2,449.21**	**2,705.10**	**2,757.86**	**2,858.37**	**2,593.17**	**2,905.96**	**2,831.99**
Total net (with LULUCF)	**952.67**	**536.40**	**-9,816.61**	**-2,059.36**	**-4,781.52**	**-5,433.85**	**-1,460.08**	**-1,573.36**	**-4,463.92**	**-5,135.15**	**791.81**	**759.22**	**-4,263.06**	**-2191.48**

3 Chapter 3: ENERGY (CRT 1)

3.1 Description of the sector

In the energy sector, Belize faces its own set of challenges as well as opportunities. Belize's energy supply in 2023, in proportion to the country's size and population, realized a total of 17,724 TJ, however, 70% of that supply was imported, both in the form of electricity and refined fossil fuels (Energy Unit, 2024). These imports were needed to meet rising country demands. In 2023, the highest recorded peak electricity demand reached 127.2 MW, while the latest overall energy intensity (2022) stood at 0.17 toe per $1,000 USD. The use of gasoline and diesel in the transportation sector, as well as electricity use in the residential sector, made up largest shares of Belize's final energy consumption (Energy Unit, 2024). This situation makes Belize highly vulnerable to market and climate shocks, which became evident in 2024, where Belizeans experienced rolling load-shedding firsthand during hot and humid conditions, leading to record-setting heat conditions. Belize's energy supply mix is also significantly carbonized, since that 70% is attributable both to refined fossil fuels (Energy Unit, 2024) and to our neighbor Mexico's gas-heavy electricity (about 82% generated from fossil fuels overall in the first half of 2024) (Comisión Federal de Electricidad, 2024).

Despite the obstacles, there is also room for investment, diversification, and ecological transformation. In 2023, 38% of Belize's in-country electricity was generated from renewable energy sources – an increase by 2% compare to the year 2022, Belize demonstrates an interesting market circumstance where cost of power from renewable sources are significantly lower than fossil-fuel based sources. (Energy Unit, 2024). In 2023, a Waste-to-Energy Pre-feasibility study was completed, exploring the in-country availability of biological wastes and byproducts for use in electricity generation (Seureca Veolia, 2023). In 2024 the Government of Belize and partners also launched the road-testing phase of the E-Mobility Pilot Project, which started trials with two city e-buses and a charging station in Belize, with the aim of collecting data that can be used to inform further investments in the EV sector (United Nations Development Programme (UNDP), 2024). Belize's energy sector remains a key area for innovation and enterprise, particularly ripe for the advancing of decarbonization and the curtailing of its significant emissions' footprint.

Belize's electricity sector is managed and driven by several key entities. Playing the role of regularization through legal structure, the Government of Belize developed the earliest version of the Electricity Act in the early 1990's, as well as the Public Utilities Commission Act stipulating that the Belize Electricity Limited (BEL), as the national electric utility, would be licensed by the Public Utilities Commission to procure, supply, transmit and distribute electricity. In addition to their in-company supply, BEL also purchases electricity from Independent Power Producers (IPPs) as well as from the Mexican Utility Company, the Comisión Federal de Electricidad (CFE) (Belize Electricity Limited (BEL), 2024).

As the regulator for all public utility services in Belize, the PUC regularly reviews and vets the electricity tariffs and major investments of BEL, to the end of protecting the national interests where the sole utility-scale electric retailer is concerned. Most recently, the PUC has approved BEL's Least Cost Expansion Plan (Public Utilities Commission, 2024) *, whereas a new set of tariffs is currently under negotiation by both parties, intended to be valid from 2024 to 2028 (Public Utilities Commission (PUC), 2024).

The year 2024 saw Belize facing one of its most critical energy challenges in the form of widespread load-shedding throughout the dry season, that is, the months of April and May, one of the hottest on record. This was triggered by electrical supply shortfalls starting with CFE and rippling over to BEL's grid as power companies in the region struggled to meet surging demands. It was further complicated by multiple equipment failures within BEL (Belize Electricity Limited (BEL), 2024), and the electrical supply was finally stabilized in mid-July, bolstered by rains that augmented local hydropower generation, and by BEL's capacity expansion of one of its gas-powered turbines.

For close to twenty years, the entity at the forefront of Belize's local hydrocarbon production has been Belize Natural Energy (BNE). Following the first commercial oil discovery at the Spanish Lookout field in 2005 and at the Never Delay field two years later, BNE has been the sole producer and exporter of crude oil in Belize (Figure 3-1). According to the Geology and Petroleum Department, a government entity which monitors and certifies BNE's activities, "At its peak the Spanish Lookout Oilfield was producing an average of 5,000 barrels of oil per day and now is in decline," and that "The Never Delay Oilfield was previously producing as much as 500 barrels of oil per day, but this has decreased dramatically" (Geology and Petroleum Department, 2024). The Energy Unit reported that in 2023 that both oilfields combined were producing an average of 432 barrels per day (Energy Unit, 2024). A local market around the sale of crude oil has developed in Belize over the past two decades. A wide variety of commercial and agricultural entities buy crude oil for their internal fuel uses, including several entities based across the border in Guatemala.

At the other end of the hydrocarbon sector are the refined fossil fuels, which make up a majority portion for Belize and therefore, our reliance on energy imports, as well as serving as a main source of national emissions. Motor gasoline makes up the largest fuel import share, followed closely by diesel. Liquefied Petroleum Gas (LPG) and kerosene also contribute considerable portions. Belize imports is considered an international fuel bunker.

It can be expected that as the in-country supply of crude oil diminishes, its consumers will switch to another commercially available fuel, such as diesel. As demands and population increase therefore, it only becomes more crucial to mitigate Belize's reliance on fossil fuel products.

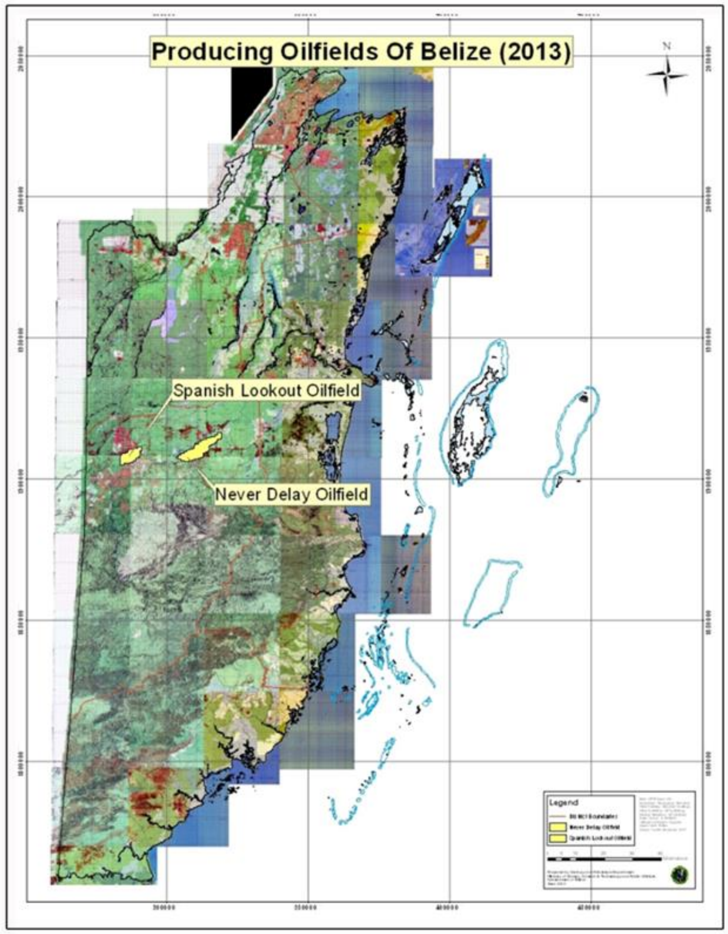


Figure 3-1 Producing Oilfields of Belize in 2013. From: Geology and Petroleum Department (Geology and Petroleum Department, 2024)

The road transport sector, certainly one of the most significant in terms of carbon and nitrogen emissions, is administered primarily through the Ministry of Transport, the National Transport Board, and the municipal governments of the principal towns. The Ministry's role is the establishment and enforcement of traffic rules, and the registration and licensing of rural vehicles. The National Transport Board licenses public transport systems and regulates their routes. Municipal town/city councils conduct registration and licensing for urban residents' fees for urban traffic infractions. According to the 2018 Comprehensive National Transportation Master Plan, Belize has a total of 8,078 miles of roads of various types, including 373 of 'primary roads or highways (Office of the Prime Minister, 2018) (Figure 3-2).

Figure 3-2 Belize Primary Highways, Sea Ports and Airports. From CNTMP (2018): (Office of the Prime Minister, 2018)

3.2 Trend in the sector's GHG emissions

The energy sector was the second largest emitter (26% of national emissions) after the waste sector, contributing 722.79 **kt CO2 eq in large part from a growing transport sector** (18% of total national emissions in 2022).

Table 3-1 Energy Sector: emissions by GHG, category and subcategory (kt) for 2022

Code	GHG source categories	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	NO_x (kt)	CO (kt)	NMVOC (kt)	SO_X (kt)	Total GHG (kt CO_2 eq)
1.	Energy	**696.426**	**0.497**	**0.047**					**722.791**
1.A.	Fuel combustion	**696.424**	**0.497**	**0.047**					722.789
1.A.1.	Energy industries	**44.222**	**0.148**	**0.020**					53.626
1.A.1.a.	Public electricity and heat production	44.222	0.148	0.020					53.626
1.A.1.b.	Petroleum refining	NO	NO	NO					
1.A.1.c.	Manufacture of solid fuels and other energy industries	NO	NO	NO					
1.A.2.	Manufacturing industries and construction								
1.A.2.a.	Iron and steel	NO	NO	NO					
1.A.2.b.	Non-ferrous metals	NO	NO	NO					
1.A.2.c.	Chemicals	NO	NO	NO					
1.A.2.d.	Pulp, paper and print								
1.A.2.e.	Food processing, beverages and tobacco								
1.A.2.f.	Non-metallic minerals	NO	NO	NO					
1.A.2.g.	Other (please specify)								
1.A.3.	Transport	498.403	0.131	0.024					508.355
1.A.3.a.	Domestic aviation	12.523	0.000	0.000					12.618
1.A.3.b.	Road transportation	472.659	0.131	0.023					482.491
1.A.3.c.	Railways	12.196	0.000	0.000					12.209
1.A.3.d.	Domestic navigation	1.026	0.000	0.000					1.036
1.A.3.e.	Other transportation	NO	NO	NO					
1.A.4.	Other sectors	153.799	0.218	0.003					160.808
1.A.4.a.	Commercial/institutional	IE	IE	IE					
1.A.4.b.	Residential	153.799	0.218	0.003					160.808
1.A.4.c.	Agriculture/forestry/fishing	IE	IE	IE					
1.A.5.	Other (not specified elsewhere)	IE	IE	IE					
1.A.5.a.	Stationary	IE	IE	IE					
1.A.5.b.	Mobile	IE	IE	IE					
1.B.	Fugitive emissions from fuels	0.00189672	0.00000119	0.00000003					0.00193908
1.B.1.	Solid fuels	NO	NO	NO					
1.B.1.a.	Coal mining and handling	NO	NO	NO					
1.B.1.b.	Fuel transformation	NO	NO	NO					
1.B.1.c.	Other (please specify)	NO	NO	NO					
1.B.2.	Oil and natural gas and other emissions from energy production	0.00189672	0.00000119	0.00000003					0.00193908
1.B.2.a.	Oil	NA	NA	NA					
1.B.2.b.	Natural gas	0.00189672	0.00000119	0.00000003					0.00193908
1.B.2.c.	Venting and flaring	NO							
1.B.2.d.	Other (please specify)	NO							
1.C.	CO_2 transport and storage	NO							
1.C.1.	Transport of CO_2	NO							
1.C.2.	Injection and storage	NO							
1.C.3.	Other	NO							
	Memo items								
1.D.1.	International bunkers	72.72	0.00	0.00					73.27
1.D.1.a.	Aviation	72.56	0.00	0.00					73.11
1.D.1.b.	Navigation	0.16	0.00	0.00					0.16
1.D.2.	Multilateral operations								
1.D.3.	CO_2 emissions from biomass	562.63							562.63
1.D.4.	CO_2 captured								
1.D.4.a	For domestic storage								
1.D.4.b	For storage in other countries								

Notation: NO – not occurring, IE – included elsewhere, NA – not applicable

Table 3-1 presents in detail the emissions generated through activities within the Energy sector, the energy industries sub sector, transport sub-sector, and other subsectors which include the residential emission and a small portion from fugitive emissions from natural gas flaring. As depicted in Figure 3-3, emissions from the sector have continuously increased from 2012 to 2019, and noted some decreases from 2020 -2022, likely the rolling effects of reduced electricity consumption nationally from COVID-19.

As a general observation, data from 1994 -2009 were captured only partially due to data collection challenges from previous inventories, however energy statistics from 2012 to 2022 can be considered more complete, having greater coverage.

Similarly, these trends coincide with the increased use of biomass for industrial and domestic energy production as an alternative to petroleum products. Biomass is primarily used in the generation of energy by utilizing sugarcane bagasse from the sugar industry. There has been an increase in the use of Biomass for the past years, especially with the addition of Santander Sugar Energy Ltd. producing electricity for the national grid.

The transport subsector contributes the highest number of emissions in the form of carbon dioxide. It should also be noted that consumption of fuel use increased within the Transport sub-sector from 2012 to 2015.

Table 3-2 Energy sector: total GHG emissions by category or subcategory (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1	**Energy**	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.21	714.80	722.79
1.A.	Fuel combustion	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79
1.A.1.	Energy industries	145.48	0.00	0.00	0.04	0.02	0.03	54.33	111.63	133.99	86.42	151.26	56.69	62.73	53.63
1.A.2.	Manufacturing industries and construction	46.20	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.14	51.91	0.00
1.A.3.	Transport	176.13	0.00	0.00	4.76	2.80	2.62	506.33	701.85	681.25	615.70	547.84	474.97	468.19	508.35
1.A.3.a.	Domestic aviation	6.50	0.00	0.00	0.00	0.00	0.00	9.37	11.99	12.87	12.42	12.89	5.94	9.83	12.62
1.A.3.b.	Road transportation	148.46	0.00	0.00	0.09	0.08	0.08	489.01	675.35	659.90	597.39	530.04	436.56	448.00	482.49
1.A.3.c.	Railways	0.00	0.00	0.00	4.67	2.72	2.55	7.95	14.51	8.47	5.27	4.24	5.05	9.61	12.21
1.A.3.d.	Domestic navigation	21.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.67	27.42	0.74	1.04
1.A.4.	Other sectors	55.14	0.00	0.00	0.02	0.08	0.02	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.a.	Commercial/institutional	12.97	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b.	Residential	16.79	0.00	0.00	0.01	0.01	0.00	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.c.	Agriculture/forestry/fishing	25.38	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194
1.B.2.	Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194
1.B.2.b.	Natural gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194
	Total	**422.95**	**NE**	**NE**	**4.89**	**2.89**	**2.68**	**567.30**	**820.98**	**823.13**	**829.87**	**849.91**	**684.21**	**714.80**	**722.79**

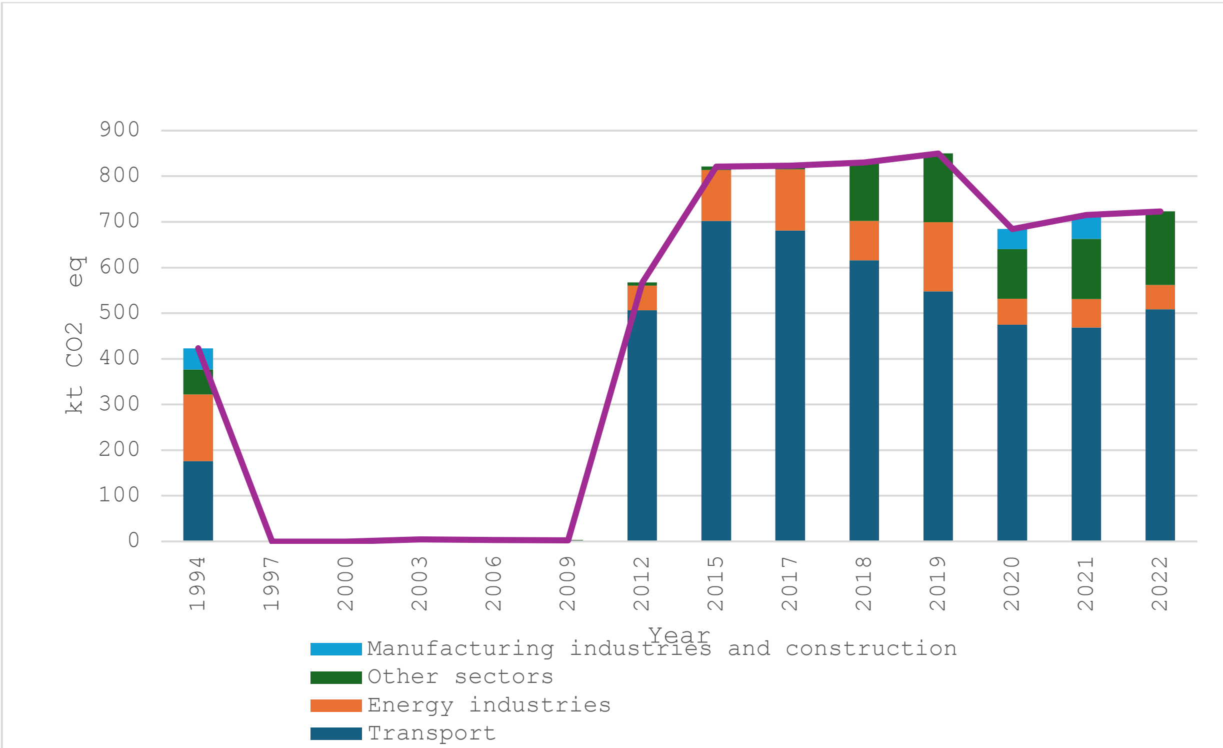


Figure 3-3 Fuel Combustion Activities: total GHG emissions by category or subcategory (kt CO2 eq), 1994-2022

Furthermore, in terms of emissions by gas for the sector, Table 3-3 and Figure 3-4 show the trends by GHG emitted in this sector. Naturally, due to the fossil fuel use in energy industries subcategory, **CO_2 gas is the major contributor to energy emissions**. Non-CO_2 emissions from these categories represent a much lesser proportion.

Table 3-3 Energy sector: emissions by GHG (kt CO2 eq)

GHG	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
CO2	414.07	0.00	0.00	4.89	2.89	2.67	545.18	793.54	794.23	801.02	821.13	660.72	686.72	696.43
CH4	3.77	0.00	0.00	0.00	0.00	0.00	10.13	11.87	12.77	14.18	14.24	12.56	16.25	13.93
N2O	5.11	0.00	0.00	0.00	0.00	0.00	12.00	15.57	16.13	14.67	14.54	10.92	11.83	12.44
Total	**422.95**	**0.00**	**0.00**	**4.89**	**2.89**	**2.68**	**567.30**	**820.98**	**823.13**	**829.87**	**849.91**	**684.21**	**714.80**	**722.79**

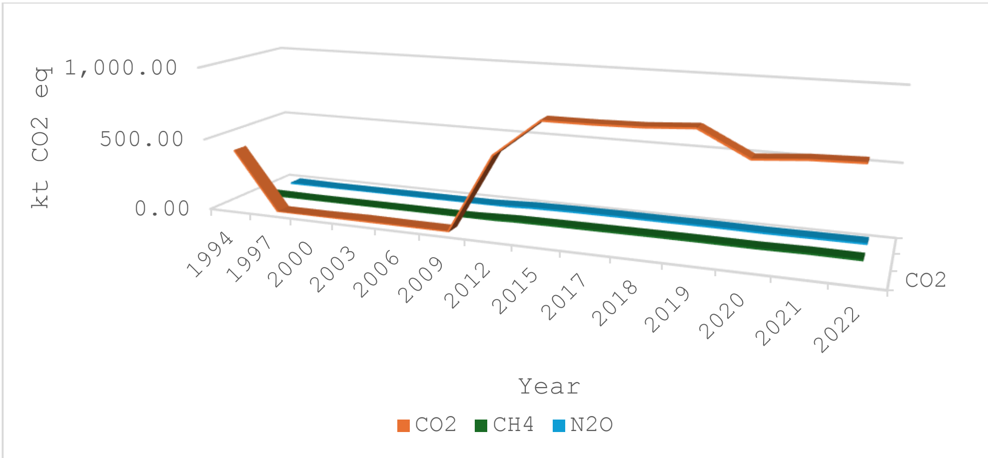


Figure 3-4 Energy sector: emissions by GHG (kt CO2 eq), 1990-2022

3.3 General methodological issues of the sector

3.3.1 Activity Data and GHG Emission Estimates

Activity data collection involved gathering quantitative information on energy production, transformation, and consumption across various sub-sectors. Thus, activity data spans a broad range of sector partners - data providers, resulting in data that varies widely in both format and degree of detail. Screening of the activity and source structure for the energy sector (as set out in the 2006 IPCC guidelines and 2019 refinements) against available information was conducted to determine existing data and new information required for reporting purposes. Table 3-4 provides a summary of activity data, methods, and emission factors used for the energy sector GHG summary report.

Table 3-4 Summary of activity data, methods, and emission factors for energy sector inventory.

Source Category	**Activity Source**	**Data Type**	**Data Source**	**CO_2**		**CH_4**		**N_2O**	
1 ENERGY				MT	EF	MT	EF	MT	EF
1A1 Energy Industries 1A1a Main Activity Electricity and Heat Production	1A1ai Electricity Generation	Fuel(s) Consumption data for electricity generation	Annual Energy Balance Worksheets, Belize Electricity Limited.	T1	D	T1	D	T1	D
	1A1aii Combined Heat and Power Generation (CHP)	Bagasse (sugar cane) consumption for electricity generation	Annual Energy Balance Worksheets, Belcogen.	T1	D	T1	D	T1	D
1A2 Manufacturing Industries and Construction	1A2d Pulp, Paper, and Print	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE	T1	D	T1	D	T1	D

	1A2e Food Processing, Beverages, and Tobacco	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE.	T1	D	T1	D	T1	D
	1A2i Mining and Quarrying	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE	T1	D	T1	D	T1	D
	1A2j Wood and wood products	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE.	T1	D	T1	D	T1	D
	1A2k Construction	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE.	T1	D	T1	D	T1	D
	1A2m Non-specified Industry	Crude Oil sale – annual consumption figures	Annual Energy Balance Worksheets, BNE.	T1	D	T1	D	T1	D
1A3 Transport									
1A3a Civil Aviation	1A3ai International Aviation (International Bunkers)	Fuel Consumption for Aviation, by fuel type (International Flights)	Petroleum Products Importation Data, Aviation Fuel Consumption data international	T1	D	T1	D	T1	D
	1A3aii Domestic Aviation	Fuel Consumption for Aviation, by fuel type (Domestic Flights)	Petroleum Products Importation Data, Aviation Fuel Consumption data (domestic)	T1	D	T1	D	T1	D
1A3b Road Transportation	1A3bi Cars	Monthly Petroleum Products Importation Data	Petroleum Products Importation Data	T1	D	T1	D	T1	D
1A3d Water-Borne Navigation	1A3di International Water-borne Navigation (International Bunkers)	Annual Water Taxi Fuel Consumption Data (International routes)	Petroleum Products Importation Data, Water Taxis.	T1	D	T1	D	T1	D
	1A3dii Domestic Water-borne Navigation	Annual Water Taxi Fuel Consumption Data (Domestic routes)	Petroleum Products Importation Data, Water Taxis.	T1	D	T1	D	T1	D
1A4 Other Sectors	1A4a Commercial/ Institutional			T1	D	T1	D	T1	D
	1A4b Residential	Monthly Petroleum Products Imports, Annual	Annual Energy Balance Worksheets, Statistical Institute of	T1	D	T1	D	T1	D

		Firewood Consumption Estimates	Belize Labour Force Survey						
1B2 Oil and Natural Gas	12B2a Oil								
	1B2b Natural Gas	Monthly Flaring Volume	Annual Energy Balance Worksheets, BNE.	T1	D	T1	D	T1	D

Notation: MT – Method, EF – Emission Factors; T1 – Tier 1 Method, D – Default.

To quantify GHG emissions for the energy sector and its associated sub-categories and sources, default emission factors were used and obtained from:

- 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories.
- IPCC's Emission Factor Database (hereinafter, EFDB): The database can be queried over the internet via the home pages of the IPCC, IPCC-NGGIP or directly at: EFDB - Main Page
- Default emission factors built into the IPCC's inventory software. IPCC's inventory software can be found directly at: Inventory Software - IPCC-TFI

No country-specific emission factors were obtained, and no country-specific methodological approaches developed for the purpose of estimating emissions. As a result, emission factors and their associated methodologies for estimating emissions were all taken from the 2006 IPCC Guidelines, Volumes 2: Energy.

The Tier 1 method was selected and used for the estimation of GHG emissions for each source category and greenhouse gas within the energy sector summary report. The selection of the Tier 1 method was based on the use of the generalized decision tree for selecting tiers for fuel combustion in the energy sector (Intergovernmental Panel on Climate Change, 2006) . Overall, the decision tree as presented in Volume 2 of the 2006 IPCC guidelines applies in general for each of the fuel combustion activities and for each of the GHGs reported.

The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated based on the quantities of fuel combusted (usually from national energy statistics) and default emission factors.

3.4 Fuel combustion activities (CRT 1.A)

3.4.1 Description and trend of GHGs in the category

The IPCC guidelines define fuel combustion as "the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus". The fuel combustion activities are divided into 4 main sub-sectors, by source category: 1A1 Energy Industries, 1A2 Manufacturing Industries and Construction, 1A3 Transport, and 1A4 Other Sectors, and 1A5 Non-Specified. Stationary combustion activities in Belize are linked to fuel combustion activities in electricity generation plants (both auto producers and combined heat and power plants), manufacturing and construction operations, and within commercial and residential activities (Table 3-5).

Table 3-5 Stationary combustion activity and source categories being reported in Belize

Sub-sector	Source Categories	Activity Code
1A1 Energy Industries	1A1a Main Activity Electricity and Heat Production	1A1ai Electricity Generation
		1A1aii Combined Heat and Power Generation (CHP)
1A2 Manufacturing Industries and Construction	1A2d Pulp, Paper, and Print	
	1A2e Food Processing, Beverages, and Tobacco	
	1A2i Mining and Quarrying	
	1A2j Wood and wood products	
	1A2k Construction	
	1A2m Non-specified Industry	
1A4 Other Sectors	1A4a Commercial/Institutional	
	1A4b Residential	

The second component under fuel combustion activities, refers to mobile combustion activities which comprises of emissions from the "combustion and evaporation of fuel for all transport activity (excluding military transport)" (Intergovernmental Panel on Climate Change, 2006) . Mobile combustion activities in Belize are linked to fuel combustion activities from all major transport activities which include civil aviation (domestic and international), road transportation, and water-borne navigation (domestic and international). Mobile combustion activities are further broken down into 3 sub-categories following the IPCC activity codes, as denoted by Table 3-6.

Table 3-6 Mobile combustion activity and source categories being reported in Belize.

Sub-sector	Source Categories	Activity Code
1A3 Transport	1A3a Civil Aviation	1A3ai International Aviation (International Bunkers)
		1A3aii Domestic Aviation
	1A3b Road Transportation	1A3bi Cars
	1A3d Water-borne Navigation	1A3di International Water-borne Navigation (International Bunkers)
		1A3dii Domestic Water-borne Navigation

In 2022, as noted in Table 3-7, the energy sector's total emissions were 722.79 kt CO2 eq, with fuel combustion accounting for the entirety of these energy emissions. The transport sector was the largest contributor, making up 70.32% of the total sector emissions, with road transportation alone contributing 66.76%. Other sectors, primarily residential (use of biomass and kerosene residentially), accounted for 22.26% of the emissions.

Over time, there has been a significant increase in emissions from the residential sector, while emissions from energy industries (electricity generation) have decreased, and manufacturing industries have increased slightly. The overall emissions saw a notable rise from 2012 onwards, with a peak in 2019, followed by a drop in 2020 likely due to the COVID-19 pandemic. Emissions began to rise again in 2021 and 2022. Key drivers of the latest inventory year's emissions include the dominance of road transportation and the substantial increase in residential emissions.

Table 3-7 Fuel Combustion 1.A. total GHG emissions by subcategory (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1	**Energy Total**	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.21	714.80	722.79
1.A.	Fuel combustion	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79
1.A.1.	Energy industries	145.48	0.00	0.00	0.04	0.02	0.03	54.33	111.63	133.99	86.42	151.26	56.69	62.73	53.63
1.A.2.	Manufacturing industries and construction	46.20	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.14	51.91	0.00
1.A.3.	Transport	176.13	0.00	0.00	4.76	2.80	2.62	506.33	701.85	681.25	615.70	547.84	474.97	468.19	508.35
1.A.3.a.	Domestic aviation	6.50	0.00	0.00	0.00	0.00	0.00	9.37	11.99	12.87	12.42	12.89	5.94	9.83	12.62
1.A.3.b.	Road transportation	148.46	0.00	0.00	0.09	0.08	0.08	489.01	675.35	659.90	597.39	530.04	436.56	448.00	482.49
1.A.3.c.	Railways	0.00	0.00	0.00	4.67	2.72	2.55	7.95	14.51	8.47	5.27	4.24	5.05	9.61	12.21
1.A.3.d.	Domestic navigation	21.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.67	27.42	0.74	1.04
1.A.4.	Other sectors	55.14	0.00	0.00	0.02	0.08	0.02	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.a.	Commercial/institutional	12.97	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.b.	Residential	16.79	0.00	0.00	0.01	0.01	0.00	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.c.	Agriculture/forestry/fishing	25.38	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.4.2 Comparison of the sectoral approach with the reference approach

Description and trend of CO2 from the approach comparison

This section provides a comparison between the national estimates of CO2 emissions from fuel combustion and those obtained using the reference approach, as outlined in the IPCC guidelines.

The results of this comparison are reported to highlight any discrepancies and ensure the accuracy and reliability of the national greenhouse gas inventory. The sectoral approach involves detailed data collection and analysis of CO2 emissions from various fuel combustion activities within specific sectors, such as energy, transport, and industry. This method provides a granular view of emissions sources and allows for targeted mitigation strategies.

In contrast, the reference approach, as described in the 2006 IPCC Guidelines, offers a top-down estimation method. It calculates CO2 emissions based on the total amount of fuel supplied to the economy, adjusted for stock changes and non-energy uses. This approach serves as a cross-check to validate the sectoral estimates and identify potential gaps or inconsistencies.

For Belize, the reference approach, or top down fuel consumption data was provided through national energy balances for 2021 and 2022 (see Table 3-8 below). The activity data provided for the sectoral approach is also sourced from the same energy balances. Accordingly, the check and balance between these approaches is limited. The differences between the two approaches are 5.81% and 14.4% respectively for 2021 and 2022. This is primarily due to the allocation of liquid fuels in international bunkers, as well as solid fuel biomass (from sugarcane), being accounted in the reference approach, however these emissions are not methodologically accounted for in national CO2 emissions in the sectoral approach.

Table 3-8 Approach comparison: CO2 emissions obtained using the sectoral approach and reference approach (kt CO2)

Method	*2021*	*2022*
Sectoral	686.72	696.42
Reference	726.67	796.62
Difference	**39.95**	**100.20**
Difference %	**5.81**	**14.39**

3.5 International bunkers

3.5.1 Description and trend of GHGs from 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. These emissions are not attributed to Belize.
International marine transport also considers frequent water taxi routes connecting Belize City to Chetumal, Mexico, as well as Dangriga Town to ports in Honduras.

Much of the increase in international flights has occurred between 2017 and 2019. This took a large downturn in 2020 due to reduction in international flights due to restricted travel during the COVID-19 pandemic of 2020. Significant increase in air travel was noted in 2022 and is expected to increase in the future. Regarding marine international bunkers, these emissions are significantly less, due to less common travel routes by sea. In any case, this data can be improved in the future.

Table 3-9 International bunkers: aviation and marine bunker fuel GHG emissions (kt CO2 eq)

	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
Aviation	37.35	0.00	0.00	0.00	0.00	0.00	40.32	40.18	48.63	52.09	54.96	16.98	48.44	73.11
Marine	4.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Total	**42.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**40.32**	**40.18**	**48.63**	**52.09**	**54.96**	**16.98**	**48.44**	**73.27**

3.5.2 Methodological issues of international bunkers

3.5.2.1 Activity data of the category

Table 3-10 International bunkers: activity data by fuel or GHG source (TJ)

Activity Source	Fuel Type	Year												
		1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2018**	**2019**	**2020**	**2021**	**2022**
1.A.3.a.i International Aviation	Aviation Gasoline	NE	NE	NE	NE	NE	NE	571.55	569.56	6.11	5.32	1.63	24.14	12.20
	Jet Kerosene	NE	NE	NE	NE	NE	NE	NE	NE	716.98	757.68	234.03	648.85	1002.9
1.A.3.d.i International Water-borne Navigation	Gas/Diesel Oil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	2.10

Note: Total Imports minus known domestic consumptions: drawn from the 3 largest local aviation companies (Aviation Gasoline and Jet Kerosene); Two water taxi companies (Gas/Diesel Oil)

3.5.3 Emission factors applied in the category

Table 3-11 International bunkers: emission factors applied by GHG source

Activity Source	**Fuel Type**	**Calorific value (TJ/Gg)**	**CO2 (kg/TJ)**	**CH4 (kg/TJ)**	**N2O (kg/TJ)**
1.A.3.a.i International Aviation	Aviation Gasoline	44.3	70000	0.5	2
	Jet Kerosene	44.1	71500	0.5	2
1.A.3.d.i International Water-borne Navigation	Gas/Diesel Oil	43	74100	7	2

3.6 Energy industries (CRT 1.A.1)

3.6.1 Description and trend of GHGs in the subcategory

From 2012 to 2022, the emissions from the energy industries (electricity generation) subcategory have shown significant fluctuations. In 2012, emissions were recorded at 54.33 kt CO2 eq. This figure more than doubled by 2015, reaching 111.63 kt CO2 eq. The upward trend continued in 2017 with emissions peaking at 133.99 kt CO2 eq.

The year 2020 saw a substantial drop in emissions to 56.69 kt CO2 eq, likely influenced by the global COVID-19 pandemic and the resulting decrease in commercial activity.

In the post-pandemic years of 2021 and 2022, emissions stabilized at lower levels compared to the peak years, with values of 62.73 kt CO2 eq and 53.63 kt CO2 eq respectively. These trends suggest that while there were periods of high emissions within this decade, recent efforts in increasing renewable energy share along with electricity imports from Mexico have been made to stabilize and potentially reduce the impact of energy industries on the overall greenhouse gas inventory.

Table 3-12 Energy Industries 1.A.1: total GHG emissions by GHG source (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1.A.1.	Energy industries	145.48	0.	0.	0.04101	0.01735	0.03368	54.33	111.63	133.99	86.42	151.26	56.69	62.73	53.63
1.A.	Total (Fuel combustion)	422.95	0.	0.	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79

3.6.2 Methodological issues of the subcategory

3.6.2.1 Activity data of Energy Industries

Energy Industries activity data is sourced from the annual national energy balance worksheets which cover consumption for the following subcategories: electricity generation, combined heat and power and heat plants. The Belize Electricity Limited (BEL) is the national electric utility provider licensed by the Public Utilities Commission to procure, supply, transmit and distribute electricity. In addition to their in-company supply, BEL also purchases electricity from Independent Power Producers (IPPs) as well as from the Mexican Utility Company, the Comisión Federal de Electricidad (CFE). Electricity Generation Plants (independent power producers and stand-by generators) use a mix of fuel types shown in Table 3-13. In the combined heat and power subcategory, the primary biomass fuel is bagasse, a sugarcane byproduct generated by the Belize Co-Generation Energy Limited and Santander Sugar.

Table 3-13 1.A.1 Energy Industries: activity data by fuel and subcategory (TJ)

Activity Source	Fuel Type	Year												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022

1.A.1.a.i Electricity Generation	Crude Oil	NE	NE	NE	NE	0.02	0.07	232.04	210.23	27.24	37.99	195.40	192.03	186.03
	Gas/Diesel Oil	NE	NE	NE	0.35	0.18	0.08	188.68	234.23	442.56	824.83	105.99	134.45	250.31
	LPG	NE	NE	NE	NE	NE	NE	NE	NE	13.57	4.33	300.54	NE	NE
	Lubricants	NE	NE	NE	NE	NE	NE	0.59	1.05	NE	NE	NE	NE	NE
	Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	13.57	4.33	300.54	NE	NE
	Residual Fuel Oil	NE	NE	NE	NE	NE	NE	3.42	107.66	358.79	793.62	118.78	392.68	155.52
1.A.1.a.ii Combined Heat and Power	Bagasse	NE	NE	NE	NE	NE	NE	4136.37	4940.50	5689.77	6164.96	3861.52	4274.85	4874.16
	Crude Oil	NE	NE	NE	NE	0.025	0.047	NE	NE	145.26	170.43	NE	NE	NE
	Other Liquid Biofuels	NE	NE	NE	NE	NE	NE	NE	NE	15.92	0.25	NE	NE	NE
	Gas/Diesel Oil	NE	NE	NE	0.016	0.016	0.023	NE	NE	NE	0.90	NE	NE	NE
1.A.1.a.iii Heat Plants	Crude Oil	NE	NE	NE	NE	0.03	0.13	NE	NE	NE	NE	NE	NE	NE
	Gas/Diesel Oil	NE	NE	NE	0.16	0.16	0.09	NE	NE	NE	NE	NE	NE	NE
	LPG	NE	NE	NE	0.03	0.03	0.03	NE	NE	NE	NE	NE	NE	NE

Note: NE: Not estimated
Source: Ministry of Public Utilities, Energy, Logistics, and E-Governance (Energy Unit) Annual Energy Balance

Crude oil and bagasse continue to be the most consumed fuels with bagasse's slowly returning to its previous consumption rate prior to its decline in 2020. Presumably, the 2019 drought, which affected agriproduce, in addition to reduced electrical demand during the pandemic years, contributed to this decline.

3.6.2.2 Emission factors applied in the subcategory

The Tier 1 method was selected and used for the estimation of GHG emissions for each source category and greenhouse gas within the energy sector summary report. The selection of the Tier 1 method was based on the use of the generalized decision tree for selecting tiers for fuel combustion in the energy sector (Intergovernmental Panel on Climate Change, 2006) . Overall, the decision tree as presented in Volume 2 of the 2006 IPCC guidelines applies in general for each of the fuel combustion activities and for each of the GHGs reported.

The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated based on the quantities of fuel combusted (usually from national energy statistics) and default emission factors. Tier 1 is the simplest approach where Activity data (AD) is combined with emission factors (EF). Therefore, the basic equation for the Tier 1 method applied for the estimates:

$$E_{GHG} = AD \times EF_{GHG}$$

Where:
E_{GHG}: Emissions of a given GHG by type of fuel (Gg GHG)
AD: Activity Data (quantities of fuel combusted)

EF$_{GHG}$: Emission Factor (default emission factor of a given GHG by type of fuel (kg of greenhouse gas per TJ on a Net Calorific Basis). For CO2, it includes the carbon oxidation factor, assumed to be 1.

Table 3-14 1.A.1 Energy Industries: emission factors applied by GHG source (fuel type)

Fuel Type	Calorific Value (TJ/Gg)	CO2 (kg/TJ)	CH4 (kg/TJ)	N2O (kg/TJ)
Crude Oil	42.3	73300	3	0.6
Gas/Diesel Oil	43	74100	3	0.6
LPG	47.3	63100	1	0.1
Lubricants	40.2	73300	3	0.6
Natural Gas	44.2	64200	3	0.6
Residual Fuel Oil	40.4	77400	3	0.6
Bagasse (Other Solid Biomass)	11.6	100000	30	4
Other Liquid Biofuels	27.4	79600	3	0.6

Source: IPCC Inventory Software Defaults

3.6.3 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

3.6.4 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.6.5 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.6.6 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.6.7 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.7 Manufacturing industries and construction (CRT 1.A.2)

3.7.1 Description and trend of GHGs in the subcategory

National emissions from the manufacturing industries and construction subcategory are very limited. Manufacturing consumptions have only been recently disaggregated in 2020 to 2022. However, data coverage and completeness issues remain throughout the timeline making impact assessments challenging. Consequently, insights, where possible, are only available for the years 2020 to 2021. This limited data highlights the relatively minor contribution of manufacturing and construction activities to the national greenhouse gas inventory.

Table 3-15 Manufacturing Industries and Construction 1.A.2: total GHG emissions by GHG source (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1.A.2.	Manufacturing industries and construction	46.20	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.14	51.91	NE
1.A.	Total (Fuel combustion)	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79

3.7.2 Methodological issues of the subcategory

3.7.2.1 Activity data of the subcategory

Manufacturing industries and construction activity data is sourced from the annual national energy balance worksheets which cover consumption extracted from crude oil sales for the following subcategories: 1. A.2.d. Pulp, Paper and Print, 1.A.2.e Food Processing, Beverages and Tobacco, 1.A.2.k Construction and Gas/Diesel oil for 1.A.2.m Non-specified industry. The Belize Natural Energy Ltd (BNE) has been the sole producer and exporter of crude oil in Belize. A wide variety of commercial and agricultural entities buy crude oil for their internal fuel uses, including several entities based across the border in Guatemala. Other fuels such as diesel or LPG are presumed to have uses in this sector, but there is currently no disaggregation and lumped under the 'Residential' and 'Other Uses - Commercial' sectors.

Table 3-16 1.A.2 Manufacturing industries and construction: activity data by fuel and subcategory (TJ)

Activity Source	Fuel Type	Year												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022
1.A.2.d.Pulp, Paper and Print	Crude Oil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	600.21	705.91	NE
1.A.2.e Food Processing, Beverages and Tobacco	Crude Oil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	159.51
1.A.2.k Construction	Crude Oil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	155.66

1.A.2.m Non-specified industry	Crude Oil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	308.27

Source: Ministry of Public Utilities, Energy, Logistics, and E-Governance (Energy Unit) Annual Energy Balance

3.7.2.2 Emission factors applied in the subcategory

Table 3-17 Manufacturing industries and construction: emission factors applied by GHG source

Activity Source	Fuel Type	Calorific Value (TJ/Gg)	CO2 (kg/TJ)	CH4 (kg/TJ)
1.A.2.d.Pulp, Paper and Print	Crude Oil	42.3	73300	3
1.A.2.e Food Processing, Beverages and Tobacco	Crude Oil	44.1	71500	0.5
1.A.2.k Construction	Crude Oil	44.3	74100	3.9
1.A.2.m Non-specified industry	Crude Oil	44.3	74100	3.9

Source: IPCC Inventory Software Defaults

3.7.3 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.7.4 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.7.5 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.7.6 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.7.7 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.7.8 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.7.9 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.7.10 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.8 Transport (CRT 1.A.3)

3.8.1 Description and trend of GHGs in the subcategory

The transport sector, as defined by the 2006 IPCC Guidelines, includes emissions from all modes of transportation such as road, rail, aviation, and navigation. These sources contribute significantly to greenhouse gas (GHG) emissions, primarily through the combustion of fossil fuels. In Belize, the transport sector is a major contributor to national GHG emissions, with road transportation being the dominant source. This subcategory includes emissions from domestic aviation, road transportation, railways[5], and domestic navigation.

In 2022, the transport sector's total emissions were 508.35 kt CO2 eq, accounting for approximately 70.32% of the Energy sector's total emissions. This represents a significant increase from the base year (1994), where emissions were 176.13 kt CO2 eq. The key drivers of this increase include the growth in road transportation and the expansion of domestic aviation. Road transportation alone contributed 482.49 kt CO2 eq in 2022, making up 66.76% of the sector's emissions. Domestic aviation and domestic navigation contributed 12.62 kt CO2 eq, and 1.04 kt CO2 eq, respectively.

As seen in Table 3-18, the emissions from the transport sector have shown significant fluctuations over the years. From 2012 to 2015, there was a sharp increase in emissions, peaking at 701.85 kt CO2 eq in 2015. This was followed by a gradual decline, reaching 474.97 kt CO2 eq in 2020, likely due to the global COVID-19 pandemic and reduced

[5] Emissions from railways is not an activity occurring in Belize, however for this submission, emissions from bitumen/asphalt used for roofing in the IPPU is accounted for in this sector.

transportation activities. In the post-pandemic years of 2021 and 2022, emissions have shown moderate recovery.

Table 3-18 Transport 1.A.3 total GHG emissions by source (kt CO2 eq)

Code	*Subcategory*	*1994*	*1997*	*2000*	*2003*	*2006*	*2009*	*2012*	*2015*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
1.A.3.	Transport	176.13	0.00	0.00	4.76	2.80	2.62	506.33	701.85	681.25	615.70	547.84	474.97	468.19	508.35
1.A.3.a.	Domestic aviation	6.50	0.00	0.00	0.00	0.00	0.00	9.37	11.99	12.87	12.42	12.89	5.94	9.83	12.62
1.A.3.b.	Road transportation	148.46	0.00	0.00	0.09	0.08	0.08	489.01	675.35	659.90	597.39	530.04	436.56	448.00	482.49
1.A.3.c.	Railways	0.00	0.00	0.00	4.67	2.72	2.55	7.95	14.51	8.47	5.27	4.24	5.05	9.61	12.21
1.A.3.d.	Domestic navigation	21.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.67	27.42	0.74	1.04
1.A.	Total (Fuel combustion)	422.95	0.00	0.00	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79

3.8.2 Methodological issues of the subcategory

3.8.2.1 Activity data of the subcategory

Transport activity data is mainly sourced from the Petroleum Products Importation Data, for the following subcategories: 1.A.3.a Domestic Aviation, 1.A.3.b Road Transportation and 1.A.3.d Water-borne Navigation. Other sources include the Domestic Aviation Fuel consumption data and Water Taxis data for each respective subcategory. Consumption data for road transport is primarily from cars but not further disaggregated. Premium and Regular are the two types of gasoline used in Belize which has been combined under motor gasoline.

Table 3-19 1.A.3 Transport: activity data by fuel and GHG source (TJ)

Activity Source	**Fuel Type**	**Year**												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022
1.A.3.a Domestic Aviation	Aviation Gasoline	NE	NE	NE	0.03	0.03	0.03	132.76	169.97	14.22	10.06	12.21	9.06	7.56
	Jet Kerosene	NE	NE	NE	NE	NE	NE	NE	NE	158.50	169.08	70.56	127.56	167.69
1.A.3.b Road Transportation	Motor Gasoline	NE	NE	NE	0.69	0.52	0.57	NE	NE	3222.60	3508.74	3097.92	3259.60	3616.04
	Gas/Diesel Oil	NE	NE	NE	0.49	0.50	0.45	NE	NE	2900.91	3730.12	2875.80	2875.25	2996.94
1.A.3.d Water-borne Navigation	Motor Gasoline	NE	NE	NE	0.032	0.02	0.02	NE	NE	8.39	8.94	8.84	10.52	14.80

Source: Ministry of Public Utilities, Energy, Logistics, and E-Governance (Energy Unit)

3.8.2.2 Emission factors applied in the subcategory

Table 3-20 1.A.3 Transport: emission factors applied by GHG source

Activity Source	Fuel Type	Calorific value (TJ/Gg)	CO2 (kg/TJ)	CH4 (kg/TJ)	N2O (kg/TJ)
1.A.3.a Domestic Aviation	Aviation Gasoline	44.3	70000	0.5	2
	Jet Kerosene	44.1	71500	0.5	2
1.A.3.b Road Transportation	Gas/Diesel Oil	44.3	74100	3.9	3.9
	Motor Gasoline	43	69300	33	3.2
1.A.3.d Water-borne Navigation	Gas/Diesel Oil	43	74100	7	2

Source: IPCC Inventory Software Defaults

3.8.3 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.8.4 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.8.5 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.8.6 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.8.7 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

3.8.8 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.8.9 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.8.10 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.9 Other sectors (CRT 1.A.4)

3.9.1 Description and trend of GHGs in the subcategory

The "Other sectors" subcategory (CRT 1.A.4) encompasses emissions from commercial/institutional, residential, and agriculture/forestry/fishing activities. According to the 2006 IPCC Guidelines, these sources contribute to greenhouse gas (GHG) emissions primarily through fuel combustion for heating, cooking, and other energy needs.

In Belize, the "Other sectors" subcategory includes emissions from commercial/institutional buildings, residential homes, and agriculture/forestry/fishing activities. These sources are relevant at the national level due to their contribution to overall GHG emissions. However, data completeness has been a challenge, with limited disaggregated data available for certain years.

In 2022, the "Other sectors" subcategory contributed 160.81 kt CO2 eq to the sector's total emissions, accounting for approximately 22.26% of the sector's emissions. This represents a significant increase from the base year (1994), where emissions were 55.14 kt CO2 eq. The key drivers of this increase include the growth in residential energy use and changes in agricultural practices (see Table 3-21 below).

Table 3-21 Other Sectors 1.A.4 total GHG emissions by source (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1.A.4.	Other sectors	55.14	NE	0.00	0.02	0.08	0.02	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.a.	Commercial/institutional	12.97	NE	NE	0.01	0.05	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.4.b.	Residential	16.79	NE	NE	0.01	0.01	NE	6.64	7.50	7.89	127.75	150.81	108.40	131.97	160.81
1.A.4.c.	Agriculture/forestry/fishing	25.38	NE	NE	0.01	0.02	0.02	NE	NE	NE	NE	NE	NE	NE	NE
1.A.	Total (Fuel combustion)	422.95	NE	NE	4.89	2.89	2.68	567.30	820.98	823.13	829.87	849.91	684.20	714.80	722.79

3.9.2 Methodological issues of the subcategory

3.9.2.1 Activity data of the subcategory

Other sectors include fuel consumption activity data from 1.A.4.a Commercial/Institution, 1.A.4.b Residential and 1.A.1.c Agriculture/Forestry/Fishing which is sourced from the Annual Energy Balance Sheets and the Statistical Institute of Belize.

Table 3-221.A.4.a Commercial/Institution, 1.A.4.b Residential and 1.A.1.c Agriculture/Forestry/Fishing Activity Data (TJ)

Activity Source	Fuel Type (TJ)	Year												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022
1.A.4.a Commercial/Institution	Gas/Diesel Oil	NE	NE	NE	0.02	0.02	0.01	NE	NE	NE	NE	NE	NE	NE
	LPG	NE	NE	NE	0.07	0.08	NE	NE	NE	NE	NE	NE	NE	NE
1.A.4.b Residential	Wood/wood waste	NE	NE	NE	NE	NE	NE	701.92	792.31	551.80	574.69	678.64	1054.46	671.56
	Other Kerosene	NE	NE	NE	NE	NE	NE	NE	NE	602.69	869.17	343.48	627.13	1002.29
	LPG	NE	NE	NE	0.08	0.09	NE	NE	NE	1247.54	1304.01	1219.14	1211.2	1295.3
	Gas/Diesel Oil	NE	NE	NE	0.00	0.01	0.00	NE	NE	NE	NE	NE	NE	NE
1.A.1.c Agriculture/Forestry /Fishing	Motor Gasoline	66.25	NE	NE	0.05	0.03	0.05	NE	NE	NE	NE	NE	NE	NE
	Gas/Diesel Oil	278.55	NE	NE	0.12	0.15	0.11	NE	NE	NE	NE	NE	NE	NE
	LPG	NE	NE	NE	0.01	0.01	0.01	NE	NE	NE	NE	NE	NE	NE
	Crude Oil	NE	NE	NE	NE	0.06	0.08	NE	NE	NE	NE	NE	NE	NE

Source: Ministry of Public Utilities, Energy, Logistics, and E-Governance (Energy Unit) Annual Energy Balance

3.9.2.2 Emission factors applied in the subcategory

Table 3-23 1.A.4 Other Sectors: emission factors applied by GHG source

Activity Source	Fuel Type	Calorific value (TJ/Gg)	CO2 (kg/TJ)	CH4 (kg/TJ)	N2O (kg/TJ)
1.A.4.a Commercial/Institution	Gas/Diesel Oil	43	74100	10	0.6
	LPG	47.3	63100	5	0.1
1.A.4.b Residential	Wood/wood waste				
	Other Kerosene	43.8	71900	10	0.6
	LPG	47.3	63100	5	0.1
	Gas/Diesel Oil	43	74100	10	0.6
1.A.1.c Agriculture/Forestry/Fishing	Motor Gasoline	43	69300	10	0.6
	Gas/Diesel Oil	43	74100	10	0.6
	LPG	47.3	63100	5	0.1
	Crude Oil	42.3	73300	10	0.6

Source: IPCC Inventory Software Defaults

3.9.3 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.9.4 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.9.5 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.9.6 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.9.7 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

3.9.8 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.9.9 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.9.10 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.10 Fugitive emissions from fuels (CRT 1.B)

3.10.1 Description and trend of GHGs in the category

In Belize, fugitive emissions from fuels are a result of oil and natural gas systems. Fugitive emissions refer to GHGs that escape during the extraction, processing, storage, and transport of fossil fuels. Particularly, these types of emissions are to be considered unintentional releases and are to be distinct in the notion that they are a result of the handling and management of energy resources, and not a direct fuel combustion activity.

Table 3-24 Fugitive emissions from fuels activity and source categories being reported in Belize.

Sub-sector	Source Categories	Activity Code
1B Fugitive Emissions from Fuels	1B2a Oil	1B2ai Exploration
		1B2aii Production and Upgrading
		1B2aiii Transport
		1B2av Distribution of Oil Products
		1B2avi Other
	1B2b Natural Gas	1B2bvii Other

Fugitive emissions were first reported within Belize's 4th GHG Inventory covering reference years 2018 – 2019. While fugitive emissions are broken down primarily into two main categories, activities within this category in relation to Belize's jurisdiction falls under the source category Oil and Natural Gas (Table 3-24).

In 2022, the "Fugitive emissions from fuels" subcategory contributed 0.00194 kt CO2 eq to the sector's total emissions. This represents a minimal contribution compared to other subcategories. The key drivers of these emissions include activities related to natural gas production and distribution.

Table 3-25 Fugitive emissions from fuels (natural gas flaring) 1.B total GHG emissions by subcategory (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
1.B.	Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194
1.B.2.	Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194
1.B.2.b.	Natural gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00093	0.00113	0.00092	0.00118	0.00194

3.10.2 Methodological issues of the category

3.10.2.1 Activity data of the category

Table 3-26 1.B Fugitive Emissions: activity data by GHG source (TJ)

Activity Source	Fuel Type	Year												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022
1.B.2.b.ii Flaring	Natural Gas	NO	NO	NO	NO	NO	NE	NE	NE	19.04	23.30	22.24	28.65	46.94

3.10.2.2 Emission factors applied in the category

Table 3-27 1.B Fugitive Emissions: emission factors applied by GHG source

Activity Source	Fuel Type	Calorific Value	Unit	CO2	CH4	N2O
1.B.2.b.ii Flaring	Natural Gas	44.2	$Gg/10^6\ m^3$	0.0014	0.00000088	0.000000025

3.10.3 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

3.10.4 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.10.5 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.10.6 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

3.10.7 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

3.10.8 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

3.10.9 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

3.10.10 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

4 Chapter 4: INDUSTRIAL PROCESSES AND PRODUCT USE (CRT 2)

4.1 Description of the sector

The Industrial Processes and Product Use (IPPU) sector is one of the five main sectors that is reported under the National Greenhouse Gas Inventory. The IPPU sector covers greenhouse gas emissions occurring from industrial processes, from the use of greenhouse gases in products, and non-energy uses of fossil fuel carbon (Eggleston, Buendia, Miwa, Ngara, & Tanabe, 2006) .

Belize is a country that is not heavily industrialized but there are a handful of activities under the IPPU sector that contribute to greenhouse gas emissions. The IPPU sector has several categories that it aims to report on which include the mineral industry, non-energy use for solvent, products used as substitutes for ozone-depleting substances, other product manufacture and use, and Nitrous Oxide (N2O) from product uses. Under these sectors, there are sub-sectors that specify more in detail exactly what type of data is required. Data was not available for all subsectors; however, this does not mean that the activity is not occurring in the country but is more than likely not being enforced hence no data being recorded.

4.2 Trend in the sector's GHG emissions

The IPPU sector was the least emitting sector (7% of national emissions) after the waste, energy and agriculture sector, contributing 199.1 kt CO2 eq.

Table 4-1 IPPU Sector: emissions by GHG, category and subcategory (kt) for 2022

Code	GHG source categories	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	HFC (kt CO_2 eq)	PFC (kt CO_2 eq)	Unspecified mix of HFCs and PFCs (kt CO_2 eq)	SF_6 (kt)	NF_3 (kt)	NO_x (kt)	CO (kt)	NMVOC (kt)	SO_x (kt)	Total GHG (kt CO_2 eq)
2	**Industrial processes and product use**	**1.5142401**			**197.5624**									**199.0766**
2.A.	Mineral industry	0.21225												0.21225
2.A.1.	Cement production	NO												
2.A.2.	Lime production	0.21225												0.21225
2.A.3.	Glass production	NO												
2.A.4.	Other process uses of carbonates	NO												
2.A.5.	Other (please specify)	NO												
2.B.	Chemical industry	NO												
2.B.1.	Ammonia production	NO	NO	NO										

2.B.2.	Nitric acid production	NO												
2.B.3.	Adipic acid production	NO												
2.B.4.	Caprolactam, glyoxal and glyoxylic acid production	NO												
2.B.5.	Carbide production	NO												
2.B.6.	Titanium dioxide production	NO												
2.B.7.	Soda ash production	NO												
2.B.8.	Petrochemical and carbon black production	NO												
2.B.9.	Fluorochemical production	NO												
2.B.10.	Other (please specify)	NO												
2.C.	Metal industry	NO												
2.C.1.	Iron and steel production	NO												
2.C.2.	Ferroalloys production	NO												
2.C.3.	Aluminium production	NO												
2.C.4.	Magnesium production	NO												
2.C.5.	Lead production	NO												
2.C.6.	Zinc production	NO												
2.C.7.	Other (please specify)	NO												
2.D.	Non-energy products from fuels and solvent use	0.669328												0.669328
2.D.1.	Lubricant use	0.669328												0.669328
2.D.2.	Paraffin wax use	NO	NO	NO										
2.D.3.	Solvent Use	NO	NO	NO										
2.D.4.	Other (please specify)	NO	NO	NO										
2.E.	Electronic industry													
2.E.1.	Integrated circuit or semiconductor													
2.E.2.	TFT flat panel display													
2.E.3.	Photovoltaics													
2.E.4.	Heat transfer fluid													
2.E.5.	Other (please specify)													
2.F.	Product uses as substitutes for ODS				197.5623									197.562388
2.F.1.	Refrigeration and air conditioning				197.5623									197.562388
2.F.1.a.	Refrigeration and Stationary Air Conditioning				171.2259									171.225989
2.F.1.b.	Mobile Air Conditioning				26.33639									26.3363983
2.F.2.	Foam blowing agents													
2.F.3.	Fire protection													
2.F.4.	Aerosols													
2.F.5.	Solvents													

2.F.6.	Other applications													
2.G.	Other product manufacture and use	NO												
2.G.1.	Electrical equipment													
2.G.2.	SF_6 and PFCs from other product use													
2.G.3.	N_2O from product uses													
2.G.4.	Other	NO												
2.H.	Other (please specify)	0.6326621												0.6326621
2.H.1.	Pulp and Paper Industry	NO												
2.H.2.	Food and Beverage Industry	0.6326621												0.6326621
2.H.3.	Other (please specify)	NO												

Table 4-2 and Figure 4-4 below presents in detail the emissions generated through activities within the IPPU sector for the time series 1994-2022. In 2022, greenhouse gas (GHG) emissions from the IPPU sector totaled 199.08 kt CO_2 eq, a substantial increase from 8.71 kt CO_2 eq in the base year 1994. The annual rate of increase is approximately 35%, with a noticeable spike between 2019 and 2021. Product Uses as Substitutes for Ozone Depleting Substances (ODS) (Code 2.F) was the top contributor of total emissions during the observed period (see figure Specifically, Refrigeration and air conditioning (2.F.1) comprising over 95% of GHG Emissions between 1994 and 2022. The Mineral Industry (2.A) emissions from the Mineral Industry were negligible until 2003, where contributions were small but consistent contributions, mainly from Lime Production. The Non-energy products from fuels and solvent use (2.D) showed minor contributions with notable emissions starting in 2012, primarily from Lubricant Use (2.D.1). Other (2.H) - The Food and Beverage Industry (2.H.2) shows small but steady emissions beginning in 2003.

As previously noted, GHG Emissions were primarily driven by Product Uses as Substitutes for ODS, a total of 197.30 kt CO2 eq in 2022. Between 1994 and 2022, Refrigeration and Stationary Air Conditioning (2.F.1.a) made up 65% of GHG Emissions from the subcategory while Mobile Air Conditioning (2.F.1.b) contributed 35%. Refrigeration and Stationary Air Conditioning grew significantly between 2009 to 2021, where emissions went from 29.39 kt CO2 eq to 171.23 kt CO2 eq. On the other hand, Mobile Air Conditioning showed steady increases, reflecting the growing usage and impact of mobile air conditioning systems.

Table 4-2 IPPU sector: total GHG emissions by category or subcategory (kt CO2 eq)

Code	*Subcategory*	*1994*	*1997*	*2000*	*2003*	*2006*	*2009*	*2012*	*2015*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
2	**Industrial processes and product use**	8.71	17.77	23.71	31.69	36.10	50.77	40.74	43.54	54.15	61.13	73.92	69.27	198.57	199.08
2.A.	Mineral industry	NE	NE	NE	3.75	4.50	2.25	1.59	1.02	0.55637	2.43	2.88	0.21216	0.21225	0.21225
2.A.1.	Cement production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

2.A.2.	Lime production	NE	NE	NE	3.75	4.50	2.25	1.59	1.02	0.55637	2.43	2.88	0.21216	0.21225	0.21225
2.D.	Non-energy products from fuels and solvent use	NE	NE	NE	0.01439	NE	NE	1.35	1.40	1.37	NE	1.69	0.44469	0.54522	0.66933
2.D.1.	Lubricant use	NE	NE	NE	NE	NE	NE	1.35	1.40	1.37	NE	1.69	0.44469	0.54522	0.66933
2.D.2.	Paraffin wax use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D.3.	Solvent Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D.4.	Other (please specify)	NO	NO	NO	0.01439	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.	Product uses as substitutes for ODS	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
2.F.1.	Refrigeration and air conditioning	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
2.F.1.a.	Refrigeration and Stationary Air Conditioning	5.37	10.97	14.63	17.13	18.90	29.39	22.66	22.52	30.38	36.98	44.98	44.02	171.98	171.23
2.F.1.b.	Mobile Air Conditioning	3.33	6.80	9.07	10.62	11.72	18.22	14.05	17.07	20.29	21.71	23.02	24.22	25.32	26.34
2.H.	Other (please specify)	NO	NO	NO	0.1825	0.97846	0.90495	1.09	1.53	1.55	0.00177	1.36	0.38265	0.51358	0.63266
2.H.1.	Pulp and Paper Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.H.2.	Food and Beverage Industry	NE	NE	NE	0.1825	0.97846	0.90495	1.09	1.53	1.55	0.00177	1.36	0.38265	0.51358	0.63266
2.H.3.	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

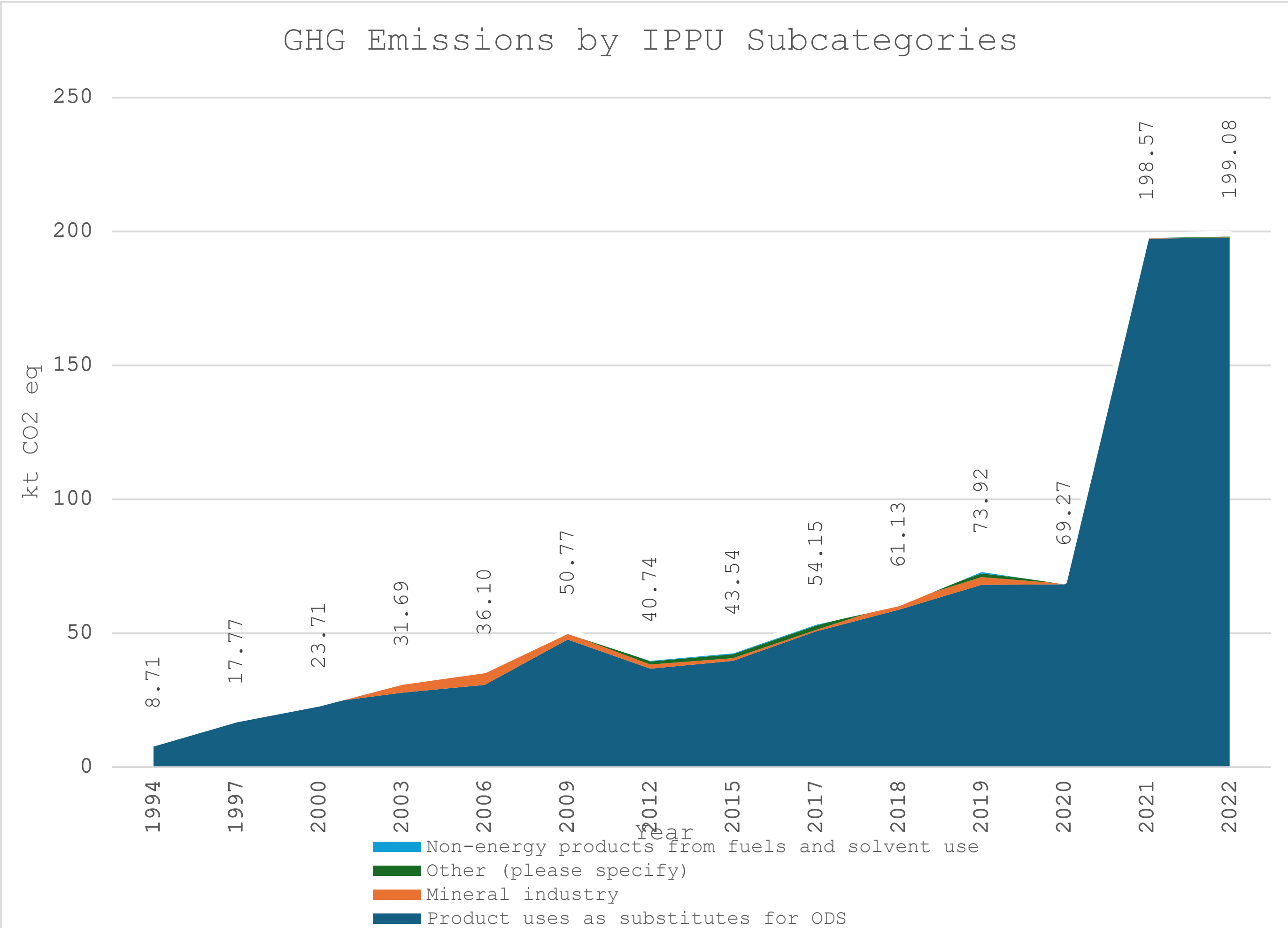


Figure 4-1 GHG Emissions by IPPU Subcategories

Table 4-3 shows the trends by GHG emitted in this sector. As previously noted, the significant consumption in the product uses as substitutes for ozone-depleting substances (ODS) category, particularly in refrigeration and air conditioning, accounts for HFCs being the dominant emitting gas.

Table 4-3 IPPU sector: emissions by GHG (kt CO2 eq)

GHG	*1994*	*1997*	*2000*	*2003*	*2006*	*2009*	*2012*	*2015*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
CO_2	0.00	0.00	0.00	3.95	5.48	3.15	4.04	3.95	3.48	2.44	5.92	1.04	1.27	1.51
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
Total	**8.71**	**17.77**	**23.71**	**31.69**	**36.10**	**50.77**	**40.74**	**43.54**	**54.15**	**61.13**	**73.92**	**69.27**	**198.57**	**199.08**

4.3 General methodological issues of the sector

The Department of Environment (DOE) leads the methodological process for the IPPU sector. For HFCs in refrigeration and air conditioning, DOE collects data specifically tracking the volume imported through its Online Permitting and Licensing (OPAL) system. Currently, no HFC production occurs in Belize. For the mineral industry cement production, the main local company reported that it does not produce 'clinkers,' which is the main ingredient of GHG emissions when produced. The company instead imports the material needed, therefore, no emission can be associated to this activity.

Lime production is not directly monitored by the DOE but falls under the Mining Unit's jurisdiction, and discussions are ongoing to enhance regulation in this area. The data for white lime production was collected directly from the kiln sources and for dolomite lime, it was retrieved from a few companies that utilize it (such as shrimp & citrus companies).

In the food and beverage industry, spirits and liquor producers must obtain environmental clearance from the DOE, which maintains a list of operators. However, the DOE lacks data on bread production, as these establishments typically comply with the Trade License regime, with varying degrees of oversight by local town and city councils. Again it is not a requirement for these businesses to submit the amount of bread they are producing.

Lastly, the DOE does issue a permit for lubricants, however, the data is not a hundred percent reliable because there are a few cases where importers uses a different unit measurement than what is on the application or the amount is recorded as the amount of boxes or barrels. As for the data provided by customs, the companies are taxed based on the gallons they are importing. The data for importation of asphalt was provided by the primary importer of this substance in the country, which is secondarily collected by the SIB.

A summary of the relevant subsectors for each category can be seen in Table 4-4 below.

This sector encompasses industrial activities that chemically and physically transform materials, leading to emissions of key gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Table 4-4 Summary of relevant activity data, methods, and emission factors for IPPU sector inventory.

Source Category	**Activity Source**	**Data Type**	**Data Source**	**CO_2**		**CH_4**		**N_2O**	
2 IPPU				MT	EF	MT	EF	MT	EF
2A Mineral Industry	2A2 Lime and Dolomite Production	Lime and Dolomite Production for shrimp, citrus, coconut industry and for soil pH alteration	Lime producers in St. Margaret Village	T1	D	NA	NA	NA	NA
2D Non-energy products from fuels and solvent use	2D1 Lubricant use	Automotive Lubricant consumption (based on amount imported)	Statistical Institute of Belize (SIB)	T1	D	NA	NA	NA	NA
	2D3 Other - Asphalt	Asphalt consumption (based on amount imported) for road paving	Belize Custom Department	T1	D	NA	NA	NA	NA
2F Product uses as substitutes for ODS	2F1 Refrigeration and air conditioning	Refrigerant consumption for domestic and commercial use	Department of Environment	T1	D	NA	NA	NA	NA
2H Other	2H2 Food and Beverage	Durum Wheat Importation,	Statistical Institute of Belize (SIB)	T1	D	NA	NA	NA	NA
	2H2 Food and Beverage	Alcohol Production	Belize Customs Department via distilleries	T1	D	NA	NA	NA	NA
	2H2 Food and Beverage	Beer Production	Belize Customs Department	T1	D	NA	NA	NA	NA

4.4 Mineral industry (CRT 2.A)

4.4.1 Description and trend of GHGs in the category

The Mineral Industry comprises of Lime and Dolomite Production. Since the 2019 Transparency Report, data regarding lime production remains relevant, as updated data collection has not occurred since that time. In 2019, there were eight lime producers located primarily along the Hummingbird Highway in St. Margaret Village, Cayo District, Belize (see Figure 1). However, based on a recent data collection survey that was conducted by the NCCO in 2024, this number has decreased to five producers with available data collected from 2018 to 2022. It is important to note that the Mining Unit does not currently regulate lime production but provides permits for limestone excavation in designated areas.

In Belize, two types of lime are produced: white lime (calcium oxide) and dolomite lime (calcium magnesium carbonate). The limestone used for lime production contains approximately 80% or more calcium and is extracted from quarries in the country's mountainous regions. White lime, commonly known as “cal,” is produced by burning limestone in an enclosed area using firewood for three to six days.

Notably, lime can reabsorb CO_2 during certain applications. For instance, when used in water quality treatment and paper production, lime can absorb CO_2, resulting in net-zero process emissions in some cases. Calcium oxide (CaO) is widely used in Belize’s shrimp, citrus, and coconut industries to alter soil pH and in wastewater treatment.

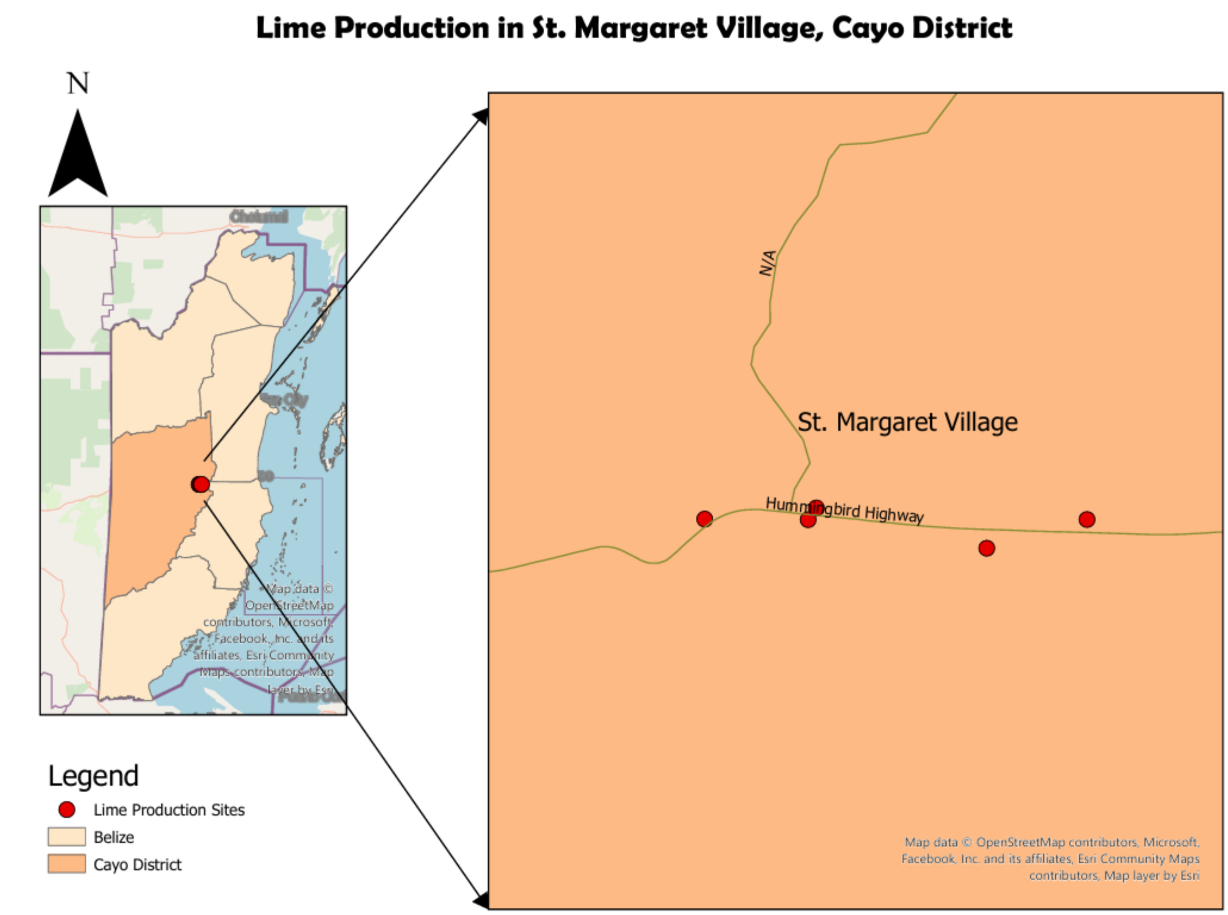


Figure 4-2 Lime Production in the country of Belize

Table 4-5 Average yearly Lime Production in Belize, 2018-2022

Liming producers in Belize (Average data from 2018 - 2022)		
St. Margaret's Village Producer	Avg. Lbs. per year	Avg. Tons (t) per year
Producer 1	120,000	60
Producer 2	88,000	44
Producer 3	64,000	32
Producer 4	127,500	63.75
Producer 5	166,250	83.125
TOTAL	565,750	282.875

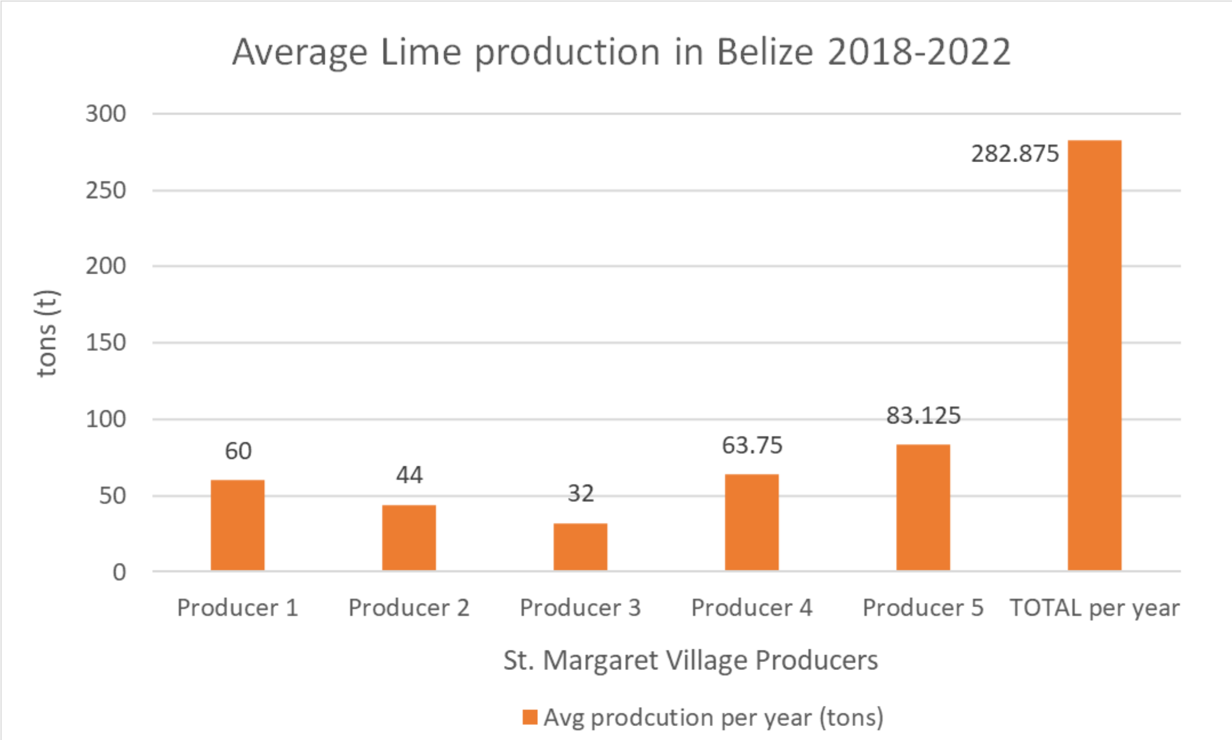


Figure 4-3 Average yearly Lime Production in Belize, 2018-2022

The data collected from the recent NCCO survey was only provided as an average per year by the current active lime producers. In Table 4-5 above the average tons (t) produced for a year is 282.87. It can then be deduced that on average for the years 2020, 2021 & 2022 the total amount of lime produced was 848.62t (282.875 x 3 years). In the last report, there was data available up to the year 2019 (with 8 active producers) and the average ton produced was 540.75t in 2019. Therefore, a slight decrease in production can be seen and may be due the fact of only 5 producers being active presently.

For Dolomite, Belize Minerals Ltd, located in the Toledo district, is recognized as the number one producer. Dolomite is classified as a common forming mineral; therefore, the chemical structure is composed of calcium, magnesium, and carbonate with a composition of Ca Mg (CO_2). It is primarily used in the banana farms, citrus orchard, shrimp industry, coconut and cacao farming to adjust the pH acidic condition of the soil.

Table 4-6 below presents in detail the emissions generated through activities within the Mineral Industry category. For the most current year 2022, emissions lime production was 0.212 kt CO_2 eq which is a decrease from the highest emitting of 4.50 kt CO_2 eq in 2006, reflecting a 95% reduction in emissions over the period. The category's contribution to the sector's total emissions remains minimal, with emissions fluctuating throughout the years. The key driver of this change has been the reduction in lime production activities, likely influenced by the decrease in lime producers. In the latest inventory year (2022), emissions were nearly unchanged compared to 2021 (0.21225 kt CO_2 eq), indicating a potential stabilization of emissions following the earlier decline.

Table 4-6 Mineral Industry total GHG emissions by GHG source (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.A.	Mineral industry	0.	0.	0.	3.75	4.50	2.25	1.59	1.02	0.55637	2.43	2.88	0.21216	0.21225	0.21225
2.A.2.	Lime production	0.	0.	0.	3.75	4.50	2.25	1.59	1.02	0.55637	2.43	2.88	0.21216	0.21225	0.21225

4.4.2 Methodological issues of the category

4.4.2.1 Activity data of category

The production of Lime and Dolomite has a great demand in Belize by the agriculture sector as it is used to alter the pH conditions in acidic soil and is a quality source of calcium and magnesium. In 2019, there were eight lime producers located primarily along the Hummingbird Highway in St. Margaret Village, Cayo District, Belize. Based on a recent data collection survey that was conducted by the NCCO in 2024, this number has decreased to five active lime producers which was used in data collection from 2018 to 2022. The Belize Minerals Ltd company is located in the Toledo district and is recognized as the number one producer of Dolomite. Dolomite is classified as a common forming mineral; therefore, the chemical structure is composed of calcium, magnesium, and carbonate with a composition of Ca Mg (CO_2). It is primarily used in the banana farms, citrus orchard, shrimp industry, coconut and cacao farming to adjust the pH acidic condition of the soil.

Table 4-7 2.A. Mineral Industry: activity data for lime and dolomite production (tonnes)

Activity Source	Lime Type	Year													
		1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.A.2 Lime Production	Lime	NE	NE	NE	5000.00	6000.00	3000.00	233.72	301.72	244.72	333.21	540.75	283.00	283.00	283.00
	Dolomite	NE	NE	NE	NE	NE	NE	1841	1035	484.2	2540.5	3209	NE	NE	NE

Note: 2020-2022 is the average lime production for the years 2018-2022
Source: Department of Environment (St. Margaretville Lime Producers and The Belize Minerals Ltd)

4.4.2.2 Emission factors applied in the category

A Tier 1 approach was used following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use. The Tier 1 method is an output-based method and applies an emission factor (shown in Table 4-8 below) to the total quantity of lime and dolomite produced.

Table 4-8 2.A. Mineral Industry: emission factors applied by Lime and Dolomite production1.A.1 Energy Industries: emission factors applied by GHG source (fuel type)

Activity Source	Mineral	Emission [tonnes tonne lime]	Factor CO_2 per
2.A.2 Lime Production	Lime	0.75	
	Dolomite	0.77	

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use Pg.2.22, Table 2.4

4.4.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

4.4.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.4.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.4.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.4.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

4.5 Non-energy products from fuels and solvents (CRT 2.D)

4.5.1 Description and trend of GHGs in the category

The Non-energy products from fuels and solvents category is comprised of Lubricant use and Asphalt. Belize imports asphalt from regional countries as it is mainly produced in petroleum refineries. Asphalt is commonly referred to as bitumen, the production and use of asphalt results mainly in emissions of CO_2, SO_2 and particulate matter. While the remaining hydrocarbons are stored in the product, less than one percent of carbon is emitted.

In 2022, emissions from the Non-Energy Products from Fuels and Solvent Use category were 0.669 kt CO_2 eq, a significant increase from 0.545 kt CO_2 eq in 2021. This category experienced a gradual rise in emissions over time, with the first notable emissions recorded in 2003 at 0.014 kt CO_2 eq. The rise in emissions is mainly attributed to Lubricant Use, which accounted for the entire emissions in recent years. In 2022, lubricant use emissions totaled 0.669 kt CO_2 eq, representing the full contribution from this subcategory.

The variation between the base year (1994) and the latest inventory year (2022) demonstrates the gradual expansion of this subcategory's emissions, which began to rise more significantly after 2003, as lubricant importation for automotive became more commonly used. The absence of emissions in the early years (1994-2000) and the minimal emissions recorded in 2003 reflect limited industrial activities in this area at the time. The increase over time is linked to the growth the data gaps in the time series especially for Asphalt consumption.

Table 4-9 Non-energy products from fuels and solvent use: total GHG emissions by category (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.D.	Non-energy products from fuels and solvent use	NE	NE	NE	0.01439	NE	NE	1.35	1.40	1.37	0.	1.69	0.44469	0.54522	0.66933
2.D.1.	Lubricant use	NE	NE	NE	NE	NE	NE	1.35	1.40	1.37	0.	1.69	0.44469	0.54522	0.66933
2.D.4.	Other (please specify)	NE	NE	NE	0.01439	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4.5.2 Methodological issues of the category

4.5.2.1 Activity data of the category

Lubricant data represents all automotive lubricants that was imported into the country obtained through the Statistical Institute of Belize (SIB) during the period 2018-2022.

The Belize Custom Department provided the data on the numerical figures of asphalt importation into the country of Belize during the period 2018-2022. Asphalt importation can be attributed to the infrastructure sector (road paving).

Table 4-10 2.D Non-energy products: activity data from lubricant and asphalt consumption (TJ)

Activity Source	Activity	Year													
		1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.D.1 Lubricant Use	Lubricant Imported	NE	NE	NE	NE	NE	NE	92.02	95.32	93.36	94.71	114.98	30.37	37.17	45.64
2.D.3 Other	Asphalt Imported	NE	NE	NE	57.85	33.65	31.52	98.49	179.69	104.92	65.20	52.54	62.51	119.03	151.19

Source: Statistics of Belize and Belize Custom Department

4.5.2.2 Emission factors applied in the category

A Tier 1 approach was used as there are no country-specific statistics available on the fates and composition of lubricants. The Tier 1 method relies on applying one default ODU factor to total lubricant consumption activity data. Only CO_2 emissions are applicable in this activity source.

The production and use of asphalt results mainly in emissions of CO_2, SO_2 and particulate matter.

.Table 4-11 2.D Non-energy products: emission factors applied from lubricant and asphalt consumption

Activity Source	Activity Type	Carbon content of lubricant (tonne C/TJ)	Oxidized During Use (ODU) factor
2.D.1 Lubricant Use	Lubricant	20	0.2
2.D.3 Other	Asphalt	0.001	NA

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use Chapter 5

4.5.3 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.5.4 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.5.5 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.5.6 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

4.5.7 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.5.8 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.5.9 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.5.10 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

4.6 Product uses as substitutes for ODS (CRT 2.F)

4.6.1 Description and trend of GHGs in the category

The Product uses as substitutes for ODS category, as defined by the 2006 IPCC Guidelines, refers to the use of certain chemicals or products as replacements for substances that deplete the ozone layer. This category specifically addresses the use of substances such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other chemicals that were introduced as substitutes for ODS like chlorofluorocarbons (CFCs) and halons in various applications, particularly in refrigeration and air conditioning. In Belize, only HFCs are relevant to emissions. This subcategory includes emissions from Refrigeration and air conditioning, Refrigeration and Stationery Air Conditioning and Mobile Air Conditioning.

In 2022, the Product uses as substitutes for ozone-depleting substances (ODS) category, particularly in refrigeration and air conditioning, accounted for 197.56 kt CO_2 eq in greenhouse gas (GHG) emissions, which was a significant increase from 8.71 kt CO_2 eq in 1994. Refrigeration and Stationary Air Conditioning accounted for 171.23 kt CO_2 eq, while Mobile Air Conditioning contributed 26.34 kt CO_2 eq in 2022.

Refrigeration and Air Conditioning (2.F.1) was the primary emitter within the category, accounting for 100% of the emissions in 2022, with Stationary Air Conditioning and Mobile Air Conditioning contributing 86.7% and 13.3%, respectively. Over the past decade, emissions from refrigeration and air conditioning have consistently risen, with significant growth between 2009.

Table 4-12 Product uses as ODS total GHG emissions by subcategory (kt CO2 eq)

Code	*Subcategory*	*1994*	*1997*	*2000*	*2003*	*2006*	*2009*	*2012*	*2015*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*

2.F.	Product uses as substitutes for ODS	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
2.F.1.	Refrigeration and air conditioning	8.71	17.77	23.71	27.75	30.62	47.61	36.71	39.59	50.68	58.69	68.00	68.23	197.30	197.56
2.F.1.a.	Refrigeration and Stationary Air Conditioning	5.37	10.97	14.63	17.13	18.90	29.39	22.66	22.52	30.38	36.98	44.98	44.02	171.98	171.23
2.F.1.b.	Mobile Air Conditioning	3.33	6.80	9.07	10.62	11.72	18.22	14.05	17.07	20.29	21.71	23.02	24.22	25.32	26.34

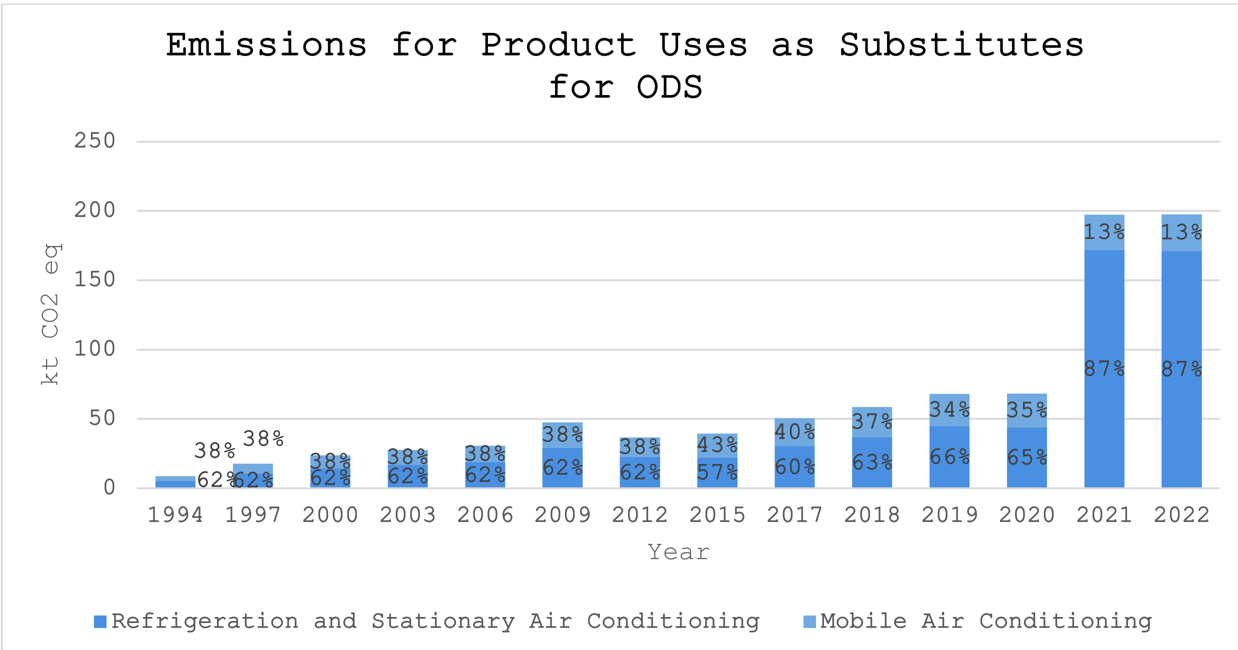


Figure 4-4 Emissions for Product Uses as Substitutes for ODS

Belize, classified as a Party operating under paragraph 1 of Article 5 of the Protocol, acceded to the Montreal Protocol on Substances that Deplete the Ozone Layer on January 17, 2008. The country also joined the London and Copenhagen Amendments on January 9, 1998, and the Montreal and Beijing Amendments on January 17, 2008. Since 2010, Belize has implemented the Hydrochlorofluorocarbons (HCFC) Phase-out Management Plan (HPMP) alongside an HCFC Quota System. As part of Stage I of the HPMP, Belize is committed to phasing out 67.5% of HCFCs by 2025 in the refrigeration and air conditioning (RAC) servicing sector. To date, the country has successfully achieved its 2020 target of a 35% reduction in HCFC consumption, measured against a baseline of 2.80 ODP tonnes (50.9 metric tonnes), and is on track to meet the 2025 target.

In light of the anticipated increase in the use of Hydrofluorocarbons (HFCs) and related technologies, Belize has proactively taken steps to address HFC emissions. The country has received approval to initiate activities to facilitate ratification of the Kigali Amendment to the Montreal Protocol, which includes revising its licensing system and implementing capacity-building and demonstration projects for adopting alternatives to HFCs. Additionally, in 2022, R-141b was banned, meaning it is no longer imported or assigned a quota. This ban contributes to the steady decrease in the total amount of refrigerants being imported. Furthermore, there is a scheduled phase-out for R-22, set to continue until 2040.

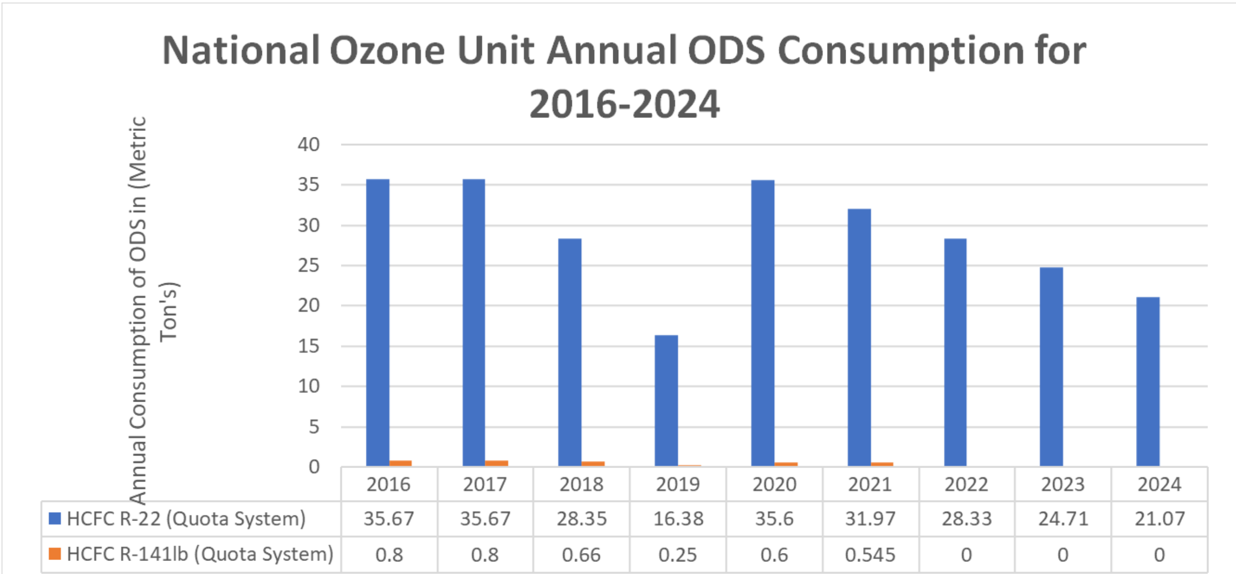


Figure 4-5 Annual ozone depleting substances (ODS) Consumption of HCFC (Quota System) for 2016-2024

Table 4-13 Annual ozone depleting substances (ODS) Phase-Out Schedule and consumption 2020-2040

	67.5 % Phase out schedule					100% Phase out Schedule					Tail consumption
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2040
	Metric Tonnes										
R-22	32.2978	29.003	25.7082	22.41346	19.119	15.8239	13.5291	11.2343	8.93956	6.6448	1.27
R-141b	0.6	0.545	0	0	0	0	0	0	0	0	0

In Figure 4-5 Annual ozone depleting substances (ODS) Consumption of HCFC (Quota System) for 2016-2024 , the diagram demonstrates the annual ODS consumption of HCFC (Quota System) from 2020-2040. There was a drastic decrease in importation of HCFCs for the year 2019, due to the importation Quota which is reduced every year as a method to phase out the ozone depleting substances and should be phased out by 2040.

4.6.2 Methodological issues of the category

4.6.2.1 Activity data of the category

Since 2010, Belize has implemented the Hydrochlorofluorocarbons (HCFC) Phase-out Management Plan (HPMP) alongside an HCFC Quota System. As part of Stage I of the HPMP, Belize is committed to phasing out 67.5% of HCFCs by 2025 in the refrigeration and air conditioning (RAC) servicing sector. To date, the country has successfully achieved its 2020 target of a 35% reduction in HCFC consumption, measured against a baseline of 2.80 ODP tonnes (50.9 metric tonnes), and is on track to meet the 2025 target.

In light of the anticipated increase in the use of Hydrofluorocarbons (HFCs) and related technologies, Belize has proactively taken steps to address HFC emissions. The country has received approval to initiate activities to facilitate ratification of the Kigali Amendment to the Montreal Protocol, which includes revising its licensing system and implementing capacity-building and demonstration projects for adopting alternatives to HFCs.

Additionally, in 2022, R-141b was banned, meaning it is no longer imported or assigned a quota. This ban contributes to the steady decrease in the total amount of refrigerants being imported. Furthermore, there is a scheduled phase-out for R-22, set to continue until 2040.

Table 4-14 2.F Product Uses as Substitutes for ODS: activity data by refrigerant imported (tonnes)

Activity Source	Refrigerant Imported	Year													
		1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.F.1. Refrigeration and air conditioning	HCFC-22	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	16.38	6.80	9.38	11.12
	HCFC-141b	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.25	0.31	0.03	0
	HFC-134a	NE	NE	NE	NE	NE	NE	17.90	24.38	NE	NE	71.92	27.95	691.85	33.86
	HFC-404A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	8.97	4.65	4.66	3.918
	HFC-407C	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	5.28	0.56	0.587
	HFC-410A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	33.49	13.42	61.42	27.22
	HFC-422B	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.02273	0	0
	HFC-507A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.23	1.594	0.26	0
	HC-600a	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.03	NE	NE	NE
	HC-290	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.76	NE	NE	NE

Note: Only HFC-134a included in emission calculation
Source: Department of Environment

HFC-134a is the refrigerant with the most activity data, more than likely because of its use in many common applications relevant to Belize. It is the only refrigerant included in emission calculation. While Belize has many other HFCs included in the list above, emission factors are not yet identified as they are also newer in the market.

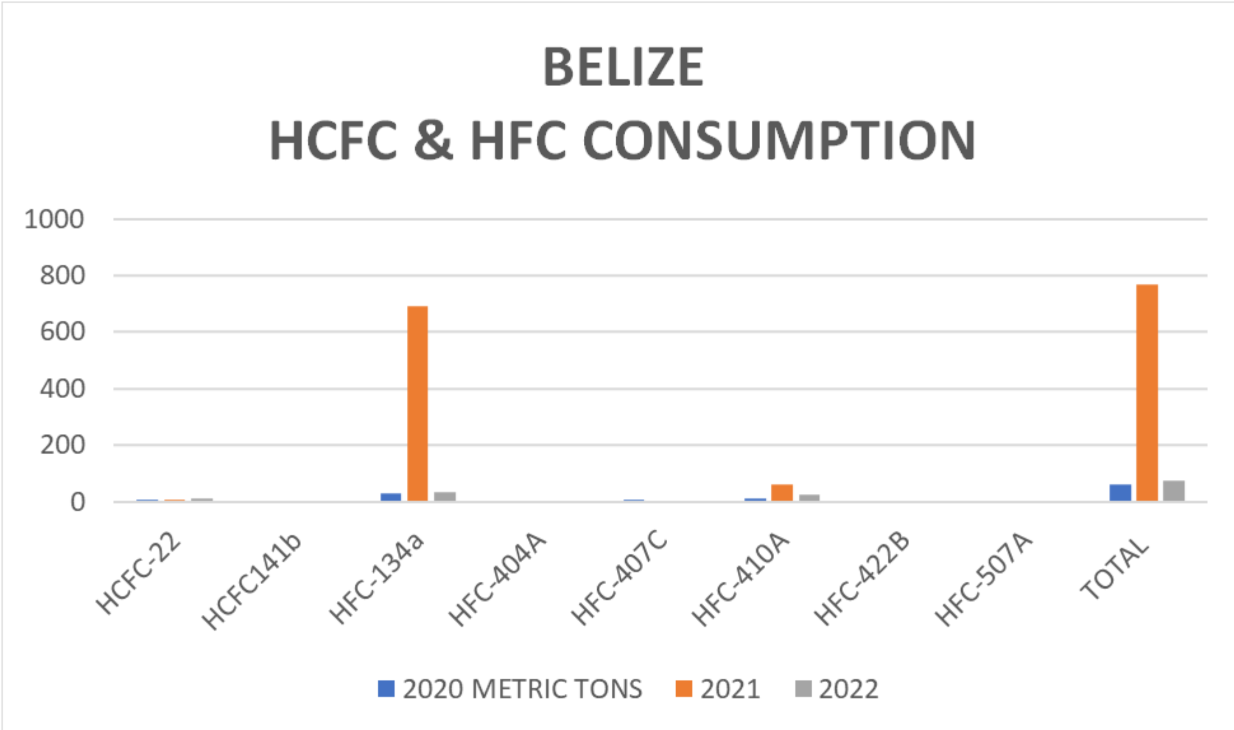


Figure 4-6 Annual consumption of ODS alternatives with open license for the year 2020 - 2022

4.6.2.2 Emission factors applied in the category

A Tier 1 a/b approach was used following the 2006 IPCC Guidelines which includes the default factors in Table 4-33. Belize uses HFC-134a for its emission calculations and this gas was first introduced in 1993. Tier 1 a/b uses a back-count method from the current year to the introduction year. It is assumed that the total new agents to domestic market are all from imports, with 0 exports and production. It is also assumed that the growth rate of new equipment is 1%. Any banks included in the emission calculation was done within the IPCC software using imports data and defaults below.

Table 4-15 2.F Product Uses as Substitutes for ODS: emission factors applied by refrigerant gas

Activity Source	Gas	Emission Factor from installed base (%)	Assumed Equipment Lifetime (years)	% of Refrigerant destroyed at End-of-Life	Growth Rate (%)
2.F.1. Refrigeration and air conditioning	HFC-134a	15	15	0	1

Note: Only HFC-134a included in emission calculation
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3 Chapter 7 Emission of fluorinated substitutes for ozone depleting substances, pg. 7.13 and 2006 IPCC Inventory Software

4.6.3 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.6.4 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.6.5 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.6.6 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

4.6.7 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.6.8 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.6.9 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.6.10 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

4.7 Other (Food and Beverages Industry) (CRT 2.H)

4.7.1 Description and trend of GHGs in the subcategory

The Food and Beverages Industry category, as defined by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, refers to the emissions of greenhouse gases (GHGs) associated with the production, processing, and preservation of food and beverages. In Belize, this category includes alcohol and beer production, along with some emissions from wheat.

In 2022, emissions from the Food and Beverage Industry subcategory, totaled 0.6327 kt CO_2 eq. Emission data starts in 2003 with 0.1825 kt CO_2 eq, has since fluctuated with the highest emission at 1.55 kt CO_2 eq in 2017.

Table 4-16 total GHG emissions for Other: Food and Beverage Industry (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.H.	Other (please specify)	NE	NE	NE	0.1825	0.97846	0.90495	1.09	1.53	1.55	0.00177	1.36	0.38265	0.51358	0.63266
2.H.2.	Food and Beverage Industry	NE	NE	NE	0.1825	0.97846	0.90495	1.09	1.53	1.55	0.00177	1.36	0.38265	0.51358	0.63266

4.7.2 Methodological issues of the subcategory

4.7.2.1 Activity data of the subcategory

Table 4-17 2H2 Food and beverages industry: activity data from Durum Wheat Imports, Alcohol and Beer Production

Activity Source	Activity Type	Year													
		1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
2.H.2. Food and beverages industry	Durum Wheat Imported (Gg)	NE	NE	NE	8.57	9.15	8.30	12.58	17.57	17.66	17.76	15.59	NE	NE	NE
	Alcohol Production (hl)	NE	NE	NE	500.00	500.00	500.00	NE	NE	970.82	1176.48	128.12	761.26	1035.16	1049.16
	Beer Production (hl)	NE	NE	NE	50,000.00	50,000.00	50,000.00	NE	NE	1.53	1.61	180.23	106065.27	142300.36	176264.20

Source: Statistics of Belize, Belize Customs Department

4.7.2.2 Emission factors applied in the subcategory

Alcoholic Beverages, CO2 and NMVOCs are produced during the processing of fermentation. The activity rate is the total annual production. The emission factor used for spirits (unspecified) is 15, given the limitation of emission factors published in the guidelines which did not provide none for spirits made from sugar cane a high emission factor is used with a high degree of uncertainty affecting emissions reported (2006 IPCC Guidelines for National Greenhouse Gas Inventories).

Table 4-18 2H2 Food and beverages industry: emission factors applied by activity source

Activity Source	Activity Type	Unit	CO2 EF
2.H.2. Food and beverages industry	Durum Wheat Imported (Bread)	Gg	0.087
	Alcohol Production (Gg/hl)	Gg/hL	0.00002
	Beer Production (Gg/hl)	Gg/hL	0.0000035

Note: Converted from kg/tonne and kg/hl to match software units
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual pg.2.42 (Table 2-24, 2-25)

4.7.3 Uncertainty and time-series consistency of the subcategory

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

4.7.4 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.7.5 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.7.6 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

4.7.7 Description of any flexibility applied to the subcategory

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

4.7.8 Subcategory QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

4.7.9 Subcategory recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

4.7.10 Planned improvements for the subcategory

Refer to the planned improvements by sector in the national inventory improvement plan.

5 Chapter 5 AGRICULTURE (CRT 3)

5.1 Description of the sector

Belize's agriculture sector is a cornerstone of its economy, contributing significantly to GDP and employment. Agriculture is vital to Belize's development, playing a key role in food self-sufficiency, employment, and as a major source of exports and foreign exchange earnings. The Agriculture sector accounts to 14 percent of the country's GDP, employs 17 percent of the labour force, and is the second most important source of the country's foreign exchange. This sector, including livestock and fisheries, is key in providing the base for enhanced economic growth of the country, especially in rural areas, whilst contributing to poverty alleviation (Food and Agriculture Organization of the United Nations, n.d.)

The agriculture sector also employs approximately 12,000 farmers. It comprises large-scale commercial production for both domestic and international consumption and traditional small-scale production for local consumption. Agricultural land (croplands and pastures) occupies 7.5% of Belize's land area, with approximately 38,800 hectares planted with sugarcane, 19,400 hectares with citrus, and 19,600 hectares with corn. Additionally, 142,000 hectares of pastures are grazed by approximately 135,400 head of cattle. Seventy-four percent of farms in Belize are less than 20 hectares in size, with farming heavily concentrated in the Toledo, Orange Walk, and Corozal districts (Ministry of Agriculture, Belize, 2023).

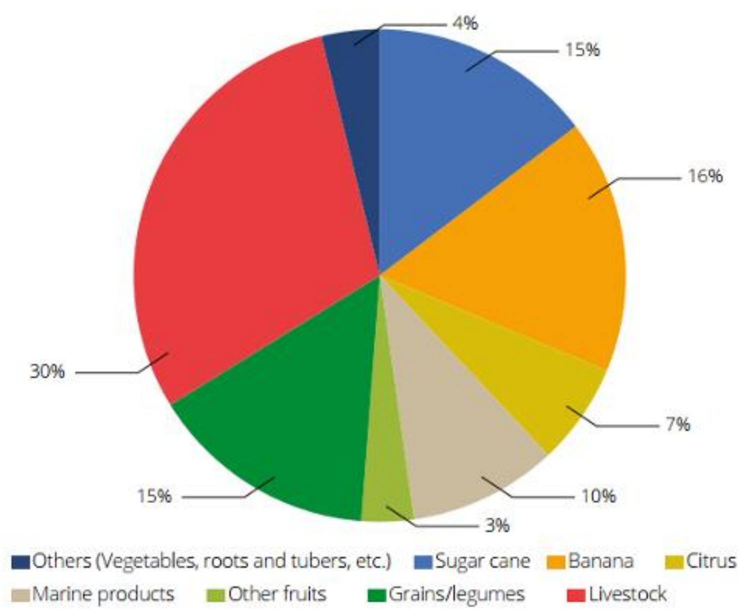


Figure 5-1 - Belize Agricultural Production (FAO, EU and CIRAD, 2022)

5.2 Trend in the sector's GHG

In the latest inventory year of 2022, the agriculture sector's total greenhouse gas (GHG) emissions amounted to 335.93 kt CO2 eq (see Table 5-1). This sector contributes 12% to the national total emissions for 2022. Over time, from 1994 to 2022, the agriculture sector's emissions have increased significantly rising from 123.15 kt CO2 eq to 335.93 kt CO2 eq, almost doubling in 28 years (see Table 5-2 and Figure 5-3).

The key drivers of these emissions in 2022 were primarily enteric fermentation, which was the largest contributor at 287.74 kt CO2 eq, followed by manure management at 16.26 kt CO2 eq, and agricultural soils at 19.19 kt CO2 eq. Enteric fermentation accounted for 85.65% of the sector's emissions, manure management for 4.84%, agricultural soils for 5.71%, rice cultivation for 2.32%, and urea application for 1.44%, with liming contributing a minimal 0.04% (see Figure 5-2below).

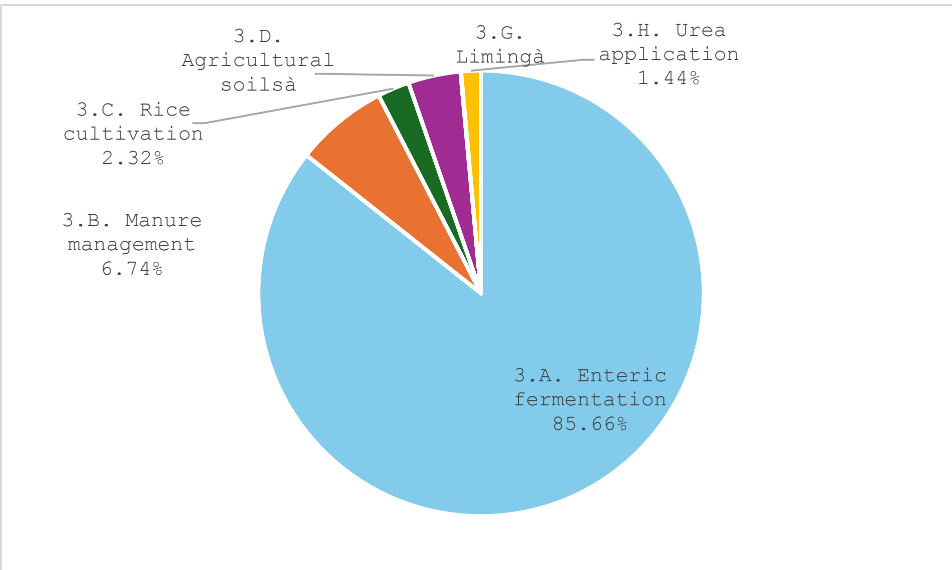


Figure 5-2 Contributions of Agriculture emissions in 2022 (%)

Throughout the years, there have been significant interannual variations and fluctuations, particularly in enteric fermentation, with notable increases in 2006, 2009, and 2017. Manure management also showed fluctuations in 2009 and 2012, while agricultural soils saw significant increases in 2012 and 2017. These variations are primarily driven by changes in livestock populations, agricultural practices, and management techniques over the years.

Table 5-1 Agriculture sector: emissions by GHG, category and subcategory (kt) for 2022

Code	GHG source categories	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	NO_x (kt)	CO (kt)	NMVOC (kt)	SO_X (kt)	Total GHG (kt CO_2 eq)
3	**Agriculture**	**4.947418667**	**310.209725**	**20.76816578**					**335.9253095**
3.A.	Enteric fermentation		287.739774						**287.739774**
3.A.1.	Cattle		281.02368						281.02368
3.A.1.a.	Dairy cattle		4.447296						4.447296
3.A.1.b.	Non-dairy cattle		276.576384						276.576384
3.A.2.	Sheep		2.4549						2.4549
3.A.3.	Swine		0.95529						0.95529
3.A.4.	Other livestock								
3.A.4.a.	Buffalo		NE						
3.A.4.b.	Camels		NO						
3.A.4.c.	Deer		NO						
3.A.4.d.	Goats		0.17556						0.17556
3.A.4.e.	Horses		3.130344						3.130344
3.A.4.f.	Mules and asses		NE						
3.A.4.g.	Poultry		NO						
3.A.4.h.	Other								
3.B.	Manure management		14.68163396	7.970506958					**22.65214092**
3.B.1.	Cattle		5.0624						5.0624
3.B.1.a.	Dairy cattle		0.123536						0.123536
3.B.1.b.	Non-dairy cattle		4.938864						4.938864
3.B.2.	Sheep		0.098196						0.098196
3.B.3.	Swine		1.27372						1.27372
3.B.4.	Other livestock								
3.B.4.a.	Buffalo		NE						
3.B.4.b.	Camels								
3.B.4.c.	Deer								
3.B.4.d.	Goats		0.00772464						0.00772464
3.B.4.e.	Horses		0.38085852						0.38085852
3.B.4.f.	Mules and asses		NE	NE					NE
3.B.4.g.	Poultry		7.8587348	1.57417986					9.43291466
3.B.4.h.	Other		NO						NO
3.B.5.	Indirect N_2O			6.396327098					6.396327098
3.C.	Rice cultivation		7.788317046						7.788317046
3.C.1.	Irrigated								0
3.C.2.	Rain-fed								0

3.C.3.	Deep water								0
3.C.4.	Other (please specify)								0
3.D.	Agricultural soils			12.79765882					**12.79765882**
3.D.1.	Direct N_2O emissions from agricultural soils			8.980813208					8.980813208
3.D.1.a.	Inorganic fertilizers								0
3.D.1.b.	Organic fertilizers								0
3.D.1.c.	Urine and dung deposited by grazing animals								0
3.D.1.d.	Crop residues								0
3.D.1.e.	Mineralization associated with soil organic matter								0
3.D.1.f.	Cultivation of organic soils (histosols)								0
3.D.1.g.	Other (please specify)								0
3.D.2.	Indirect N_2O emissions from agricultural soils			3.816845613					3.816845613
3.D.2.a.	Atmospheric deposition								0
3.D.2.b.	Leaching and run-off								0
3.E.	Prescribed burning of savannahs		NE						**0**
3.F.	Field burning of agricultural residues		NE						**0**
3.F.1.	Wheat								0
3.F.2.	Pulses								0
3.F.3.	Tubers and roots								0
3.F.4.	Sugar cane								0
3.F.3.	Other (please specify)								0
3.G.	Liming	0.12452							**0.12452**
3.G.1.	Limestone								0
3.G.2.	Dolomite								0
3.H.	Urea application	4.822898667							**4.822898667**
3.I.	Other carbon-containing fertilizers	NO							NO
3.J.	Other (please specify)	NO							NO

Note: Use the following notation keys where numerical data are not available: NA = not applicable; NE = not estimated; NO = not occurring; IE = included elsewhere; C = confidential.

Table 5-2 Agriculture sector: total GHG emissions by category (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.A.	Enteric fermentation	91.52	63.85	88.58	96.48	126.17	156.40	162.97	171.24	216.86	254.64	274.82	274.82	270.88	287.74
3.B.	Manure management	10.80	3.62	11.23	4.52	6.05	6.88	17.84	19.85	28.34	13.46	14.76	14.76	20.02	22.65
3.C.	Rice cultivation	1.20	3.10	3.01	6.76	5.19	8.54	5.20	5.57	7.39	5.86	8.29	8.29	7.00	7.79
3.D.	Agricultural soils	7.71	1.99	6.98	2.22	2.69	3.00	10.75	12.17	20.55	1.72	11.31	11.31	11.97	12.80
3.G.	Liming	2.55	3.67	4.39	5.31	4.90	4.25	0.94	1.02	0.12	1.36	0.12	0.12	0.12	0.12
3.H.	Urea application	9.37	1.40	1.26	15.18	2.10	4.30	4.47	12.92	0.46	0.02	0.10	0.10	0.46	4.82
3	**Total Agriculture**	**123.15**	**77.64**	**115.47**	**130.46**	**147.10**	**183.36**	**202.16**	**222.76**	**273.72**	**277.06**	**309.40**	**309.40**	**310.46**	**335.93**

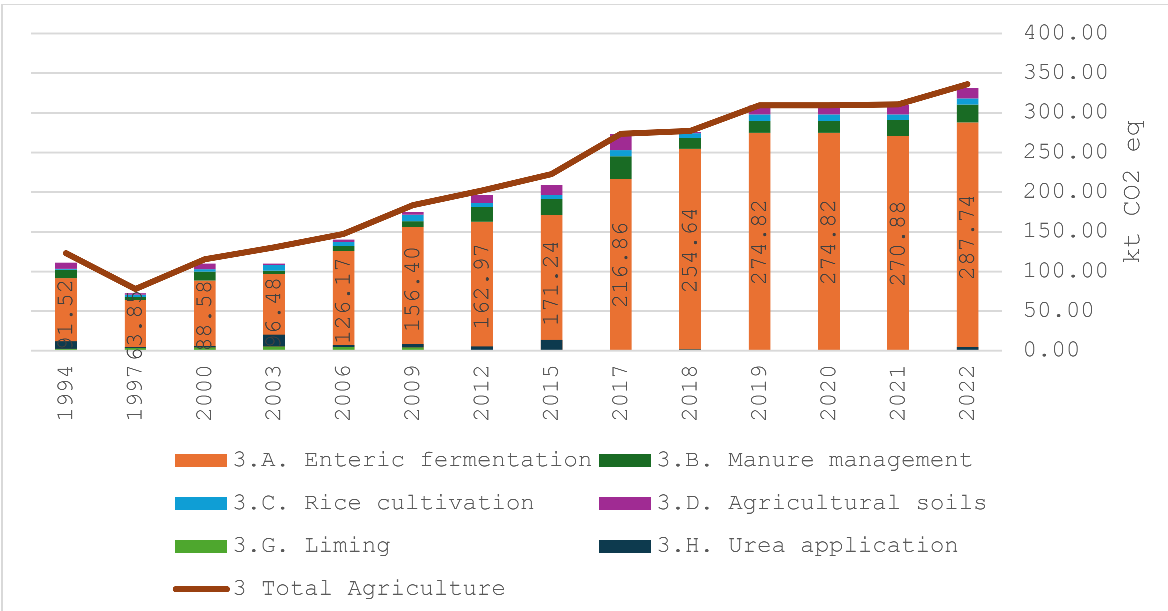


Figure 5-3 Agriculture sector: total GHG emissions by category or subcategory (kt CO2 eq), 1994-2022

In terms of emissions by gas (table 5-3) in agriculture sector, the emissions are primarily methane (CH4), accounting for 92.34% of agriculture sector emissions. These are driven by a steadily growing livestock sector, for both domestic and exportation. These methane emissions result from enteric fermentation in livestock and manure management practices.

In smaller quantities were N2O emissions (6.19%) characterized by soil management practices and fertilizer application; and CO2 emissions (1.47%) driven by urea application on soils, and liming for soil enrichment., for CH4 were 310.21 kt CO2 eq., and for N2O were 20.77 kt CO2 eq. CO2 emissions in 2022 were primarily driven by factors such as fuel combustion and land-use changes, contributing 1.47% to the total emissions.

Table 5-1. Agriculture sector: emissions by GHG (kt CO_2 eq)

Table 5-3 Agriculture sector: emissions by GHG (kt CO2 eq)

GHG	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
CO_2	11.92	5.08	5.65	20.49	6.99	8.54	5.41	13.93	0.58	1.38	0.23	0.23	0.58	4.95
CH_4	99.26	70.10	98.02	107.00	135.94	170.24	178.40	188.09	239.84	273.83	296.50	296.50	290.46	310.21
N_2O	11.98	2.47	11.79	2.98	4.16	4.57	18.35	20.74	33.30	1.84	12.67	12.67	19.41	20.77
Total	**123.15**	**77.64**	**115.47**	**130.46**	**147.10**	**183.36**	**202.16**	**222.76**	**273.72**	**277.06**	**309.40**	**309.40**	**310.46**	**335.93**

5.3 General methodological issues of the sector

5.3.1 Activity Data and GHG Emission Estimates

The table below presents the methods and emission factors used for the Agriculture sector. This inventory uses Tier 1 methods with default values for the agriculture emissions. Belize has not yet produced country specific information for most of the categories.

Table 5-4 Activity Data sources and Methodologies for the Agriculture sector

Source Category	Activity Source	Data Type	Data Source	CO_2		CH_4		N_2O	
3 AGRICULTURE				MT	EF	MT	EF	MT	EF
3AEnteric fermentation	3.A.1. Cattle	Annual average heads of livestock	National Census			T1	D	T1	D
	3.A.2. Sheep					T1	D	T1	D
	3.A.3. Swine								
	3.A.4. Other livestock								
3BManure management	3.B.1. Cattle	Manure Management System (MMS) and % Livestock handled with MMS	Ministry of Agriculture			T1	D	T1	D
	3.B.2. Sheep					T1	D	T1	D
	3.B.3. Swine					T1	D	T1	D
	3.B.4. Other livestock					T1	D	T1	D
3.C.Rice cultivation	3.C.1. Irrigated	Annual harvested	Ministry of Agriculture			T1	D	T1	D
	3.C.2. Rain-fed					T1	D	T1	D
	3.C.4. Other (Milpa)					T1	D	T1	D
3.D. Agricultural soils								T1	D
3.G. Liming	3.G.1. Limestone CaCO3	Annual limestone consumption	Ministry of Agriculture	T1	D			T1	D
	3.G.2. Dolomite CaMg(CO3)2	Annual dolomite consumption		T1	D				
3.H. Urea application			Ministry of Agriculture	T1	D	T1	D	T1	D

5.4 Enteric fermentation (CRT 3.A)

5.4.1 Description and trend of GHGs in the category

Enteric fermentation is a digestive process in herbivores that releases CH4 as a by-product. In ruminant livestock, enteric fermentation occurs more extensively in their digestive system, releasing more CH4. For poultry, there are no emissions inventory methods in the 2006 IPCC Guidelines.

In the context of Belize, enteric fermentation emissions are primarily driven by cattle, with dairy and non-dairy cattle being the main contributors. Other livestock such as sheep, swine, and horses also contribute to enteric fermentation emissions but to a lesser extent.

In the latest inventory year (2022), enteric fermentation emissions were recorded at 287.74 kt CO2 eq (Table 5-5). This category contributed significantly to the sector's total emissions, accounting for approximately 85.65% agriculture sector emissions.

Table 5-5Agriculture total GHG emissions by animal subcategory 1994 – 2022 (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.A.	Enteric fermentation	91.52	63.85	88.58	96.48	126.17	156.40	162.97	171.24	216.86	254.64	274.82	274.82	270.88	287.74
3.A.1.	Cattle	83.91	58.85	83.29	92.22	121.59	150.71	156.49	164.20	209.99	248.95	269.06	269.06	264.56	281.02
3.A.1.a.	Dairy cattle	3.79	5.12	4.76	7.16	15.58	7.82	7.82	7.40	12.22	3.80	4.59	4.59	4.45	4.45
3.A.1.b.	Non-dairy cattle	80.12	53.73	78.54	85.06	106.01	142.89	148.67	156.80	197.77	245.14	264.47	264.47	260.12	276.58
3.A.2.	Sheep	0.38	0.35	0.42	0.88	1.09	1.82	2.03	2.13	1.60	1.64	1.86	1.86	2.43	2.45
3.A.3.	Swine	0.68	0.65	0.50	0.59	0.41	0.48	0.64	0.73	0.91	0.80	0.63	0.63	0.61	0.96
3.A.4.	Other livestock	*6.55*	*3.99*	*4.37*	*2.79*	*3.09*	*3.40*	*3.81*	*4.18*	*4.35*	*3.25*	*3.27*	*3.27*	*3.28*	*3.31*
3.A.4.a.	Buffalo	3.03	0.23	0.35	0.09	0.12	0.14	0.37	0.59	0.74	0.00	0.00	0.00	0.00	0.00
3.A.4.d.	Goats	0.00	0.02	0.02	0.09	0.10	0.11	0.11	0.11	0.03	0.26	0.20	0.20	0.18	0.18
3.A.4.e.	Horses	2.28	2.51	2.76	2.47	2.72	2.99	3.14	3.26	3.33	2.99	3.08	3.08	3.10	3.13
3.A.4.f.	Mules and asses	1.23	1.23	1.23	0.14	0.15	0.17	0.19	0.22	0.25	0.00	0.00	0.00	0.00	0.00
3.A.4.g.	Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.4.2 Methodological issues of the category

5.4.2.1 Activity data of the category

Table 5-6 3A Enteric Fermentation: activity data by annual average population of different livestock

Activity Source	Livestock	Year													
		1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
3.A.1 Cattle	Dairy Cattle	1882	2539	2360	3550	7728	3877	3877	3670	6060	1886	1988	2275	2205	2206
	Other Cattle (Beef)	51097	34269	50087	54250	67611	91129	94817	100000	126129	156342	166603	168670	165891	176388
3.A.2 Sheep	Sheep	2688	2525	3000	6265	7770	13018	14500	15200	11434	11696	11834	13293	17323	17535
3.A.3 Swine	Swine	24224	23248	18000	21224	14533	17038	22800	25992	32674	28706	29361	22346	21654	22745
3.A.4 Other Livestock	Buffalo	1970	150	230	60	75	89	239	383	479	NE	NE	NE	NE	NE
	Goats	32	130	140	620	720	750	820	780	244	1823	2179	1421	1294	1254
	Horses	4527	4980	5478	4902	5392	5931	6227	6476	6605	5942	6042	6103	6157	6211
	Mules and asses	4400	4400	4400	490	540	595	684	786	903	NE	NE	NE	NE	NE
	Poultry	5516766	478926	6275322	869857	1855606	1984358	9960934	11221957	16726274	12932381	12201814	12201814	13092275	14033455

5.4.2.2 Emission factors applied in the category

Table 5-7 3A Enteric Fermentation: emission factors applied by GHG source

Activity Source	Livestock	Emission Factor [kg CH4/(head yr)] (T)
3.A.1 Cattle	Dairy Cattle	72
	Other Cattle (Beef)	56
3.A.2 Sheep	Sheep	5
3.A.3 Swine	Swine	1
3.A.4 Other Livestock	Buffalo	55
	Goats	5
	Horses	18
	Mules and asses	10
	Poultry	0

5.4.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.4.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.4.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.4.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.4.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

5.5 Manure management (CRT 3.B)

5.5.1 Description and trend of GHGs in the category

CH4 and N2O emissions result from the management of livestock manure in different manure management systems.
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 such as Springfield and Barton Creek where the Mennonite farmers produce vegetables. However, poultry manure cannot be applied immediately to plants due to its high Nitrogen content that “burns” the plant. Poultry manure needs to be aged or composted before use.

In the context of Belize, manure management emissions, the second largest contributor to the agriculture sector after enteric fermentation, are primarily driven by cattle, with dairy and non-dairy cattle being the main contributors. Other livestock such as sheep, swine, and horses also contribute to manure management emissions but to a lesser extent (Table 5-8).

Table 5-8 3.B Manure Management: total GHG emissions by animal subcategory 1994 – 2022 (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.B.	Manure management	7.36	3.22	7.37	3.89	4.86	5.60	11.73	12.97	18.11	13.33	14.76	14.76	14.05	16.26
3.B.1.	Cattle	1.54	1.10	1.53	1.72	2.33	2.77	2.87	3.01	3.87	4.48	4.85	4.85	4.77	5.06
3.B.1.a.	Dairy cattle	0.11	0.14	0.13	0.20	0.43	0.22	0.22	0.21	0.34	0.11	0.13	0.13	0.12	0.12
3.B.1.b.	Non-dairy cattle	1.43	0.96	1.40	1.52	1.89	2.55	2.65	2.80	3.53	4.38	4.72	4.72	4.64	4.94
3.B.2.	Sheep	0.02	0.01	0.02	0.04	0.04	0.07	0.08	0.09	0.06	0.00	0.07	0.07	0.10	0.10
3.B.3.	Swine	1.36	1.30	1.01	1.19	0.81	0.95	1.28	1.46	1.83	1.61	1.25	1.25	0.00	1.27
3.B.4.	Other livestock	*4.46*	*0.80*	*4.81*	*0.95*	*1.68*	*1.80*	*7.50*	*8.42*	*12.35*	*7.24*	*8.58*	*8.58*	*9.19*	*9.82*
3.B.4.a.	Buffalo	0.11	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00
3.B.4.d.	Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
3.B.4.e.	Horses	0.28	0.31	0.34	0.30	0.33	0.36	0.38	0.40	0.41	0.00	0.37	0.37	0.38	0.38
3.B.4.f.	Mules and asses	0.15	0.15	0.00	0.02	0.02	0.02	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00
3.B.4.g.	Poultry	3.92	0.34	4.46	0.62	1.32	1.41	7.08	7.97	11.88	7.24	8.20	8.20	8.80	9.43
3.B.4.h.	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.5.2 Methodological issues of the category

5.5.2.1 Activity data of the category

Activity data for this category is the same livestock population data as used in Category 3A Enteric Fermentation (Table 5-6).

5.5.2.2 Emission factors applied in the category

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.

Table 5-9 3B Manure Management: activity data and emission factors for MMS in Livestock

Activity Source	Livestock	Manure Management System (MMS)	% Livestock handled with MMS	Emission Factor [kg CH_4/(head yr)] (T)	Emission Factor for direct N_2O-N emissions from MMS (kg N_2O-N/ kg N in MMS)	
3.A.1 Cattle	Dairy Cattle	Pasture/Range/Paddock	100	2	NA	
	Other Cattle (Beef)	Pasture/Range/Paddock	100	1	NA	
3.A.2 Sheep	Sheep	Pasture/Range/Paddock	100	0.2	NA	
3.A.3 Swine	Swine	Daily Spread	100	2	0.02	
3.A.4 Other Livestock	Buffalo	Pasture/Range/Paddock	100	2	NA	
	Goats	Pasture/Range/Paddock	100	0.22	NA	
	Horses	Pasture/Range/Paddock	100	2.19	NA	
	Mules and asses	Pasture/Range/Paddock	100	1.2	NA	
	Poultry	Poultry manure with litter	100	0.02	0.001	

5.5.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.5.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.5.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.5.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.5.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

5.6 Rice cultivation (CRT 3.C)

5.6.1 Description and trend of GHGs in the category

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.

In the latest inventory year (2022), rice cultivation emissions were recorded at 7.79 kt CO2 eq (see Table 5-10). This category contributed approximately 2.32% to the sector's total emissions. The key drivers of rice cultivation emissions in the latest inventory year include irrigated rice, which makes up the majority of hectares of rice cultivated in Belize (see activity data Table 5-11).
From 1994 to the latest inventory year (2022), rice cultivation emissions increased slowly but steadily.

Table 5-10 3.C Rice cultivation total GHG emissions by subcategory (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.C.	Rice cultivation	1.20425	3.10295	3.01396	6.76373	5.1896	8.53944	5.19792	5.5692	7.38847	5.86294	8.28643	8.28643	7.00384	7.78832

5.6.2 Methodological issues of the category

5.6.2.1 Activity data of the category

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 5-11 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.

Table 5-11 3C Rice cultivation: activity data by annual harvested (ha)

Activity Source	Year													
	1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
3.C.1 Irrigated	NE	NE	3624	NE	NE	4600	2800	3000	3980	2294.73	2099.08	2628.37	2187.2	2450.15
3.C.2 Rainfed	1448	3731	NE	4533	2912	NE	NE	NE	NE	375.18	202.34	178.06	273.16	239.58
3.C.4 Upland (Milpa in Belize)	NE	NE	NE	NE	NE	NE	NE	NE	NE	48.16	114.14	273.16	182.93	215.35

Source: Ministry of Agriculture

5.6.2.2 Emission factors applied in the category

Table 5-12 3C Rice cultivation: emission factors applied by GHG source

Activity Source	Annual CH_4 emissions from Rice Cultivation (Gg CH_4/yr)
3.C.1 Irrigated	0.27074
3.C.2 Rainfed	0.00741
3.C.4 Upland (Milpa in Belize)	0

5.6.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.6.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.6.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.6.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.6.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

5.7 Agricultural soils (CRT 3.D)

5.7.1 Description and trend of GHGs in the category

Emissions from agricultural soils primarily arise from the application of synthetic and organic fertilizers, crop residues, and the cultivation of nitrogen-fixing crops, which lead to the release of nitrous oxide (N2O). Direct N2O emissions occur with N additions to agricultural soils. Nitrification oxidizes ammonium to nitrate, and denitrification reduces nitrate to nitrogen gas, releasing N2O as one of the intermediates during denitrification.
Indirect N2O emissions result when N added to the soils also undergo volatilization, leaching and runoff.

In Belize, agricultural soils contribute a small degree to the country's overall GHG emissions profile, with both direct and indirect N2O emissions being relevant subcategories. In the latest inventory year (2022), emissions from agricultural soils were recorded at 12.80 kt CO2 eq. This category contributed approximately 3.81% to the agriculture sector's total emissions. The key drivers of emissions from agricultural soils in the latest inventory year include the quantity of fertilizers applied. In general, more data on synthetic fertilizers, their composition, and exact quantities applied to soils each year is required.

Table 5-13 3.D. Agricultural soils total GHG emissions by subcategory (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.D.	Agricultural soils	7.71384	1.99184	6.9842	2.21717	2.69407	2.99508	10.7457	12.166208	20.5536	1.71598	11.306	11.306	11.9696	12.7977
3.D.1.	Direct N2O emissions from agricultural soils	5.41322	1.62599	5.70139	1.80993	2.19924	2.44496	8.7687	9.9315982	14.4334	1.4008	7.93404	7.93404	8.3997	8.98081
3.D.2.	Indirect N2O emissions from agricultural soils	2.30062	0.36585	1.28281	0.40723	0.49483	0.55012	1.97695	2.2346096	6.12019	0.31518	3.37197	3.37197	3.56987	3.81685

5.7.2 Methodological issues of the category

5.7.2.1 Activity data of the category

Direct and indirect N2O emissions from managed soils were estimated using Tier 1 methodology.

Agriculture data report their production volumes annually. The application quantities in kg of inorganic nitrogen fertilizers, including urea are available (activity data for Urea in section 5.10.2). the actual N content of each synthetic fertilizer used in country is not clear, so this data was not included and remains an ongoing area of improvement.

5.7.2.2 Emission factors applied in the category

Table 5-14 Emission factors for direct N2O emissions from synthetic fertilizer and urine and dung on grazed soils

Anthropogenic N input type	**Emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals *[kg N_2O-N (kg N input)-1]***	**Emission factor for N_2O emissions from N inputs *[kg N_2O-N (kg N input)-1]***
Cattle, Poultry and Pigs, and Sheep	0.02	-
Sheep and Other Animals	0.01	-
Synthetic Fertilizers	0.01	0.01
Source	IPCC 2006 GL, Vol 4, Chapt 11, Table 11.1	

Table 5-15 Emission factors for indirect N2O emissions on managed soils

Fraction of all N additions to managed soils that is lost through leaching and runoff	**Emission factor for N_2O emission from N leaching and runoff**	**Fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing**	**Emission factor for N_2O emission from atmospheric deposition of N on soils and water surfaces**

		animals (F_{PRP}) that volatilizes	
[kg N (kg of N additions)$^{-1}$]	[kg N_2O-N (kg N leaching and runoff)$^{-1}$]	(kg NH_3-N + NO_x-N) (kg of N applied or deposited)$^{-1}$	(kg N_2O-N) (kg NH_3-N + NO_x-N volatilized)$^{-1}$
$Frac_{LEACH-(H)}$	**EF**	**$Frac_{GASM}$**	**EF**
0.3	0.0075	0.2	0.01
Source	IPCC 2006 GL, Vol 4, Chapt 11, Table 11.3		

Table 5-16 Emission factors for indirect N2O emissions on managed soils

Fraction of all N additions to managed soils that is lost through leaching and runoff	**Emission factor for N_2O emission from N leaching and runoff**	**Fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilizes**	**Emission factor for N_2O emission from atmospheric deposition of N on soils and water surfaces**
[kg N (kg of N additions)$^{-1}$]	[kg N_2O-N (kg N leaching and runoff)$^{-1}$]	(kg NH_3-N + NO_x-N) (kg of N applied or deposited)$^{-1}$	(kg N_2O-N) (kg NH_3-N + NO_x-N volatilized)$^{-1}$
$Frac_{LEACH-(H)}$	**EF**	**$Frac_{GASM}$**	**EF**
0.3	0.0075	0.2	0.01
Source	IPCC 2006 GL, Vol 4, Chapt 11, Table 11.3		

5.7.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.7.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.7.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.7.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.7.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

5.8 Liming (CRT 3.G)

5.8.1 Description and trend of GHGs in the category

Liming is a subcategory within the agriculture sector that involves the application of lime (calcium carbonate or calcium magnesium carbonate) to soils to reduce acidity and improve soil health. According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, liming results in the release of carbon dioxide (CO2) as the lime reacts with soil acids. In Belize, liming is practiced to enhance soil fertility and crop productivity

In the latest inventory year (2022), emissions from liming were recorded at 0.12 kt CO2 eq. This category contributed approximately 0.04% to the sector's total emissions.

The percentage contribution of liming to the sector's total emissions has varied over time. In 1994, liming emissions were 2.55 kt CO2 eq., contributing about 2.07% to the total agricultural emissions (see Table 5-17). By 2022, the emissions had decreased to 0.12 kt CO2 eq., reflecting a significant reduction in the contribution percentage to 0.04%. This decrease in emissions is linked to the production of lime in the country for both agricultural and some industrial uses. More information is required to understand the exact quantities applied to soil versus other small scale industrial purposes.

Table 5-17 3.G Liming: total GHG emissions by subcategory (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
3.G.	Liming	2.55	3.67	4.39	5.31	4.90	4.25	0.94	1.02	0.12	1.36	0.12	0.12	0.12	0.12
3	Total Agriculture	123.15	77.64	115.47	130.46	147.10	183.36	202.16	222.76	273.72	277.06	309.40	309.40	310.46	335.93

5.8.2 Methodological issues of the category

5.8.2.1 Activity data of the category

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.

Table 5-18 3G Liming: activity data by GHG source (tonnes/yr)

Activity Source	Year													
	1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
3.G.1. Limestone CaCO3	372.00	3371.00	5224.00	5224.00	5224.00	5224.00	143.00	211.00	154.00	333.21	540.75	282.88	282.88	282.88
3.G.2. Dolomite CaMg(CO3)2	5000.00	4592.00	4383.00	6319.00	5448.00	4086.00	1841.00	1935.50	484.20	2540.50	3209.00	NO	NO	NO

5.8.2.2 Emission factors applied in the category

Table 5-19 3G Liming: emission factors applied by GHG source

Activity Source	Emission Factor [tonnes of C/tonne of lime]
3.G.1. Limestone CaCO3	0.12
3.G.2. Dolomite CaMg(CO3)2	0.13

5.8.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.8.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.8.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.8.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.8.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

5.9 Urea application (CRT 3.H)

5.9.1 Description and trend of GHGs in the category

Urea application refers to the use of urea as a nitrogen fertilizer, which releases carbon dioxide (CO2) when it hydrolyzes in the soil. In the context of Belize, urea application emissions are driven by agricultural practices and the extent of urea usage as a fertilizer.

In the latest inventory year (2022), urea application emissions were recorded at 4.82 kt CO2 eq. This category contributed to the sector's total emissions, accounting for approximately 1.44% of the total agriculture sector emissions. Overall, urea application emissions are decreasing, except for 2022, which may signal farming preferences and changes in fertilizer usage.

Table 5-20 3.H Urea Application: total GHG emissions by subcategory (kt CO2 eq)

Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
Urea application	9.37	1.40	1.26	15.18	2.10	4.30	4.47	12.92	0.46	0.02	0.10	0.10	0.46	4.82
Total Agriculture	123.15	77.64	115.47	130.46	147.10	183.36	202.16	222.76	273.72	277.06	309.40	309.40	310.46	335.93

5.9.2 Methodological issues of the category

5.9.2.1 Activity data of the category

Table 5-21 3H Urea application: activity data name (tonnes/year)

Activity Source	Year													
	1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
3.H Urea Application	12774.94	1914.85	1723.37	20694.00	2861.00	5858.00	6095.85	17614.87	16811.64	32.59	924.02	140.60	625.62	6576.68

5.9.2.2 Emission factors applied in the category

Table 5-22 3H Urea application: emission factors applied by GHG source

Activity Source	Emission Factor [(tonnes of C/tonne of urea)]
3.H Urea Application	0.2

5.9.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

5.9.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

5.9.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

5.9.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

5.9.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6 **Chapter 6:** LAND USE, LAND-USE CHANGE AND FORESTRY (CRT 4)

6.1 Description of the sector

Vast and unique tropical forests exist in Belize which is a habitat to unique biodiversity of global significance. Most of the country and the entire coastal area consist of low-lying plains. Belize is known for its abundant natural resources and a vast array of ecotypes especially concerning water and biodiversity.

Belize also has the highest forest cover in both Central America and the Caribbean, including the largest intact blocks of forests in Central America, namely the Selva Maya and the Maya Mountain Massif.

As part of its reporting commitments, the country reports on greenhouse gas emissions and removals from all sectors, including the Forestry and Other Land Use (FOLU) sector as part of its reporting commitments to the UNFCCC. The Forest Department (FD), as the LULUCF sector lead, is responsible for the associated measurement, reporting and verification (MRV) of national emissions and removals from activities within this sector. The Department, as part of the broader Ministry of Sustainable Development and Climate Change, is the country's regulatory agency that aims to sustainably manage forest resources for long-term benefits

Protected Areas

Forest conservation has, historically, been a major priority for Belize. This is evidenced by the country's extensive protected areas system. 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.

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. 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 Archaeological Reserves, 8 Private Reserves, 8 Marines Reserves, 13 Spawning Sites, 6 Public Reserves, and 7 Bird sanctuaries (see figure 4). The terrestrial PAs cover 34.9% of the total land surface, while the marine reserves cover 10.6% of the country's marine area.

Over the past year, Belize's Protected Lands have expanded to include more areas under conservation management, incorporating corridors, community sustainable logging, and private estates. The National Protected Areas System officially records lands under statutory instruments, while other areas are governed through management plans and co-management agreements. Figure 6-1 provides a visualization of these Protected Lands. Protected Areas in Belize include archaeological reserves and “accepted” private reserves. As part of Belize’s protected areas system, there are bird sanctuaries that are some of the oldest protected areas. Archaeological Reserves include several Maya Sites managed by the National Institute of Culture and History (NICH).

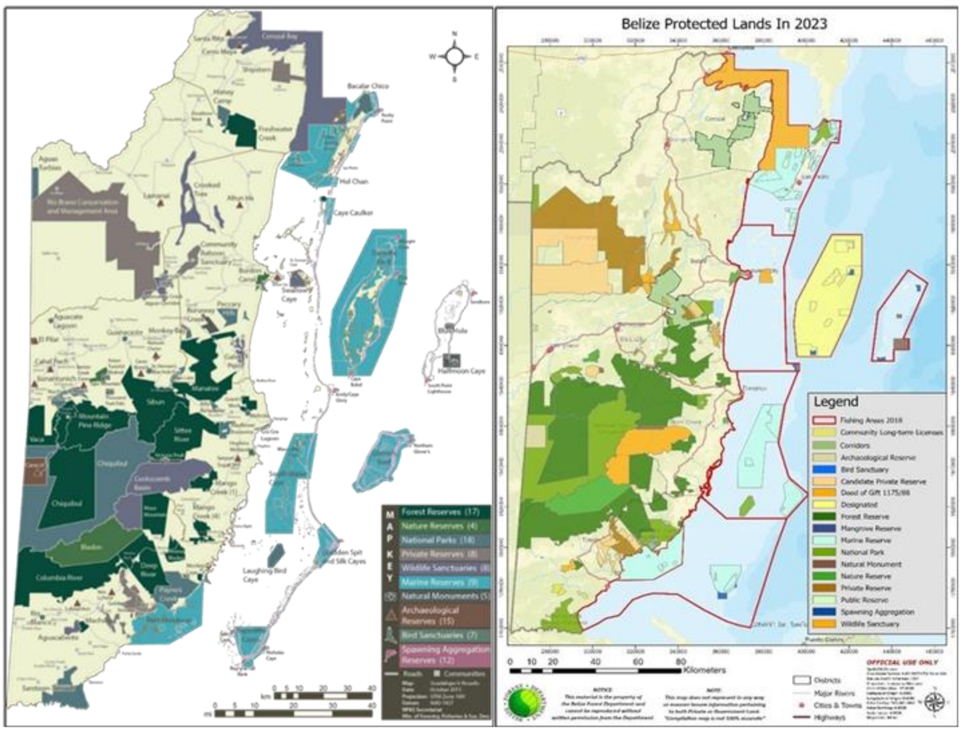


Figure 6-1 Map showing National Protected Areas System 2015

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

These forests also provide sustenance for much of the population. Recently, forests have been under increasing pressure from land conversion and degradation activities. Belize’s biodiversity is exposed to various direct anthropogenic and natural threats both within and outside of the Protected Areas (PAs). Over the last five decades, the forest cover in Belize has 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 conversions of forest to intense anthropogenic land and extensive damages from climate climate-related hurricanes, and storms and pests. These include the unregulated development of urban and coastal areas and the rising 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.

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

6.2 Trend in the sector's GHG

Table 6-1 shows the GHG sources and sinks in the LULUCF sector for the year 2022. The country remains to be a net sink in 2022, removing -4980.62 kt CO2 eq.

Table 6-1 LULUCF sector: emissions and removals by GHG, category and subcategory (kt) for 2022

Code	GHG source and sink categories	Net CO_2 (kt)	CH_4 (kt)	N_2O (kt)	NO_x (kt)	CO (kt)	NMVOC (kt)	Total GHG (kt CO_2 eq)
4	**Land use, land-use change and forestry**	**-5,020.4942**	**1.05**	**0.04**				**-5,023.47**
4.A.	Forest land	-9671.620567	0.92	0.03				**-9638.855**
4.A.1.	Forest land remaining forest land	-9418.163333	0.92	0.03				**-9,385.3883**
4.A.2.	Land converted to forest land	-253.4572333						**-253.457233**
4.B.	Cropland	2120.41866						**2120.41866**
4.B.1.	Cropland remaining cropland	-94						**-94**
4.B.2.	Land converted to cropland	2214.615333						**2214.615333**
4.C.	Grassland	2021.946667	0.14	0.01				**2029.04196**
4.C.1.	Grassland remaining grassland	-32.362	0.14	0.01				**-25.27**
4.C.2.	Land converted to grassland	2054.308667						**2054.308667**
4.D.	Wetlands	NO						
4.D.1.	Wetlands remaining wetlands	NO						
4.D.2.	Land converted to wetlands	NO						
4.E.	Settlements	508.761						**508.761**
4.E.1.	Settlements remaining as settlements	NO						
4.E.2.	Land converted to settlements	508.761						**508.761**
4.F.	Other land	NO						
4.F.1.	Other land remaining other land							
4.F.2.	Land converted to other land							
4.G.	Harvested wood products	-42.85350609						**-42.8535061**
4.H.	Other (please specify)							
	Memo items							
	Emissions and subsequent removals from natural disturbances on managed lands							

Note: Use the following notation keys where numerical data are not available: NA = not applicable; NE = not estimated; NO = not occurring; IE = included elsewhere; C = confidential.

When looking at trends from 1994 – 2022 in Table 6-2, the time series for LULUCF is incomplete from 1994 – 1999 as a result of the methodology for acquiring activity data is limited to 2000 –

present (see information in Section 6.5 on Country specific methods). Due to time constraints the completion of the time series from 1994 was not possible, however remains a priority.

The LULUCF sector has experienced significant fluctuations from 2000 to 2022, however marked by substantial net removals throughout. Details on drivers are discussed at length in Section 6.6 on Forest Land.

Table 6-2 LULUCF sector: total net GHG by category (kt CO2 eq)

Code	Category	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
4.A.	Forest land	0.00	0.00	-10,914.02	-7,642.98	-9,293.09	-10,979.81	-10,112.82	-10,621.22	-10,228.70	-11,284.87	-7,953.13	-5,015.43	-10,228.70	-9638.85
4.B.	Cropland	0.00	0.00	325.24	2,037.56	1,602.58	2,177.27	3,971.41	3,125.73	1,345.74	1,556.25	3,066.25	1,388.75	1,345.74	2120.42
4.C.	Grassland	0.00	0.00	181.38	1,621.66	1,591.27	1,701.70	2,363.84	3,100.66	1,047.13	1,543.84	2,340.62	1,646.53	1,047.13	2029.04
4.D.	Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E.	Settlements	0.00	0.00	0.00	207.06	539.59	225.89	184.51	395.81	718.37	346.16	546.09	212.59	718.37	508.76
4.F.	Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.G.	Harvested wood products	-16.40	-14.68	-39.18	-10.95	-0.26	6.18	1.62	-23.54	-51.57	-54.39	-66.39	-66.39	-51.57	-42.85
4.H.	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**LULUCF Total net**	**-16.40**	**-14.68**	**-10,446.59**	**-3,787.65**	**-5,559.91**	**-6,868.78**	**-3,591.44**	**-4,022.56**	**-7,169.02**	**-7,893.01**	**-2,066.56**	**-1,833.94**	**-7,169.02**	**-5,023.48**

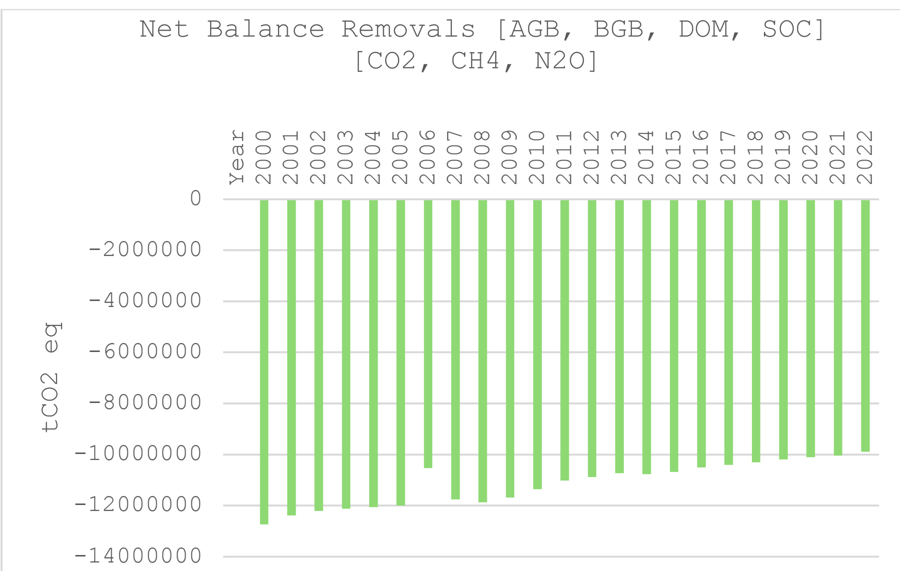


Figure 6-2 Net Balance Removals [AGB, BGB, DOM, SOC] [CO2, CH4, N2O](tCO2 eq)

The graph above (see Figure 6-2) presents an analysis of greenhouse gas (GHG) removals across all carbon pools—Above-Ground Biomass (AGB), Below-Ground Biomass (BGB), Dead Organic Matter (DOM), and Soil Organic Carbon (SOC)—and gases, including CO_2, CH_4, and N_2O, as recorded in the inventory from 2000 to 2022. The data reveals a sustained decline in GHG removals, particularly from 2020 to 2022, primarily due to forest cover loss resulting from the expansion of agricultural activities driven by increasing demand for agricultural commodities. During this study period, GHG removals were recorded at -10,100,894.24 in (2020), -

10,046,403.15 in (2021), and -9,886,512.49 in (2022), with an average annual removal of -10,011,269.96. This trend highlights the substantial impact of land-use changes on the ecosystem's carbon sequestration capacity.

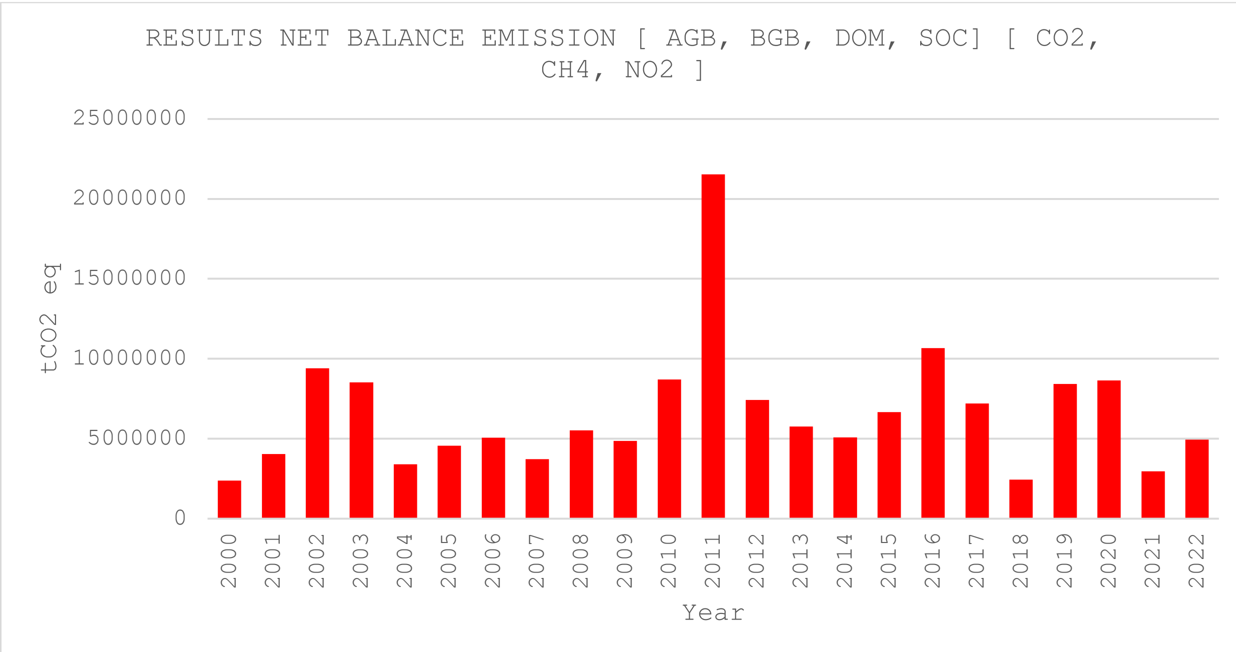


Figure 6-3 RESULTS NET BALANCE EMISSION [AGB, BGB, DOM, SOC] [CO2, CH4, NO2] (tCO2 eq)

Figure 6-3 provides a comprehensive analysis of greenhouse gas (GHG) emissions across all carbon pools—Above-Ground Biomass (AGB), Below Ground Biomass (BGB), Dead Organic Matter (DOM), and Soil Organic Carbon (SOC)— as well as gases, including CO_2, CH_4, and N_2O, based on inventory data from 2000 to 2022. Notably, on October 24, 2010, Hurricane Richard made landfall in Belize, significantly impacting forest structure and increasing ground fuel loads. This event was followed by a major fire outbreak in 2011, contributing to a pronounced spike in emissions that year, as reflected in the graph.

For the study period, emissions were recorded at 5,671,313.32 tCO_2eq in 2020, 190,751.77 tCO_2eq in 2021, and 400,391.91 tCO_2eq in 2022, resulting in an average emission of 2,087,485.67 tCO_2eq from 2020 to 2022. This reduction in emissions is largely attributed to a decline in the frequency and intensity of both anthropogenic and natural disturbances.

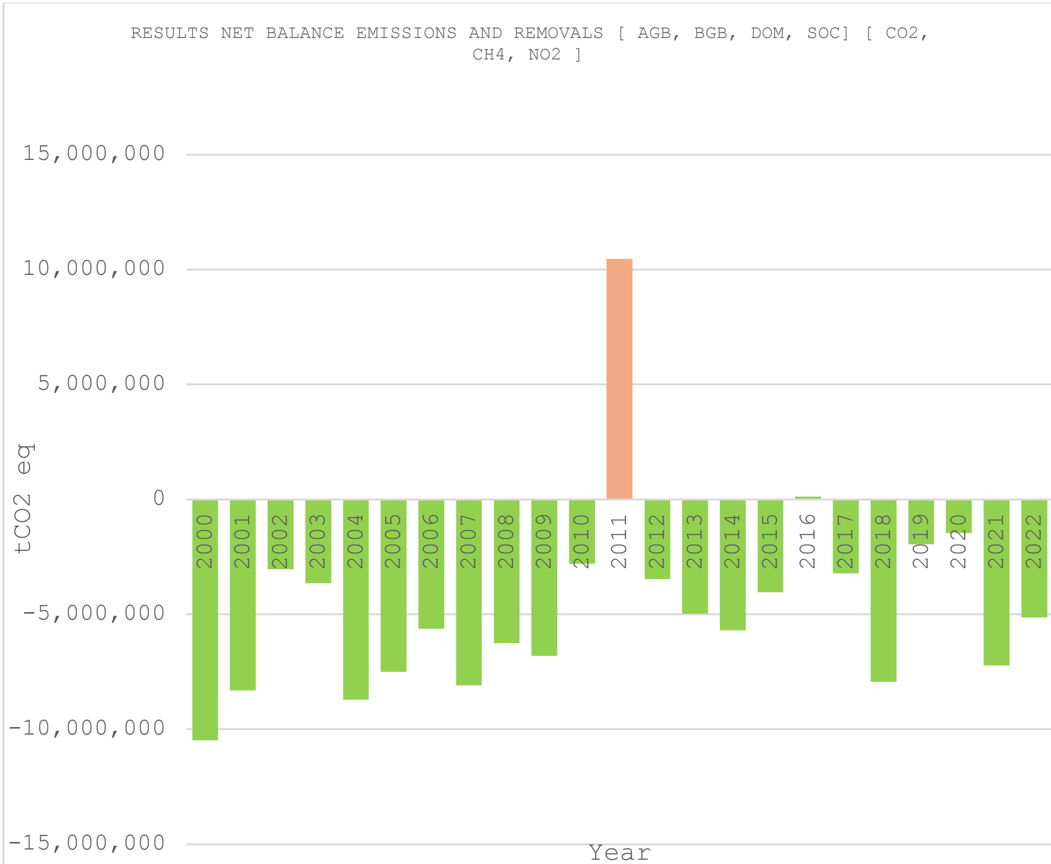


Figure 6-4 Net Balance Emissions and Removals [AGB, BGB, DOM, SOC] [CO2, CH4, NO2] 2000-2022 (tCO2 eq)

The above graph (see Figure 6-4) shows Belize's net greenhouse gas (GHG) emissions and removals, covering all carbon pools—Above-Ground Biomass (AGB), Below-Ground Biomass (BGB), Dead Organic Matter (DOM), and Soil Organic Carbon (SOC)—and key gases, including CO_2, CH_4, and N_2O, over the inventory period from 2000 to 2020. The data indicates a variable trend in GHG removals, highlighting fluctuations in carbon sequestration rates throughout this timeframe.

Two notable deviations in this trend occurred in 2011 and 2016, primarily due to natural disturbances. In 2011, Belize experienced a marked increase in emissions, totaling 10,457,484.37 tCO_2eq, attributed to a large-scale wildfire outbreak that significantly disrupted forest ecosystems and increased carbon release. Similarly, in 2016, Hurricane Earl, a Category 1 storm, struck Belize and generated emissions of 114,062.03 tCO_2eq by damaging forests, depleting biomass, and increasing fuel loads on the forest floor. Together, these events contributed to a cumulative emission increase of 10,571,546.41 tCO_2eq, as reflected in the graph, illustrating the substantial impact of such natural disasters on Belize's carbon balance.

These fluctuations underscore the dual impact of anthropogenic pressures and natural disturbances on the country's net emissions and removals. They further emphasize the critical need for adaptive land management and proactive disaster preparedness strategies to preserve and enhance Belize's carbon sequestration potential amidst changing environmental conditions.

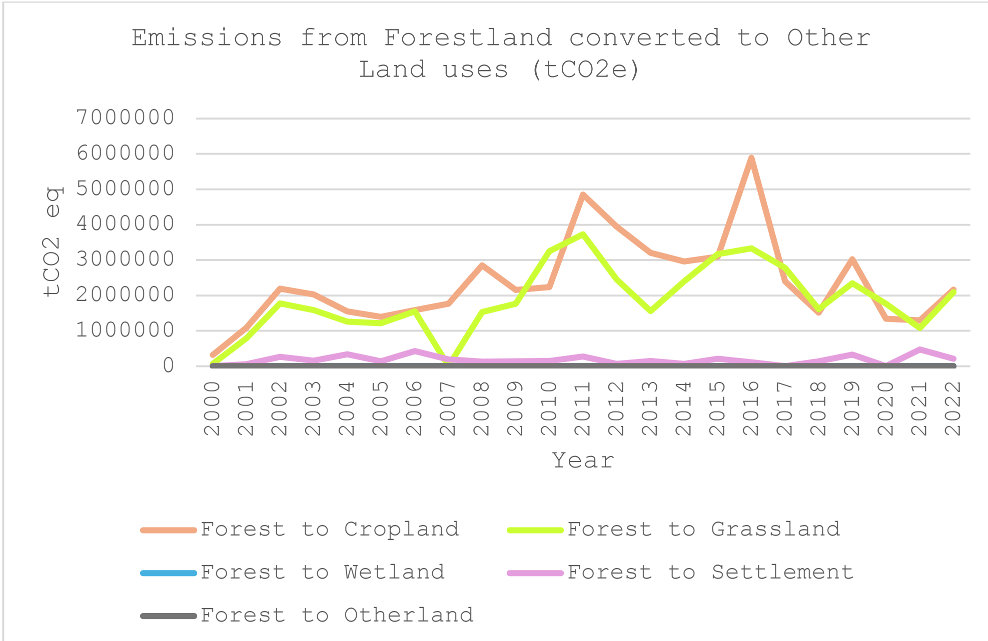


Figure 6-5 emission and removal from forestland conversions

Figure 6-5 shows greenhouse gas (GHG) emissions across all carbon pools and other key gases as discussed earlier. It illustrates emission levels resulting from the conversion of forestland to other land use types. For the reporting years, there was a decrease from the constant increases in emission from the years prior where the highest peak was seen in 2016, with emissions reported at 5,890,224 tCO2 eq. In 2020, total GHG emissions from land conversions were 3,114,350 tCO2 eq. The primary contributors were forest to grassland conversion, responsible for 57%, followed by forest to croplands, which emitted 43%. In 2021, emissions decreased to 2,855,184 tCO2 eq, with forest to cropland now being the largest source, emitting 43% of the total emission for that year. However, emissions from forest to grassland conversions decreased, representing 38% of the total emission. For the year 2021, we also had notable emissions from forest land converted to settlements, with a percentage of 17%. Emissions in 2022 totaled 4,468,533 tCO2 eq, marking an increase from 2021. While forest to cropland conversion still led with 48%, forest to grassland increased to 47% and forest to grassland decreased to 5%.

6.3 General methodological issues of the sector

The national Greenhouse Gas (GHG) inventory comprehensively accounts for all carbon pools, including above-ground biomass, belowground biomass, dead wood, litter, and soil carbon. It encompasses emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) associated with biomass burning. Emissions are reported in carbon dioxide equivalents (CO_2e) using the 100-year global warming potentials (GWPs) from the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5).

Table 6-3 Summary of relevant activity data, methods, and emission factors for LULUCF sector inventory.

Source Category	Activity Source	Data Type	CO_2		CH_4		N_2O	
4 Land Use, Land-Use Change and Forestry			MT	EF	MT	EF	MT	EF
4A Forest Land	4A1 Remaining Forest land (managed)	Land area	T2, T3	CS	T1	D	T1	D
	4.A.2 Land converted to Forest	Land area	T2, T3	CS	T1	D	T1	D
4B Cropland	4.B.1 Remaining Cropland	Land area	T1	D	T1	D	T1	D
	4.B.2 Land converted to cropland	Land area	T1	D	T1	D	T1	D
4C Grassland	4.C.1. Grassland remaining grassland (managed)	Land area	T2	CS	T1	D	T1	D
	4.C.2. Land converted to grassland	Land area	T2	CS	T1	D	T1	D
4D Wetlands	4.D.1. Wetlands remaining wetlands (managed)	Land area	T1	D	T1	D	T1	D
4E Settlements	4.E.1. Settlements remaining settlements	Land area	T1	D	T1	D	T1	D
	4.E.2. Land converted to settlements	Land area	T1	D	T1	D	T1	D
4D Other Land	4.F.1. Other land remaining other land	Land area	T1	D	T1	D	T1	D
4G Harvested Wood Products 4.G.1. Solid wood	4.G.1.a. Sawnwood	Production, Imports, Exports	T1	D	T1	D	T1	D
	4.G.1.b. Wood panels	Production, Imports, Exports	T1	D	T1	D	T1	D
	4.G.2. Paper and paperboard	Production, Imports, Exports	T1	D	T1	D	T1	D
	4.G.3. Other (Industrial Roundwood, Wood pulp + Rec paper, Roundwood (Fuelwood + Industrial Roundwood), Chips and particles, Wood charcoal, Wood Residues)	Production, Imports, Exports	T1	D	T1	D	T1	D

Emission Factors
Belize’s methodological approach to emission factor development within the Forest and Other Land Use (FOLU) sector is highly rigorous, following the IPCC methodological guidelines utilizing systematic ground assessments and a tiered approach to ensure precise greenhouse gas (GHG) emissions and removals reporting. The establishment of the FORMNET-B Emission Factor Database has been instrumental, as it calculates emission factors tailored to Belize's diverse ecosystems, encompassing various forest types such as broadleaf, pine, and mangroves, as well as non-forest areas like grasslands.

In the FOLU sector, Belize employs Tier 2, country-specific data, leveraging emission factors derived from the FORMNET-B database, which provides estimates sensitive to national conditions. Additionally, Belize's Measuring, Reporting, and Verification (MRV) program applies advanced Tier 3 modelling techniques, incorporating extensive field data collected through a network of permanent sample plots and ground-based assessments. This advanced approach enhances the precision of estimations by integrating detailed ecological and geographic data, making it well-suited for accurate GHG accounting tailored to Belize’s unique environmental context.

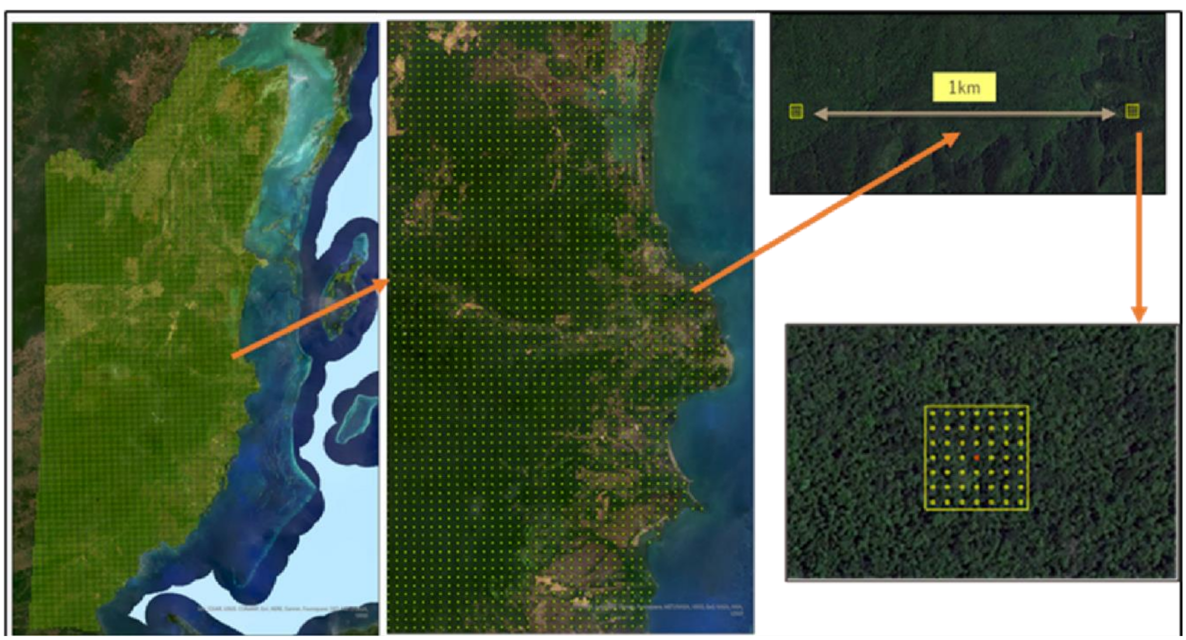


Figure 6-6 1x1 km systematic grid design used within the Belize LUA app for collection of AD. Emission Factor

Activity Data

The information on Activity Data (AD) used was obtained from a land use and land-use change assessment, which was conducted based on a spatially explicit sample-based methodology (IPCC approach 3) using the Land Use Assessment (LUA) app.

The data for the estimation of wood removals (IPCC equation 2.12) was derived from the same sample-based land use assessment, by equating canopy cover loss with above-ground biomass loss. Various contributing factors to these losses were identified, including hurricanes, fires, logging, grazing, shifting cultivation, pest infestations, infrastructure development, mining activities, and other human impacts.

One significant improvement over the previous FREL/FRL is the ability to monitor multiple land use changes and multiple disturbances occurring on the same plot throughout time. This advancement enables us to account for emissions or removals associated with each specific disturbance or land use change. In contrast, the earlier FRL/FREL only considered the initial and final land use states, along with the primary disturbance event. The new approach implemented in this FRL is higher tier as it increases the accuracy of the GHG estimations.

6.4 Land-use definitions

The Intergovernmental Panel on Climate Change has the following six (6) categories for the Forestry, and Other Land Use (FOLU) sectors. These are forest, cropland, grassland, wetland, settlement, and other lands.

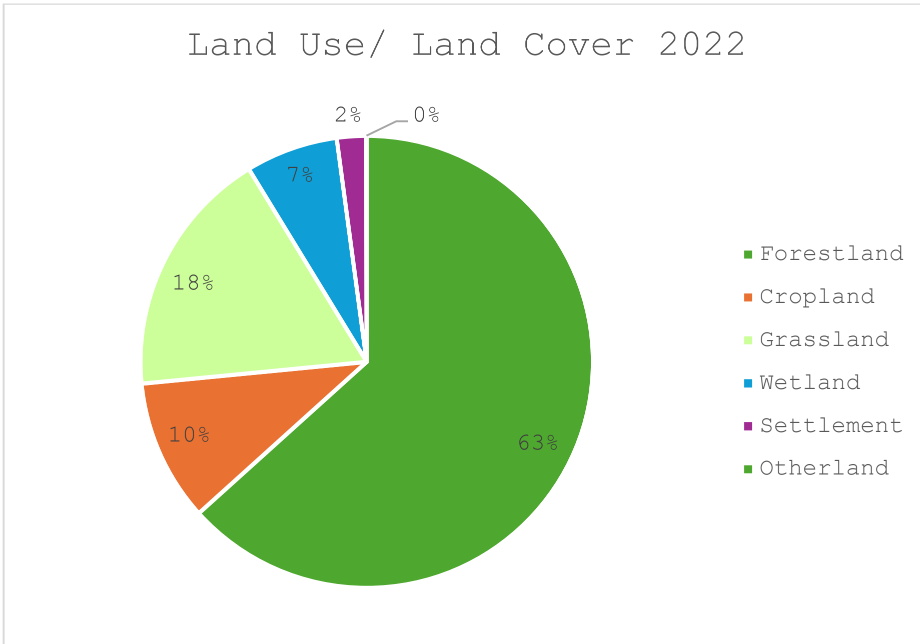


Figure 6-7 Land Use/Land Cover Distribution by Percentage in Belize – 2022

These classes are displayed in the map below (Figure 6-8). Each IPPC category has further subcategories and specific classes. The following section provides a definition of the IPCC categories for the FOLU sector of Belize. For 2022, the percentages of each land use types are seen above (Figure 6-7). Forestland comprises 63% of the national land area, followed by grasslands at 18% and cropland at 10%. The remaining 9% is collectively made up of wetlands, settlements, and other lands.

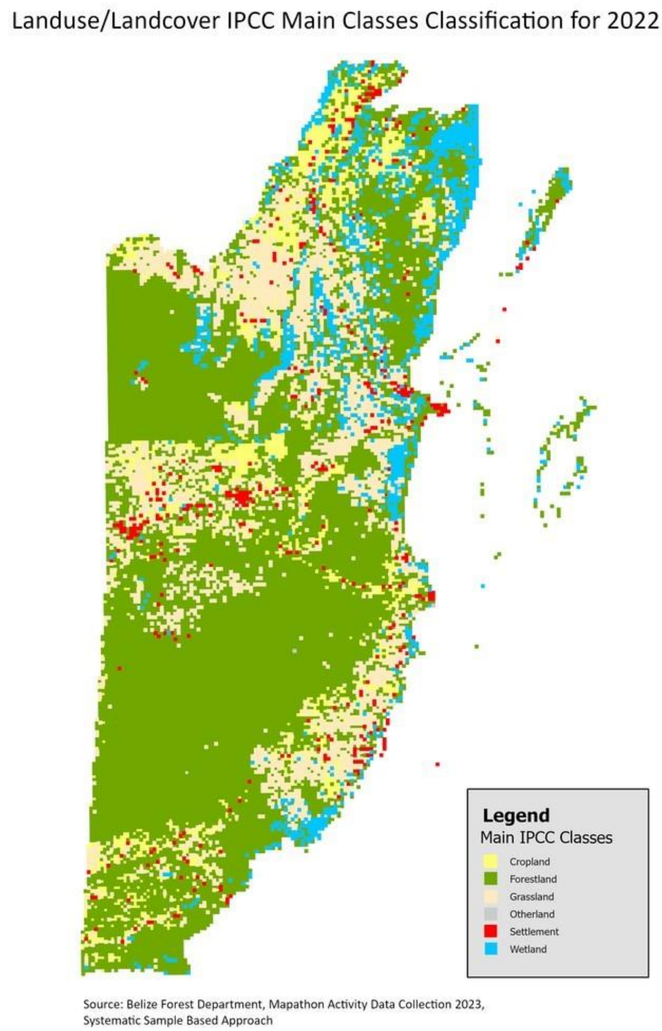


Figure 6-8 2022 Land Use/Land Cover Map, classified according to the main categories defined by the IPCC

As depicted in Figure 6-7, forest cover represents the largest land use/land cover category in 2022, accounting for 63% of the area. This is followed by cropland at 18% and grassland at 10%.

Definitions

Forest: A forest is a plot of land with an area of 0.5 hectares or more, with trees of heights of 5 meters or higher, and a canopy cover of 30% or higher. This definition also includes forest plantation. In addition, it includes an ecosystem that due to biotic conditions (terrain, soil type, rainfall, et cetera) the trees cannot grow higher than 5 meters. Below (Figure 6-9) is a map depicting the plots listed as forested areas for Belize for the year 2022.

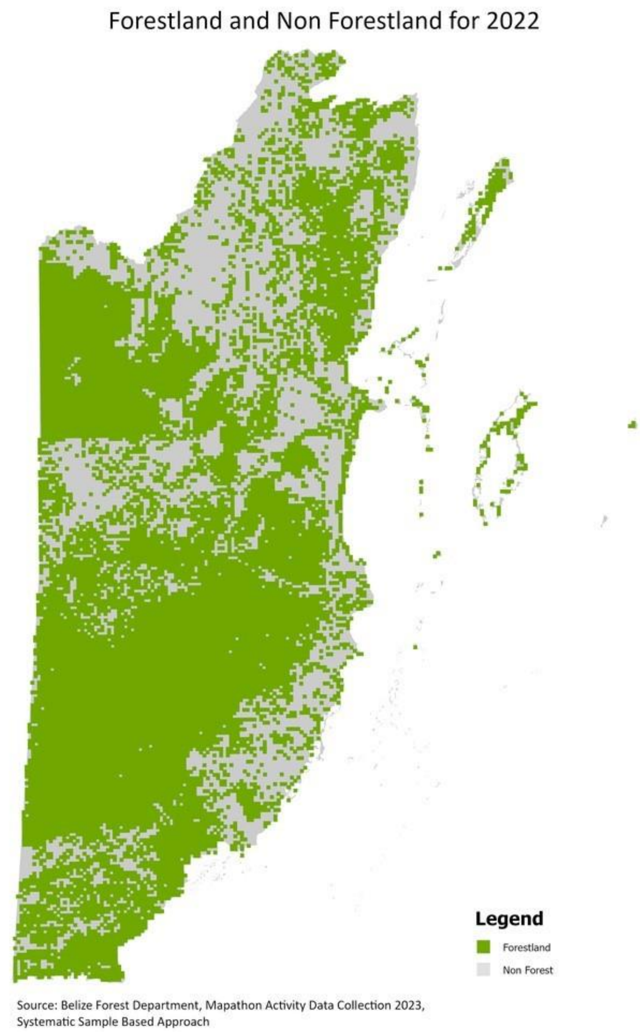


Figure 6-9 Classification of Forestland and Non-Forestland for 2022.

Figure 19: Shows the classification of Forestland and Non-Forestland for 2022.

Definitions

Cropland: Agricultural activity is 0.5 hectares of land that has a 20% cover with crops in the sample plot/point. Land that was once used for swidden agriculture and has been abandoned and is 'regenerating toward a secondary forest' is also considered cropland under specific class fallow land. Below (Figure 6-10) is a map depicting the plots listed as croplands across the country for the year 2022.

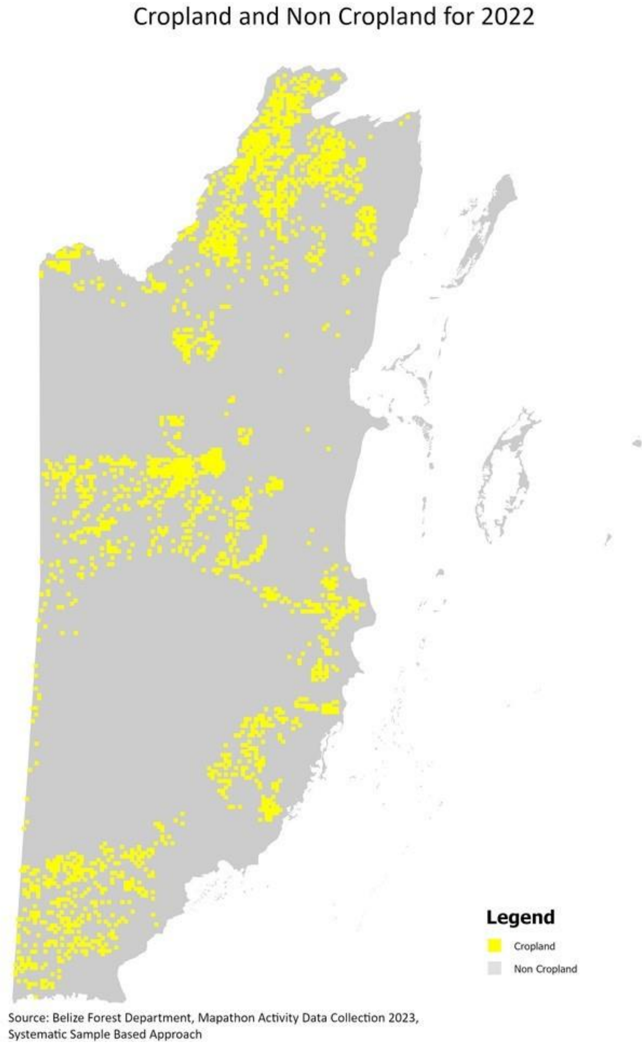


Figure 6-10
Classification of Cropland and Non-Cropland for 2022.

Definitions

Grassland: Grassland is 0.5 hectare of land that has a 20% cover of savannah, grass, shrubs, ferns, and tickets in the sample plot/point. 28 Cattle pasture is considered grassland. Below (Figure 6-11) is a map depicting areas classified as grasslands in the country for 2022.

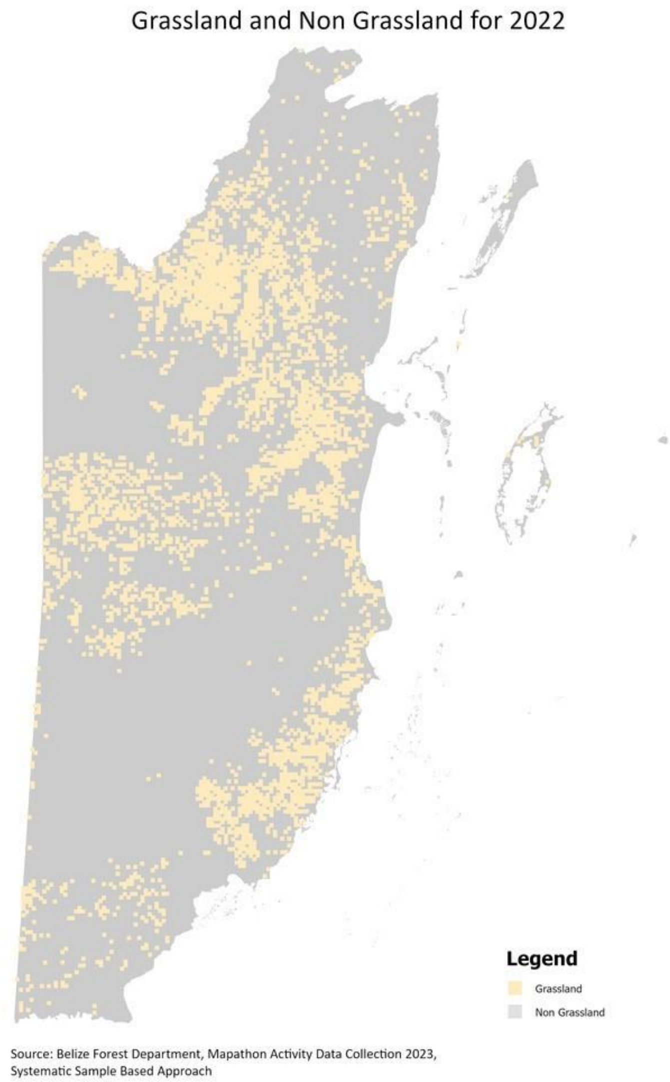


Figure 6-11 classification of Grassland and Non- Grassland for 2022.

Definitions

Wetlands: Wetland is an area that is 0.5 hectare or more that has 20% permanent or seasonal floods, dominated by herbaceous/graminoid vegetation. Wetlands can have trees such as calabash (Cresentia cujete) or no trees. This class also includes inland water bodies.

Settlements: Settlement is an area that is 0.5 hectare or more that has 20% of urban construction that fall within the categories of, cities, towns, villages, roads, aquaculture farms, mining, and other settlements

Other lands: Other lands are areas that are 0.5 hectare or more that has 80% of soils that fall in the categories of bare soil, bare soil rocks and beaches/sand dunes.

6.5 Country-specific methods

6.5.1 Methods used for land representation

Information on approaches used for representing land areas and on land use databases used for the inventory preparation

Belize employs the Land Use Assessment app to gather activity data, which is then incorporated into the foundational platform. This data collection process, detailed in earlier sections of this report, serves as the foundation for compiling the country's greenhouse gas inventory. After collection, the data is processed and analyzed to support accurate inventory compilation, contributing to Belize's emissions tracking and reporting.

6.5.2 Methods used for natural disturbances

Information on approaches used for disturbances

The Land Use Application included a MODIS data graph to visualize the presence of fires within and around the plot throughout the years. The Google Earth KML layer contained hurricane paths, allowing the observation of plot damages through high-resolution images across different time frames. Furthermore, changes in the canopy were noted within high-resolution imagery. Logging disturbances were noted in the area due to the best expert knowledge of logging roads and barquediers. Pest-related disturbances within Mountain Pine Ridge were also recognized based on expert insight. Infrastructure and mining disturbances could also be seen within the high resolution imagery over the time frame. Other human impacts were noted from constant disturbances within an area of best expert knowledge. These areas included roadsides, buffer zones of protected areas, electrical boundary lines, and regularly maintained properties in both urban and rural regions.

Losses in forests that remain as forests were assessed due to various disturbances. These include Fires, Shifting cultivation, Infrastructure/Other
Human Impact, Mining, Pest, Logging, Hurricanes, Grazing.

Disturbances were divided in groups based on whether regeneration after disturbance is expected or not, and if there were specific modifications to the general growth rate. Each time a disturbance was identified, the year and disturbance fraction were assigned. In the end, averages were estimated for each disturbance.
After analyzing the data, it becomes evident that fires are the most significant contributors to CO_2 emissions, as illustrated in Figure 6-12.

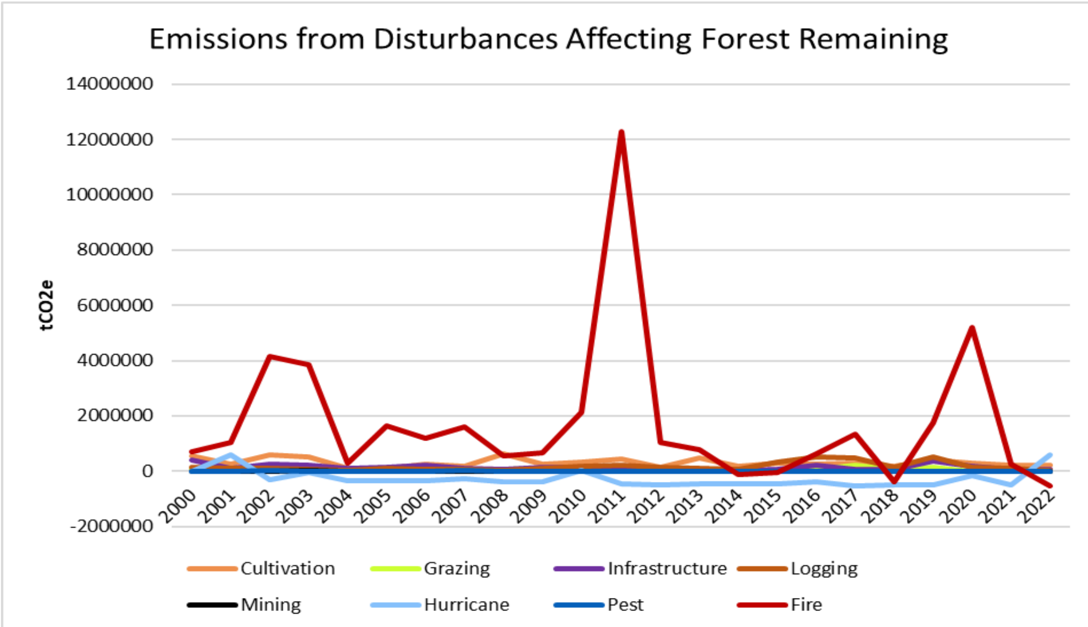


Figure 6-12 Emissions from disturbances affecting forest remaining for 2022.

Fires can originate from a range of conditions, with hurricanes playing a notable role. When hurricanes strike, they often damage large numbers of trees and leave substantial debris on the ground. This debris acts as fuel, increasing the risk of fires in the aftermath. Additionally, hurricanes can indirectly lead to other types of land disturbances, including increased logging activities, as fallen trees are harvested, or land is cleared. Hurricanes may also contribute to land conversion, where forested areas are turned into pastures or cultivated lands to utilize the cleared space.

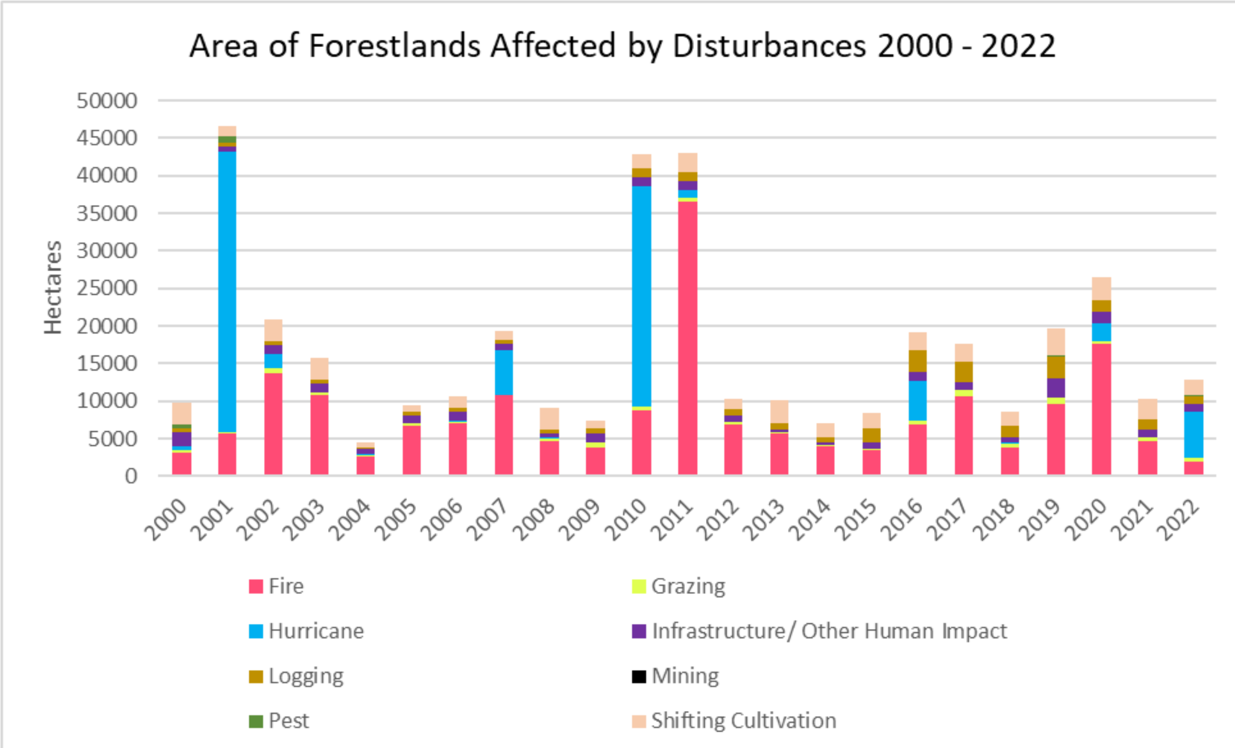


Figure 6-13 Area of Forestlands Affected by Disturbance 2001- 2022.

Figure 6-13 displays the extent of disturbances in hectares and highlights a pattern: following a hurricane, there is a strong likelihood of heightened fire disturbances and associated emissions in the following year. This pattern is particularly noticeable in the years 2001 and 2010, where significant disturbances were recorded in areas that, while not undergoing land conversion, were still affected by hurricane events.

These disturbances, though not always leading to direct land-use changes, nevertheless contribute to substantial CO_2 emissions due to the fires and land management activities that follow such natural disasters. This cycle illustrates the interconnected nature of natural disturbances and their compounding impact on emissions.

6.6 Forest land (CRT 4.A)

6.6.1 Description and trend of GHGs in the category

Forestland Remaining Forestland encompasses five main categories: mature broadleaf forest, secondary broadleaf forest, pine forest, mangrove forest, and plantation. Figure 6-14 provides an overview of forest land remaining by area. For 2020, forest land remaining was estimated at 1,411,441 hectares. This decreased to 1,407,018 hectares in 2021 and further declined to 1,388,880 hectares in 2022. This trend indicates a gradual decline in forest land cover over the three-year period, with a total reduction of 22,561 hectares (approximately 1.6%).

The observed decrease reflects ongoing pressures on forest resources, such as agricultural expansion, which often leads to the conversion of forested areas into croplands or pastures. Additionally, other factors, such as urbanization, infrastructure development, or unsustainable or illegal logging practices, also contributes to this decline.

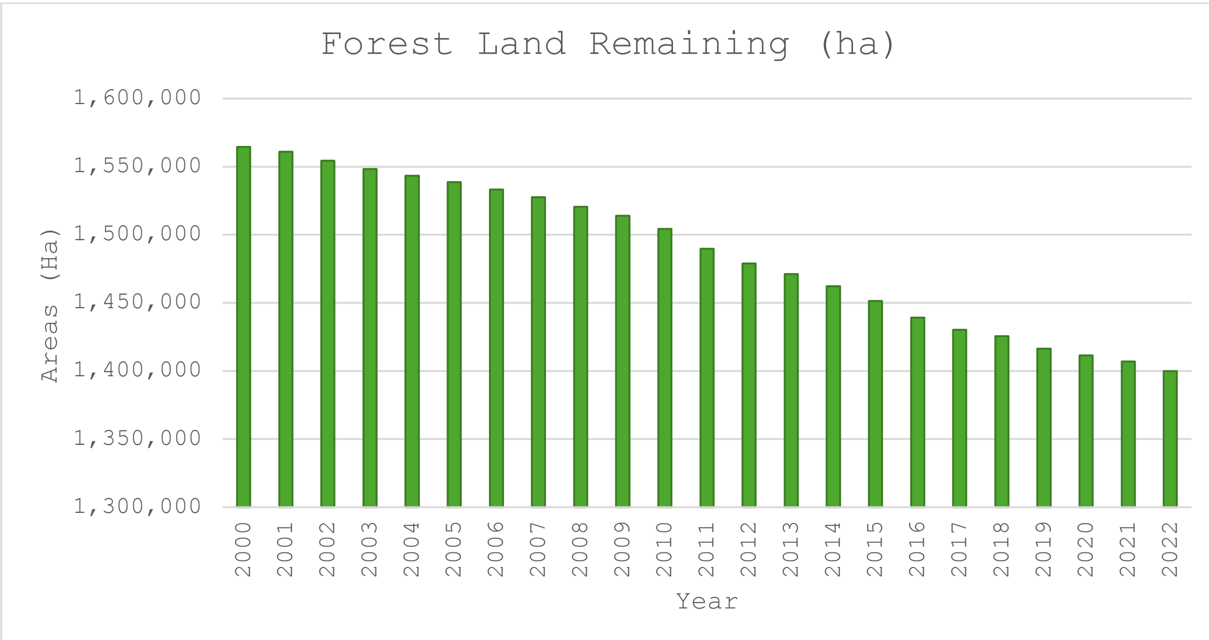


Figure 6-14 Areas (ha) converted to Forestland from 2000 to 2022.

Conversely, significant areas of forestland were converted to other land uses, as illustrated in Figure 6-15. The most extensive conversion was from forest to cropland, covering 91,281 hectares, followed by forest land converted to grassland at 72,080 hectares. Lastly, 6,635 hectares of forest were converted for settlement purposes. These conversions represent notable shifts in land use, impacting both the landscape and carbon dynamics in these areas.

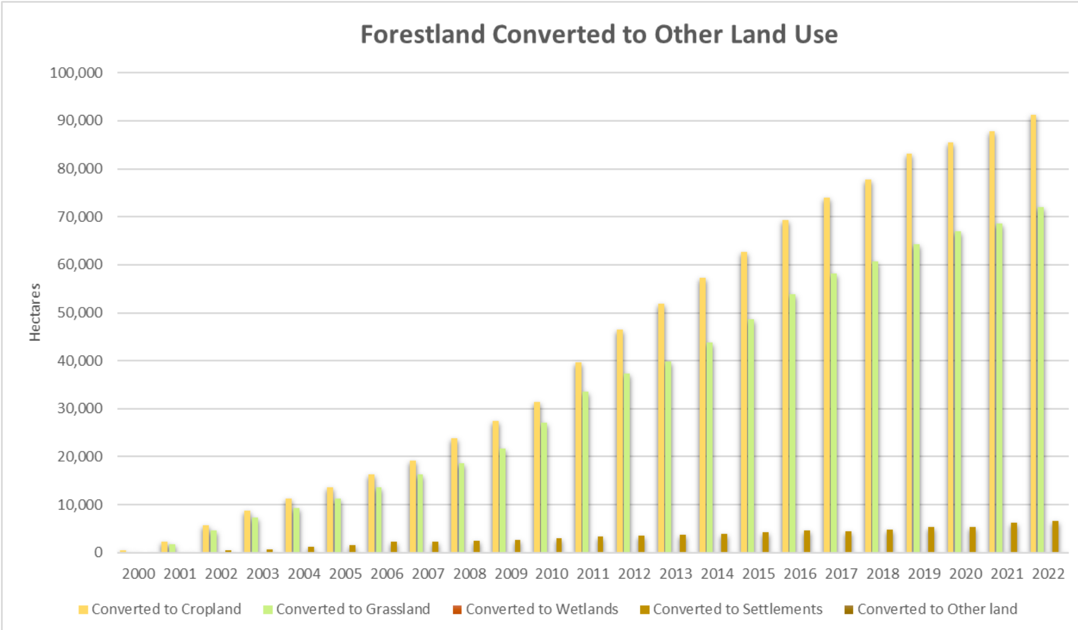


Figure 6-15 Hectares of Forestland converted to other land uses from 2000 to 2022

6.6.2 Methodological issues of the category

6.6.2.1 Specific activity data of the category

The activity data for this category is noted below.

Table 6-4 4A Forest Land: activity data by land area (ha)

4.A Forest Land Area	Years													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.A.1 Remaining Forest land (managed)	NE	NE	NE	1,564,448	1,561,030	1,554,294	1,548,263	1,543,337	1,538,712	1,533,083	1,527,453	1,520,416	1,513,881	1,504,230
4.A.2 Land converted to Forest	NE	NE	NE	0	0	0	0	101	101	201	302	503	804	905
Total Forest Land	NE	NE	0	1,564,448	1,561,030	1,554,294	1,548,263	1,543,438	1,538,813	1,533,284	1,527,755	1,520,919	1,514,685	1,505,135

4.A Forest Land Area	Years											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.A.1 Remaining Forest land (managed)	1489654	1478997	1471156	1462108	1451352	1439288	1430240	1425616	1416367	1411441	1407018	1399880
4.A.2 Land converted to Forest	1307	1508	2,111	241300	2714	3016	3116	5529	6333	7339	8344	9048
Total Forest Land	1490961	1480505	1473267	1464521	1454066	1442304	1433356	1431145	1422700	1418780	1415362	1408928

Source: Belize Forest Department Sector Summary Report 2024

6.6.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.6.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.6.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.6.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.6.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.7 Cropland (CRT 4.B)

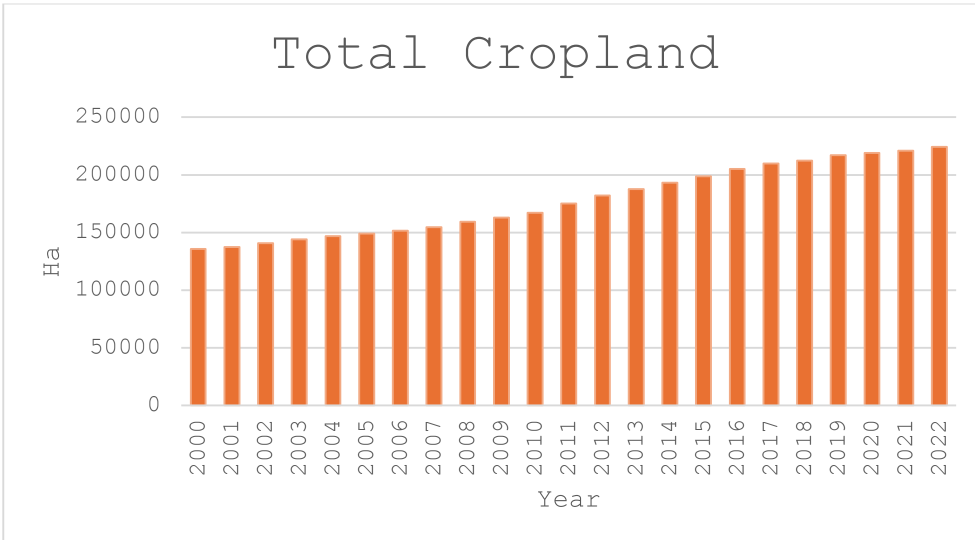
6.7.1 Description and trend of GHGs in the category

In Belize's context, cropland is considered agricultural activity is 0.5 hectares of land that has a minimum of 20% cover with crops in the sample plot/point. Land that was once used for swidden agriculture and has been abandoned and is 'regenerating toward a secondary forest' is also considered cropland under specific class fallow land year, and their key drivers; (3) percentage contribution of each subcategory in the latest.

In Table 6-1, Cropland has generally shown growth, indicating net emissions over time. The subcategory emission peaked in 2012 and 2019, reflecting significant emissions during these years. This trend suggests that agricultural practices have contributed to carbon emissions due to land conversion for crop agricultural purposes.

The data below on total cropland (cropland remaining plus land converted to cropland) shows a gradual increase in total cropland conversions over the 22year period with the area rising from 135,716 ha in 2000 to 224,282ha in 2022. This represents a cumulative growth of 88,566ha. The average annual increase in cropland areas was approximately 4,026ha per year. The consistent growth trend suggests steady expansion of croplands, likely driven by increased agricultural activities, economic and population growth.

In Figure 6-16 it depicts that the area of land converted to cropland has been increasing steadily, from 503 hectares in 2000 to 96,609 hectares in 2022. This increase suggests that new areas are being brought under cultivation to meet the growing demand for agricultural products.



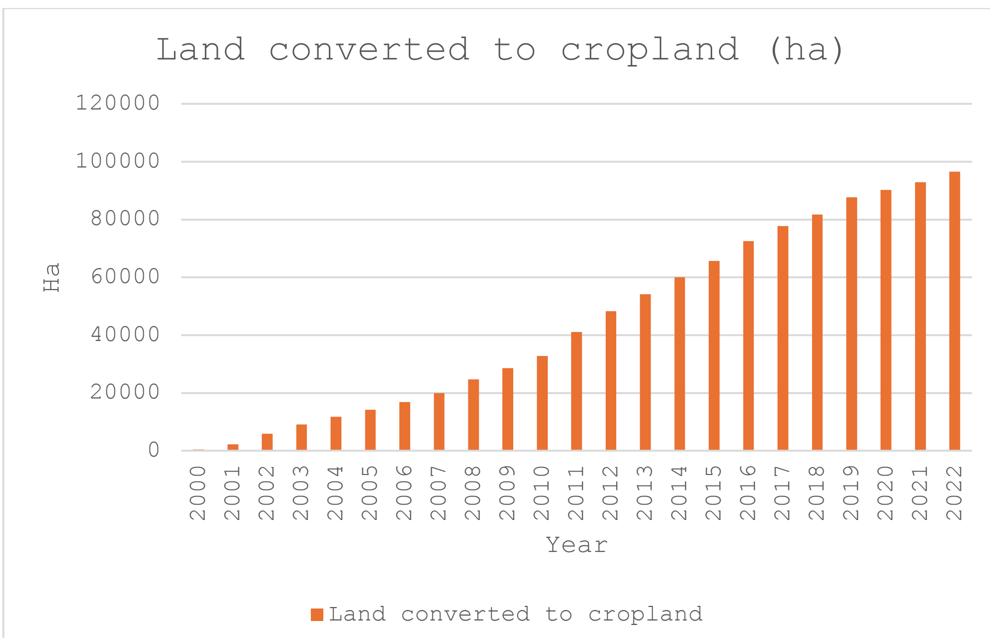


Figure 6-16 Total Cropland and Land converted to Cropland (ha)

6.7.2 Methodological issues of the category

6.7.2.1 Specific activity data of the category

The activity data for this category is noted below.

Table 6-5 4B Cropland: activity data by land area (ha)

4.B Cropland Land area	**Years**													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.B.1 Remaining Cropland	NE	NE	NE	135,212.85	135,212.85	135,011.79	135,011.79	135,011.79	134,911.26	134,710.20	134,609.67	134,509.14	134,509.14	134,308.08
4.B.2 Land converted to cropland	NE	NE	NE	503.00	2,212.00	5,831.00	9,048.00	11,762.00	14,175.00	16,889.00	19,905.00	24,730.00	28,551.00	32,773.00
Total Cropland	NE	NE	NE	135,715.85	137,424.85	140,842.79	144,059.79	146,773.79	149,086.26	151,599.20	154,514.67	159,239.14	163,060.14	167,081.08

4.B Cropland Land area	**Years**											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.B.1 Remaining Cropland	134,006.49	133,805.43	133,604.37	133,302.78	133,101.72	132,498.54	132,096.42	130,689.00	129,281.58	128,879.46	128,175.75	127,673.10
4.B.2 Land converted to cropland	41,117.00	48,254.00	54,186.00	60,016.00	65,646.00	72,583.00	77,710.00	81,731.00	87,662.00	90,276.00	92,890.00	96,609.00
Total Cropland	175,123.49	182,059.43	187,790.37	193,318.78	198,747.72	205,081.54	209,806.42	212,420.00	216,943.58	219,155.46	221,065.75	224,282.10

Source: Belize Forest Department Sector Summary Report 2024

6.7.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.7.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.7.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.7.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.7.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.8 Grassland (CRT 4.C)

6.8.1 Description and trend of GHGs in the category

Grassland is 0.5 hectare of land that has a 20% cover of savannah, grass, shrubs, ferns, and tickets in the sample plot/point. Cattle pasture and abandoned pastures are considered grassland. Sub-mountainous grasslands, found specifically in the mountain pine ridge region of the country is also considered grassland.

In the figures below, it indicates that between 2000 and 2022, total grassland area which includes grassland remaining and conversions increased from 326,924hectares to 393,877hecatres, reflecting a cumulative growth of 66,953hectares over 22years. This equates to an average annual increase of approximately 3,043ha, representing a total growth of 20.48%. the growth trend is steady and linear rather than exponential, indicating a gradual and consistent rise in land transitioning into grasslands.
Furthermore, the area of land converted to grassland has been increasing steadily, from 101 hectares in 2000 to 78,816 hectares in 2022. This represents a substantial cumulative increase of 78,715 hectares. The average annual conversion rate during this time was approximately 3,578ha/year. The data reflects a dramatic shift in land use toward grassland, suggesting significant efforts or natural processes driving these transitions.

Figure 6-17 Total Grassland and Other land Use converted to Grasslands (ha)

6.8.2 Methodological issues of the category

6.8.2.1 Specific activity data of the category

The activity data for this subcategory is noted below.

Table 6-6 4C Grassland: activity data by land area (ha)

4.C Grassland Land area	Years													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.C.1. Grassland remaining grassland (managed)	NE	NE	NE	326,823	326,723	326,220	325,818	325,516	325,315	324,712	324,611	324,511	324,008	323,506
4.C.2. Land converted to grassland	NE	NE	NE	101	1,709	4,725	7,339	9,349	11,460	14,074	17,693	20,307	23,323	28,953
Total Grassland	NE	NE	NE	326,924	328,432	330,945	333,157	334,865	336,775	338,786	342,304	344,818	347,331	352,459

4.C Grassland Land area	Years											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.C.1. Grassland remaining grassland (managed)	323,304	322,902	321,696	320,691	320,188	319,585	319,082	317,675	316,770	316,368	315,564	315,061
4.C.2. Land converted to grassland	35,688	39,609	42,223	46,445	51,672	57,805	62,731	65,546	70,371	73,186	75,297	78,816
Total Grassland	358,992	362,511	363,919	367,136	371,860	377,390	381,813	383,221	387,141	389,554	390,861	393,877

Source: Belize Forest Department Sector Summary Report 2024

6.8.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.8.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.8.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.8.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.8.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.9 Wetlands (CRT 4.D)

6.9.1 Description and trend of GHGs in the category

A Wetland is an area that is 0.5 hectare or more that has 20% permanent or seasonal floods, dominated by herbaceous/graminoid vegetation. Wetlands can have trees such as calabash (Cresentia cujete) or no trees. This class also includes inland water bodies.

There is no data available for conversions and associated emissions for the Wetlands category.

6.9.2 Methodological issues of the category

6.9.2.1 Specific activity data of the category

The activity data for this category is noted below.

Table 6-7 4D Wetlands: activity data by land area (ha)

4.D Wetlands Land area	**Years**													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.D.1. Wetlands remaining wetlands (managed)	NE	NE	NE	147,276	147,276	147,276	147,276	147,176	147,176	147,176	147,075	146,874	146,874	146,774

4.D Wetlands Land area	**Years**											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.D.1. Wetlands remaining wetlands (managed)	146,774	146,774	146,673	146,472	146,271	146,271	146,171	146,070	146,070	146,070	146,070	145,970

Source: Belize Forest Department Sector Summary Report 2024

6.9.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.9.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.9.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.9.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.9.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.10 Settlements (CRT 4.E)

6.10.1 Description and trend of GHGs in the category

A settlement is an area that is 0.5 hectare or more that has 20% of urban construction that fall within the categories of, cities, towns, villages, roads, aquaculture farms, mining, and other settlements.

There is no data available for conversions and associated emissions for the Wetlands subcategory.

6.10.2 Methodological issues of the category

The activity data for this category is noted below.

6.10.2.1 Specific activity data of the category

Table 6-84 E Settlements: activity data by land area (ha)

4.E Settlements Land area	Years													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.E.1. Settlements remaining settlements	NE	NE	NE	35,990	35,990	35,990	35,990	35,990	35,990	35,789	35,085	34,884	34,884	34,884
4.E.2. Land converted to settlements	NE	NE	NE	0	202	1,006	1,609	2,212	2,614	3,921	3,920	4,122	4,323	4,927
Total Settlements	NE	NE	NE	35,990	36,192	36,996	37,599	38,202	38,604	39,710	39,005	39,006	39,207	39,811

4.E Settlements Land area	Years											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.E.1. Settlements remaining settlements	34,482	34,482	34,482	34,381	34,381	33,979	33,879	33,879	33,879	33,879	33,879	33,879
4.E.2. Land converted to settlements	5,329	5,530	6,334	6,937	7,742	8,344	8,445	9,148	9,952	10,254	11,461	12,466
Total Settlements	39,811	40,012	40,816	41,318	42,123	42,323	42,324	43,027	43,831	44,133	45,340	46,345

Source: Belize Forest Department Sector Summary Report 2024

6.10.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.10.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.10.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.10.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.10.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.11 Other land (CRT 4.F)

6.11.1 Description and trend of GHGs in the category

Other lands are areas that are 0.5 hectare or more that has 80% of soils that fall in the categories of bare soil, bare soil rocks and beaches/sand dunes.

There is no data available for conversions and associated emissions for the Wetlands subcategory.

6.11.2 Methodological issues of the category

6.11.2.1 Specific activity data of the category

The activity data for this category is noted below.

Table 6-9 4F Other Land: activity data by land area (ha)

4.F Other land - Land area	Years													
	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.F.1. Other land remaining other land	NE	NE	NE	603	603	603	603	603	603	603	603	603	603	603

4.F Other land - Land area	Years											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.F.1. Other land remaining other land	603	603	603	603	603	603	603	603	603	603	603	603

Source: Belize Forest Department Sector Summary Report 2024

6.11.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.11.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.11.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.11.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.11.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

6.12 Harvested wood products (CRT 4.G)

6.12.1 Description and trend of GHGs in the category

Harvested Wood Products (HWP) refer to wood and paper products that store carbon after the wood is harvested from forests. According to the Intergovernmental Panel on Climate Change (IPCC), HWPs play a significant role in carbon accounting because they continue to store carbon throughout their lifecycle, which can range from a few years to several decades.

The Harvested Wood Products category, seen in Table 6-1, has mostly shown negative values, indicating net removals from stored carbon in wood and paper products.

6.12.1.1 Methodological issues of the category

6.12.1.2 *Specific activity data of the category*

The data was obtained for HWP is from FAO Statistics website.

Table 6-10 4G Harvested Wood Products: activity data by production, imports and exports (m3)

Activity Source	Activity Type	Year													
		1994	**1997**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
4.G.1.a. Sawnwood	Production	17700	17700	17700	17700	400	8000	8000	8000	15300	15300	15300	15300	15300	15300
	Imports	838	710	15084	365	8578	1547	2973	17014	25664	19624	26192	26192	21319	18313
	Exports	45	100	115	396	184	174	161	47	4389	2518	3199	1606	1722	2084
4.G.1.b. Wood panels	Production	NE	NE	NE	NE	NE	NE	NE	NE	4000	4000	4000	4000	4000	4000
	Imports	114	24	89	89	9	7	335	10	8476	13111	11112	13765	8458.21	16723
	Exports	NE	NE	682	395	485	343	343	1	449	647	806	521	639	575
4.G.2. Paper and paperboard	Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Imports	211	NE	27	165	175	174	159	543	8287	5239	6749	6826	8590.84	2166
	Exports	NE	NE	NE	NE	NE	901	NE	NE	756	718	692	614	614.14	638.14
Industrial Roundwood	Production	NE	NE	NE	NE	NE	NE	NE	NE	41000	41000	41000	41000	41000	41000
	Imports	NE	NE	61	423	38	215	96	563	823	3295	16113	1177	5159	5992
	Exports	NE	NE	NE	NE	61	25	152	184	656	312	180	77	6000	318
Wood pulp + Rec paper	Production	NE	NE	NE	NE	NE	NE	NE	NE	300	300	300	300	300	300
	Imports	15	15	46	114	632	915	458	69	6244	4875	4329	8550	6143.94	5188.45
	Exports	NE	NE	3	3	5	398	2363	536	461	2448	703	603	476.83	425
Roundwood (Fuelwood + Industrial Roundwood)	Production	NE	NE	NE	NE	NE	NE	NE	NE	126000	126000	126000	126000	126000	126000
	Imports	NE	NE	61	423	38	215	96	563	NE	NE	NE	NE	NE	NE
	Exports	NE	NE	NE	NE	61	25	152	184	NE	NE	NE	NE	NE	NE
Chips and particles	Imports	NE	273	273	3	3	30	126	2	126	126	126	126	3.35	1
Wood charcoal	Imports	15	15	15	15	15	96	2	2	7	10	3	4	11.99	4
	Exports	NE	NE	NE	NE	NE	21	21	20	20	20	0	0	45.58	0
Wood Residues	Imports	NE	NE	84	29	29	38	1	248	3	3	3	1	0.04	0.04
	Exports	1550	NE	NE	953	4279	1099	1099	1099	1099	1099	1099	1099	1099	1099

6.12.1.3 Emission factors applied in the category

Table 6-11 4G Harvested Wood Products: emission factors applied by GHG source or sinks

Activity Source	Half-life (years)	Average Lifetime	Decay rate k (k = ln(2)/ half-life)
Sawn Wood, Other Industrial Roundwood	30	43.281	0.023
Wood Panels	25	36.067	0.28
Paper Products	2	2.885	0.347

Source: 2006 IPCC Guidelines, Vol 4 Table 12.2 and IPCC Inventory Software Defaults

6.12.2 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

6.12.3 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

6.12.4 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

6.12.5 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

6.12.6 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

7 **Chapter 7** WASTE (CRT 5)

7.1 Description of the sector

Belize Waste sector can be divided into Solid Waste and Liquid Waste categories with subcategories Solid Waste Disposal (5.A) and Wastewater Treatment and Discharge (5.D). While, the category Incineration and Open burning (5C) does occur in Belize, more information is required for proper estimations. Carbon dioxide, Methane, and Nitrous oxide were the GHG gases for which the emissions were estimated in this sector.

There are significant gaps in both the solid and liquid waste categories. Steps have been taken from the Government of Belize, to address the need for improved waste management through the construction of several infrastructure facilities to properly dispose of waste including a National landfill and transfers stations (Figure 7-1Map of Sanitary Landfill & Transfer Stations in Belize). The solid waste sector still faces challenges with respect to waste composition data collection from the active transfer stations. The inactive transfer stations within the northern and southern part of the country are significantly impacting their surrounding municipalities in terms of waste disposal and data collection. Moreover, in the liquid waste sector exist data gaps because of the lack of enforcement of laws by the different entities in charge. 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.

Sanitary Landfill & Transfer Stations

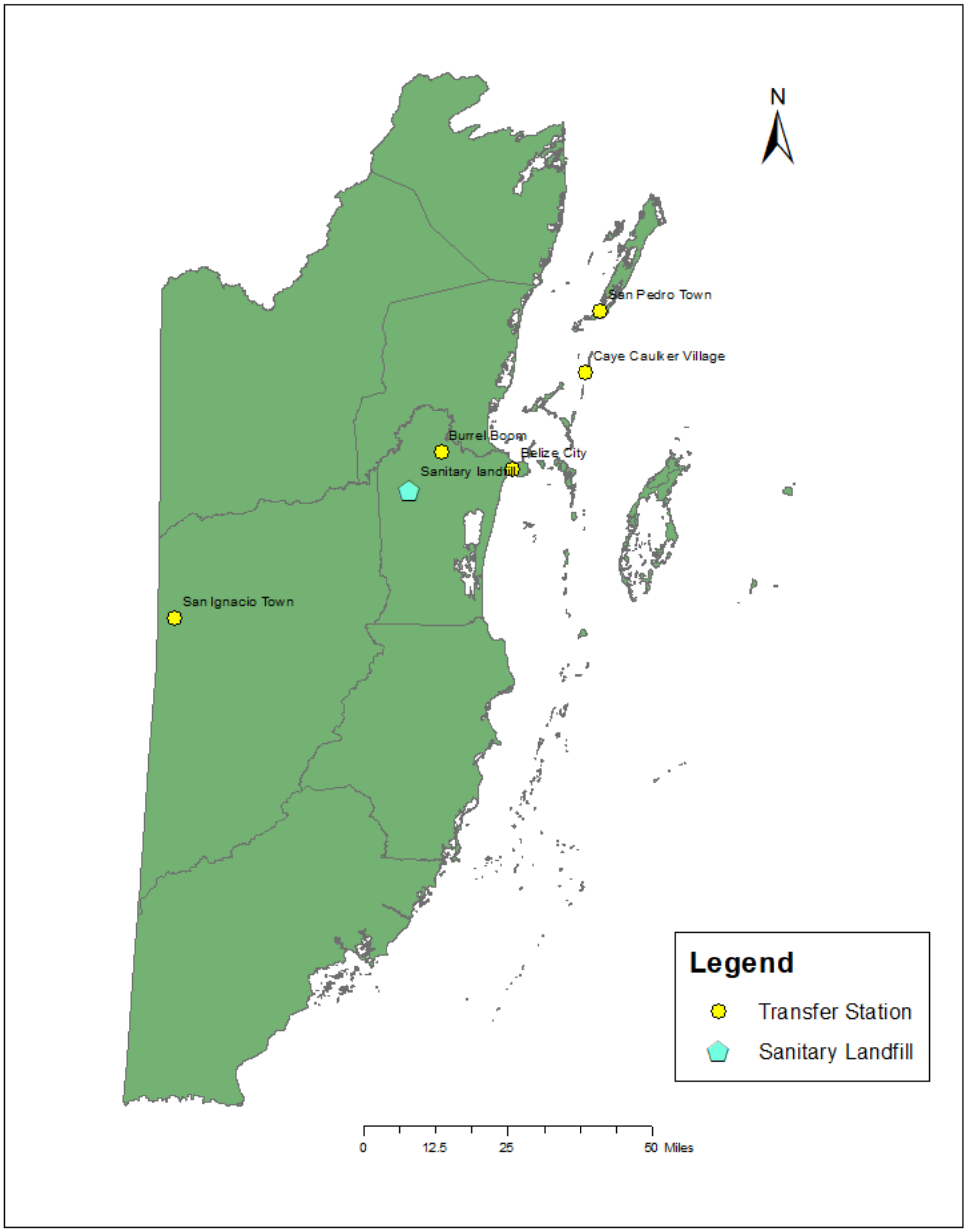


Figure 7-1Map of Sanitary Landfill & Transfer Stations in Belize

Institutional Arrangements

The Solid Waste Management Authority in Belize works in conjunction with Local Government bodies and other stakeholders, to ensure the safe and environmentally sound management of solid waste in Belize. However, it 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 aims to manage solid waste generated in the country in an environmentally sound manner. Also, 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.

The Authority is also now the lead in data collection and management for the waste sector. However, with the financial support of loans from IFCs the SWMA 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.

National Legislation

Legislation pertinent to the Waste sector includes:

- **Belize Environmental Protection Act, 1992**
- **Solid Waste Management Authority Act, 1991**
- **Effluent Limitations Regulations, 1996**

7.2 Trend in the sector's GHG emissions

The Waste sector was the largest emitting sector (55% of national emissions without LULUCF removals) followed by energy and agriculture sector, contributing 1574.19 kt CO2 eq in 2022.

Table 7-1 Waste sector: emissions by GHG, category and subcategory (kt) for 2022

Code	*GHG source categories*	*CO_2 (kt)*	*CH_4 (kt)*	*N_2O (kt)*	*NO_x (kt)*	*CO (kt)*	*NMVOC (kt)*	*SO_X (kt)*	*Total GHG (kt CO_2 eq)*
5	**Waste**		**1574.19**	**0.00436**					**1574.19**
5.A.	Solid waste disposal		0.10519						0.10519
5.A.1.	Managed waste disposal sites		0.06584						0.06584
5.A.2.	Unmanaged waste disposal sites		0.03936						0.03936
5.A.3.	Uncategorized waste disposal sites		NO						
5.B.	Biological treatment of solid waste		NO						
5.B.1.	Composting		NA						
5.B.2.	Anaerobic digestion at biogas facilities		NO	NO	NO	NO	NO		
5.C.	Incineration and open burning of waste	NE							
5.C.1.	Waste incineration	NE							
5.C.2.	Open burning of waste	NE							

5.D.	Wastewater treatment and discharge		1574.09	0.00436					1574.09
5.D.1.	Domestic wastewater		747.62	0.00436					747.62
5.D.2.	Industrial wastewater		826.47						826.47
5.D.3.	Other (please specify)								
5.E.	Other (please specify)	NO							
	Memo items								
5.F.1.	Long-term storage of C in waste disposal sites	NO							
5.F.1.a.	Annual change in total long-term C storage	NO							
5.F.1.b.	Annual change in total long-term C storage in HWP waste	NO							

Table 7-2 the presents in details the emissions generated through activities within the Waste sector. The total GHG emissions in the Waste sector increased significantly by 280% or 1,159.94 (kt CO2 eq) from 1994 to 2022. There was a notable spike in 2003, followed by fluctuations with another peak around 2017-2021. The only two contributors of GHG Emissions in the Waste sector are Wastewater Treatment and Discharge (5.D) and Solid Waste Disposal (5.A).

Solid Waste Disposal contributes less than 1/10th of a percent of total Waste emissions and has consistently shown minor but steadily increasing emissions, indicating an increase in solid waste management activities. Wastewater Treatment and Discharge (5.D) still makes up 99.99% of total emissions in the Waste sector and grew exponentially after 2006. Wastewater Treatment and Discharge increased by 166% over the 2 decades (592.27 kt CO2 eq in 2006 to 1,574.09 kt CO2 eq in 2022).

Domestic Wastewater (5. D.1.) emissions are consistent over the years with a steady increase, indicating continuous domestic wastewater generation and treatment. Between 1994 and 2006, Domestic Wastewater was the leading contributor (~99%) to overall Waste sector GHG emissions and averaging 49% thereafter. Industrial Wastewater (5.D.2.) made up less than 1/10th of a percent of total Wastewater Treatment and Discharge between 1994 and 2006, with a spike in 2003 where the total contribution was 66%. This may be due to industrial activities or changes in reporting and treatment processes. After 2006, Industrial wastewater contributed 52%, mostly Methane (CH4), of Wastewater Treatment and Discharge emissions.

Table 7-2 Waste sector: total GHG emissions by category (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
5	**Waste**	414.26	455.67	490.80	1561.24	592.30	1198.13	1321.16	1361.93	1554.09	1589.81	1625.13	1530.28	1682.14	1574.19
5.A.	Solid waste disposal	NE	0.01191	0.01969	0.02322	0.02735	0.03186	0.03621	0.08143	0.08717	0.09071	0.09495	0.09871	0.1021	0.10519
5.A.1.	Managed waste disposal sites	NE	0.00505	0.00854	0.00976	0.01151	0.01363	0.01584	0.04623	0.05159	0.05463	0.05798	0.0609	0.0635	0.06584
5.A.2.	Unmanaged waste disposal sites	NE	0.00686	0.01115	0.01346	0.01584	0.01823	0.02037	0.0352	0.03557	0.03608	0.03697	0.03781	0.0386	0.03936
5.A.3.	Uncategorized waste disposal sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.B.	Biological treatment of solid waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.B.1.	Composting	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B.2.	Anaerobic digestion at biogas facilities	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.C.	Incineration and open burning of waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C.1.	Waste incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C.2.	Open burning of waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D.	Wastewater treatment and discharge	414.26	455.65	490.78	1561.22	592.27	1198.10	1321.12	1361.85	1554.01	1589.72	1625.04	1530.18	1682.04	1574.09
5.D.1.	Domestic wastewater	414.26	455.49	490.44	537.36	591.55	618.61	644.94	697.73	729.60	746.48	763.22	778.87	793.38	747.62
5.D.2.	Industrial wastewater	0.	0.15873	0.3373	1023.86	0.72181	579.49	676.18	664.12	824.41	843.23	861.82	751.32	888.66	826.47
5.D.3.	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.E.	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total		**414.26**	**455.67**	**490.80**	**1,561.24**	**592.30**	**1,198.13**	**1,321.16**	**1,361.93**	**1,554.09**	**1,589.81**	**1,625.13**	**1,530.28**	**1,682.14**	**1,574.19**

Methane (CH_4) contributed 100% of the total recorded emissions at 1,574.19 kt CO_2 eq in 2022, while nitrous oxide (N_2O) contributed minimally at 0.00436 kt CO_2 eq. Methane emissions increased significantly from 414.26 kt CO_2 eq in 1994 to 1,574.19 kt CO_2 eq in 2022 possibly with the increase in population as well as increasing access to wastewater treatment facilities for a large part of the population.

Table 7-3 Waste sector: emissions by GHGs (kt CO2 eq)

GHG	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CH_4	414.26	455.66	490.79	1561.24	592.29	1198.13	1321.16	1360.46	1554.09	1589.80	1625.13	1530.28	1682.14	1574.19
N_2O	0.00216	0.00238	0.00283	0.0031	0.00345	0.00435	0.00454	1.47	0.00514	0.00436	0.00445	0.00454	0.00458	0.00436
Total	**414.26**	**455.67**	**490.80**	**1561.24**	**592.30**	**1198.13**	**1321.16**	**1361.93**	**1554.09**	**1589.81**	**1625.13**	**1530.28**	**1682.14**	**1574.19**

7.3 General methodological issues of the sector

The Solid Waste Management Authority (SWMA) and *a Board of Directors of the Solid Waste Management Authority* have the responsibility to deal with all matters pertaining to and conducive to the management of solid waste. This authority oversees seven transfer stations, and one National sanitary landfill located on a parcel of land of 370 acres 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, Belize City, Belmopan, and Dangriga. The National sanitary landfill is the final disposal location for waste generated from municipalities in the Western Corridor of Belize. The Western Corridor is served by waste disposal services including waste management at the National Sanitary Landfill.

The SWMA has conducted several investigations and reports in relation with solid waste management as it relates to the SWMA's roles and functions. In the year 2011, the first study was conducted, which was a *Hydroplan for Solid Waste Management Authority*, waste characterization study of the major population centres of the Western Corridor. 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. Moreover, the 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). In the year 2016, another study conducted by *Hydea Limited & SWMA was Solid Waste Master Plan for Emerging Tourism Areas* for the northern and southern corridors resulted in another average of 0*.72 kg/capita per day* (Hydea Limited & SWMA was Solid Waste Master Plan for Emerging Tourism Areas, July 2016). This new rate average was used because it was considered more accurate rate of waste generation at the national level. Therefore, for this inventory report it will use the new rate average. Methane was the GHG gases for which the emissions were estimated in this sector. Rates were established based on tons generated by municipalities (Western Corridor) weighted against populations being served for the specific year.

The calculations of the Greenhouse Gas (GHG) emissions from the Waste sector utilized the Tier 1 approach as limited data/information exists.

Table 7-4 Summary of relevant activity data, methods, and emission factors for IPPU sector inventory.

Source Category	Activity Source	Data Type	Data Source	CO_2		CH_4		N_2O	
4 Waste				MT	EF	MT	EF	MT	EF
5A Solid Waste Disposal	5A Solid waste disposal	Population, Waste per capita, Total Waste, % to SWDS, Total to SWDS Waste composition	Municipality Waste Management Municipal Authorities and Sanitary Landfill	NA	NA	T1	D	T1	D
5C Incineration and Open Burning of waste	NE								
5D Wastewater treatment and discharge and solvent use	5D1 Domestic wastewater	Organically degradable material in wastewater	Belize Water Services (BWSL)	T1	D	NA	NA	T1	D
	5D2 Industrial Wastewater	Industry production	Department of Environment	T1	D	NA	NA	T1	D

7.4 Solid waste disposal (CRT 5.A)

7.4.1 Description and trend of GHGs in the category

According to the 2006 IPCC Guidelines, Solid Waste Disposal refers to the process of managing municipal, industrial, and other waste types through facilities such as landfills or other disposal systems or Solid Waste Disposal Systems (SWDS). These sites are significant sources of methane (CH_4) due to the anaerobic decomposition of organic matter in waste.

Data of solid waste was available in cumulative tonnage per month for the western corridor of the country which includes San Ignacio/Santa Elena, Belize City, San Pedro, Burrell Boom and Caye Caulker from the establishment of the sanitary landfill. The data available are from municipalities in the western corridor, municipal waste is generally defined as waste collected by municipalities or other local authorities. Municipal Solid Waste (MSW) includes household waste, garden (yard) and park waste and Commercial/institutional waste. This data along with the population served by type of waste disposal or treatment method were key in entering data into the software.

In the latest inventory year (2022), emissions from the Solid Waste Disposal category steadily increased from earlier years to 0.10519 kt CO_2 eq. The relevant subcategories in Belize are shown in Table 7-5. Emissions from managed waste disposal sites (5.A.1) contributed 62.6% of total emissions in 2022, while unmanaged waste disposal sites (5.A.2) accounted for 37.4%. The main driver of the increase includes population growth, urbanization, and enhanced waste management practices. In comparison to the previous inventory year (2021), emissions increased slightly. Notably, there was a significant rise in emissions after 2012, likely resulting from more structured data collection and the expansion of managed disposal sites.

Table 7-5 Waste sector: total GHG emissions by Solid Waste Disposal subcategories (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
5.A.	Solid waste disposal	0.	0.01191	0.01969	0.02322	0.02735	0.03186	0.03621	0.08143	0.08717	0.09071	0.09495	0.09871	0.1021	0.10519
5.A.1.	Managed waste disposal sites	0.	0.00505	0.00854	0.00976	0.01151	0.01363	0.01584	0.04623	0.05159	0.05463	0.05798	0.0609	0.0635	0.06584
5.A.2.	Unmanaged waste disposal sites	0.	0.00686	0.01115	0.01346	0.01584	0.01823	0.02037	0.0352	0.03557	0.03608	0.03697	0.03781	0.0386	0.03936

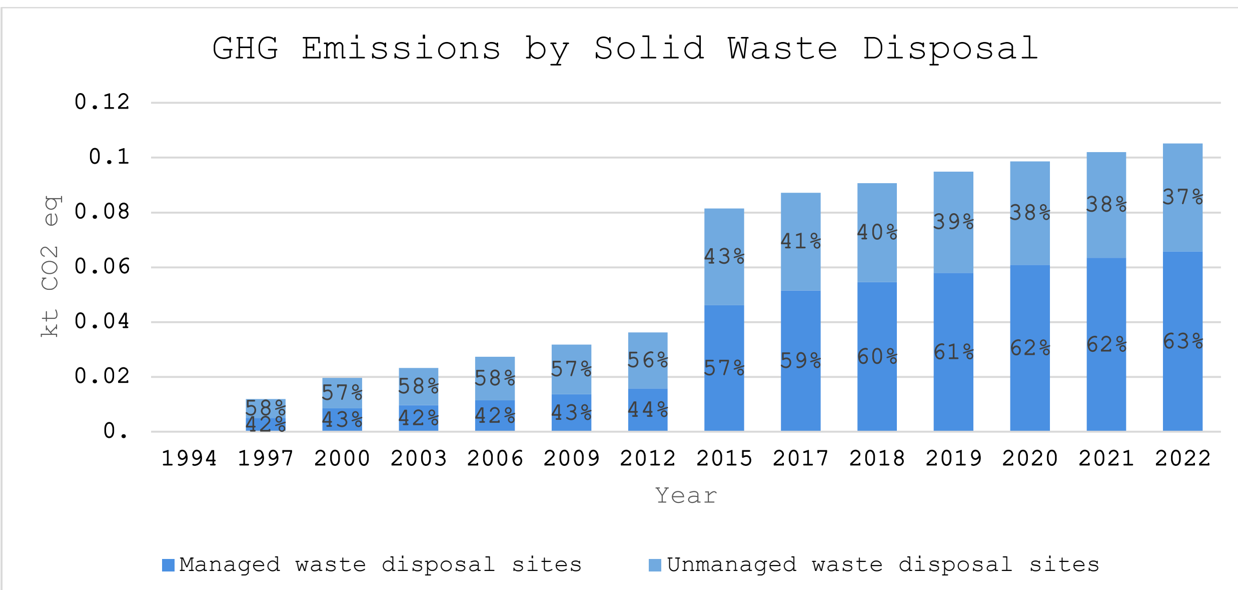


Figure 7-2 Solid Waste Disposal Sites Comparison

Table 7-6 shows a summary of the relevant SWDS in Belize. Managed Waste Disposal Sites include Managed anaerobic sites and Managed semi-aerobic sites. Unmanaged Waste Disposal sites include Unmanaged Shallow waste disposal sites and Unmanaged Deep. Unmanaged deep was an existing disposal option prior to 2012 in Belize City. Managed Waste Disposal sites are mostly practiced at the municipalities. Belize has one managed waste disposal site that fits the criteria of Managed semi-aerobic, the National Landfill which has characteristics fitting the description of a managed anaerobic site.

The second category of Managed Waste Disposal sites, are *Managed anaerobic sites*, that are those sites having characteristics of some level of management practiced mostly at the municipal levels (including sites serving the Placentia Peninsula area and the Independence/Big Creek/Cow Pen communities) because these are given some degree of control by local municipal bodies.

The disposal category *Unmanaged Waste Disposal* sites are divided into *Unmanaged shallow* sites and *Managed anaerobic* sites. Unmanaged shallow sites are used in rural communities having little or no waste disposal services; some which are considered “illicit” dumpsites, but are often designated disposal sites by local village authorities.

Table 7-6 Summary of Disposal Categories and Relevant to Belize

CATEGORY	SOFTWARE 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.

7.4.2 Methodological issues of the category

7.4.2.1 Activity data of the category

For 2018-2019, Solid Waste Disposal waste composition and production rate activity data is sourced from both Municipal Waste Management Authorities (managed anaerobic) and the Sanitary Landfill (managed semi-aerobic). Municipal Solid Waste (MSW) includes household waste, garden (yard) and park waste and Commercial/institutional waste which is received from managed anaerobic sites controlled by local municipal bodies in the districts of Corozal, Orange

Walk, Dangriga, Punta Gorda, and villages (Placencia, Burrell Boom and Independence). Available data of solid waste from Sanitary Landfill is in cumulative tonnage per month for the western corridor of the country which includes San Ignacio/Santa Elena (towns in the Cayo district), Belize City, Burrell Boom (village in Belize district) and Caye Caulker and San Pedro (Cayes).

For previous and recent years, population data from the Statistical Institute of Belize (SIB) were used to estimate emissions.

Table 7-7 5A Solid Waste Disposal: activity data by GHG source

Activity Source	Activity Type	Year													
		1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
5.A Solid Waste Disposal	Population	211000	232000	249800	273700	301300	315082	334158	356705	371352	378770	386121	392997	399373	397484
	Waste per capita	1.07	1.07	1.07	1.07	1.07	1.07	1.07	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	Total Waste	0.22577	0.24824	0.26729	0.29286	0.32239	0.33714	0.35755	0.25683	0.26737	0.27271	0.27801	0.28296	0.28755	0.28619
	% to SWDS	51	52	46	47	48	50	48	49	52	52	52	52	52	52
	Total to SWDS	0.11514	0.12908	0.12295	0.13764	0.15475	0.16857	0.17162	0.12585	0.13903	0.14181	0.14456	0.14714	0.14953	0.14882

Source: NCCO, Statistical Institute of Belize and IPCC Inventory Software

7.4.2.2 Emission factors applied in the category

The waste sector uses country specific waste per capita values derived from the 2011 Hydroplan and 2016 Hydea studies. The Hydroplan 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 which was used in calculations for the years 1994-2012. The 2016 study by Hydea Limited & SWMA was Solid Waste Master Plan for Emerging Tourism Areas for the northern and southern corridors resulted in another average of 0*.72 kg/capita per day* which became the new rate average and used from 2015-2022. Both studies also resulted in waste composition data percentages shown in Table 7-8.

Table 7-8 Solid Waste Category Waste Composition Rates

YEAR DATA USED	SOURCE	FOOD	GARDEN	PAPER	WOOD	TEXTILE	NAPPIES	PLASTICS OTHER INERT
1994-2012	HYDRO-PLAN	23.4	7.6	16	1.98	3.5	9.8	19
2015-2022	HYDEA	23.40	7.60	16.00	1.98	3.50	9.80	19.00
2018 -2022	AVERAGE USED	25.89	7.85	11.71	1.05	4.52	10.76	17.92

Default values were used for all other emission factors such as the Methane Correction Factor (MCF) for the SWDS types, BOD and % to SWDS following the 2006 IPCC Guidelines and IPCC Inventory Software.

Table 7-9 5A Solid Waste Disposal: emission factors applied by GHG source

Activity	Emission Factor
Solid Waste Disposal (Tier 1)	0.6 Kg CH4/Kg BOD
Methane Correction Factor – Solid Waste Disposal	
Unmanaged Deep	0.8
Shallow	0.4
Managed Aerobic	1.0
Managed semi-aerobic	0.5

Source: IPCC Inventory Software

7.4.3 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

7.4.4 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

7.4.5 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

7.4.6 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

7.4.7 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

7.5 Incineration and open burning of waste (CRT 5.C)

This category is not estimated in Belize – more information required

7.6 Wastewater treatment and discharge (CRT 5.D)

7.6.1 Description and trend of GHGs in the category

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories describes the Wastewater Treatment and Discharge category (5.6) as a source of greenhouse gas (GHG) emissions primarily due to the treatment processes and discharge of domestic, industrial, and commercial wastewater. The main GHGs emitted in this sector are methane (CH_4) and nitrous oxide (N_2O), though carbon dioxide (CO_2) can also be released depending on the treatment method.

Wastewater Treatment and Discharge includes Domestic wastewater and Industrial wastewater, where data is limited. Domestic wastewater treated by the Belize Water Services (BWSL) system was the only source of data that 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. The existing sewerage system in each municipality consists of conventional gravity sewers in zones (Belmopan – 2, Belize – 15 and San Pedro – 6). In each zone, sewage is collected by gravity at each pumping station and pumped to a neighboring zone towards the treatment works. Pump operations in each station are automatic and controlled by float switches. 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.

Sewage treatment and disposal of effluent varies for each of the municipality and are briefly set out below.

Table 7-10 Sewage treatment Types in Belize

Municipalities	Sewage treatment and disposal of effluent
Belize City	Treatment is provided by a two-cell facultative lagoon system and the treated effluent is discharged into the Caribbean Sea via canals cut through a mangrove wetland. The lagoon cells operate in series and are designed to provide 10 days' hydraulic retention time in each.
San Pedro town	Two facultative lagoons operating in series followed by one maturation pond with impermeable layers at their bottoms are used to treat the collected sewage in San Pedro Town. The treated effluent from the maturation pond is discharged to the surrounding mangrove wetland, via a dispersion pipe, for polishing before final disposal into the natural lagoon environment (the Caribbean Sea). The cells are each designed to provide a hydraulic retention time of 10 days.
Belmopan	A primary treatment plant made up of a settling tank and four sludge drying beds together with 1½ miles of 18″ diameter disposal pipe makes up the facility for treatment of sewage in Belmopan. The treated effluent (clarified wastewater) empties into the Belize River via the disposal pipe and the sludge is deposited onto the drying beds and later made available for agricultural uses.

Notably, the above information is only an estimate which they calculate. They do not keep track of sewage waste and these are the only municipalities in which they can do an estimation base on the type of drainage system.

Table 7-11 presents details of the subcategory. In the latest inventory year (2022), the total emissions for the wastewater treatment and discharge category were 1,574.09 kt CO_2 eq, which represents a significant portion of the waste sector's total emissions. This subcategory has experienced notable fluctuations since the base year of 1994, where emissions were much lower at 414.26 kt CO_2 eq. Over time, emissions have generally increased, with a marked peak in 2003 at 1,561.22 kt CO_2 eq, driven by rising wastewater treatment volumes and industrial discharge. However, emissions showed some variability in subsequent years, with a temporary increase in 2006 (592.27 kt CO_2 eq) and a substantial rise in 2009 (1,198.10 kt CO_2 eq). By 2022, emissions had slightly decreased compared to the previous year, reflecting a drop from 1,682.04 kt CO_2 eq in 2021.

In 2022, emissions were primarily driven by domestic wastewater, which accounted for approximately 47.5% of the total emissions (747.62 kt CO_2 eq), and industrial wastewater, which contributed 52.5% (826.47 kt CO_2 eq). Both sources are major contributors of methane (CH_4), with some nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions, depending on the treatment processes used. The change in emissions between the base year and 2022 is largely attributable to the increase in wastewater volumes and the expansion of industrial activities, which have placed higher demands on wastewater treatment. Furthermore, the variation between the most recent two inventory years (2021 and 2022) highlights a slight reduction in emissions, potentially reflecting changes in treatment efficiency or a temporary decline in industrial wastewater output.

Table 7-11 Waste sector: total GHG emissions by Wastewater Treatment and Discharge subcategories (kt CO2 eq)

Code	Subcategory	1994	1997	2000	2003	2006	2009	2012	2015	2017	2018	2019	2020	2021	2022
5.D.	Wastewater treatment and discharge	414.26	455.65	490.78	1561.22	592.27	1198.10	1321.12	1361.85	1554.01	1589.72	1625.04	1530.18	1682.04	1574.09
5.D.1.	Domestic wastewater	414.26	455.49	490.44	537.36	591.55	618.61	644.94	697.73	729.60	746.48	763.22	778.87	793.38	747.62
5.D.2.	Industrial wastewater	0.	0.15873	0.3373	1023.86	0.72181	579.49	676.18	664.12	824.41	843.23	861.82	751.32	888.66	826.47

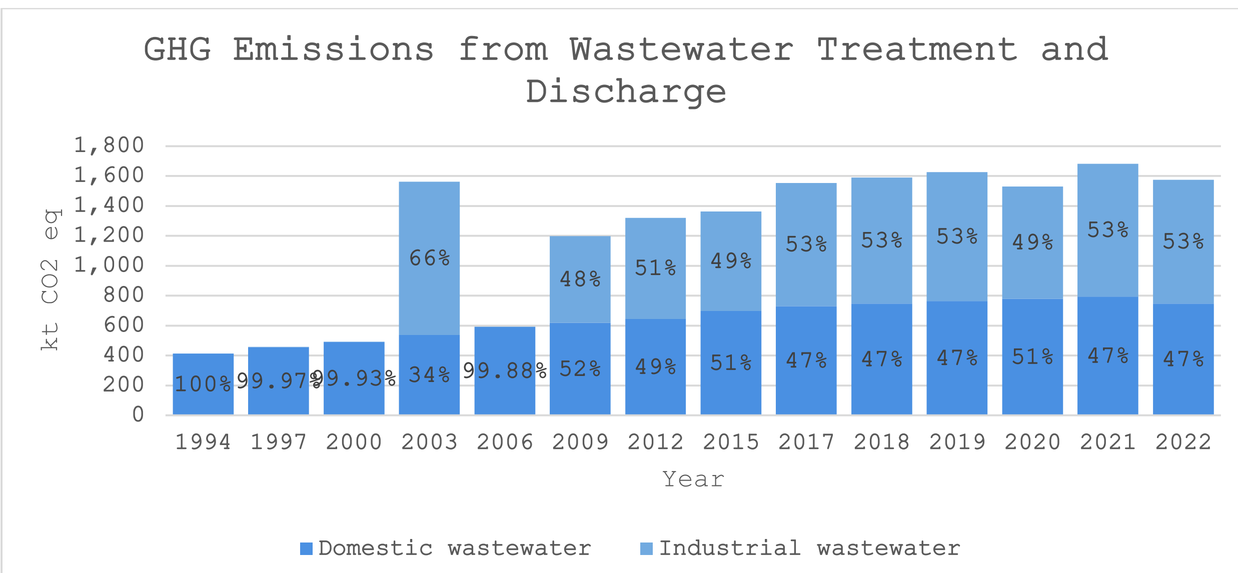


Figure 7-3 Sewage treatment and disposal of effluent

7.6.2 Methodological issues of the category

7.6.2.1 Activity data of the category

The Intergovernmental Panel on Climate Change (IPCC) software requires the total population data at the national level which is entered along with waste generation rates (source Table). These population data were obtained from the SIB.

The data in Table 7-12 outlines the population of Belize City, San Pedro Town and Belmopan City who utilize formal sewage system for 1994 - 2024, this fraction of the total population is used to estimate the population served by sewage plants. The ratio of 3.8 was used, which aligns with the average proportion of users on the sewage system for Belize city, San Pedro town and Belmopan City.

Table 7-12 5D1 Wastewater treatment and discharge: activity data by GHG source

Data	Unit	1994	1997	2000	2003	2006	2009	2011	2012
Total Population	people	211000	232000	249800	273700	301300	315082	328,375	334,158
Population covered by BWS	people	55526	61053	65737	72026	79289	82916	84,682	86,446
annual per capita protein consumption	kg/person/year	0.062	0.062	0.071	0.072	0.072	0.072	0.072	0.072

Data	Unit	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total Population	people	341,655	349,169	356,705	364,118	371,352	378,770	386,121	392,997	399,373	397,484	404,198	410,919
Population covered by BWS	people	88,733	91,026	93,325	95,586	97,793	100,056	102,299	104,397	106,342	100,209	100,422	101,760
annual per capita protein consumption	kg/person/year	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072

Activity data for industrial wastewater was based on organically degradable materials in wastewater for industrial consumption from alcohol refining, beer and malt, sugar refining, oranges and bananas.

Table 7-13 5.D2 Industrial Wastewater Activity data

Activity Source	Activity Type (tons of product generated/year	Year												
		1994	1997	2000	2003	2006	2009	2012	2015	2018	2019	2020	2021	2022
5.D.2 Industrial Waste Water	Alcohol Refining	NE	NE	NE	39.25	39.25	NE	NE	NE	NE	NE	59.76	81.27	82.37
	Beer & Malt	NE	NE	NE	5050	5050	NE	NE	NE	NE	NE	10712.59	14372.34	17802.68
	Sugar Refining	NE	NE	NE	NE	NE	918000	1186000	1186000	1708000	1794000	1537000	1894000	1804000
	Oranges	NE	NE	NE	NE	NE	229306.12	166244.90	166244.90	99306.12	86816.33	95102.04	54448.98	53387.76
	Banana	NE	NE	NE	NE	NE	68063.49	98829.93	98829.93	78675.74	83827.66	90721.09	97414.97	84607.71
	Shrimp	NE	NE	3854.88	7646.26	5442.18	3628.12	4254.42	4254.42	132699	7499.86	462.59	529.66	771.76

7.6.2.2 Emission factors applied in the category

A tier 1 approach was used for domestic and industrial wastewater emissions using 2006 IPCC Inventory software defaults. This approach uses the assumption that domestic and industrial wastewater are combined and treated under general conditions. The default emission factors, Biochemical Oxygen Demand (BOD5) is applied to the total wastewater volume or the population served by wastewater treatment systems. The BOD5 measures the organic material in the wastewater. Since anaerobic treatment is the most relevant to Belize, a methane correction factor (MCF) was included.

Table 7-14 Wastewater treatment and disposal emission factors

Activity	Emission Factor
Wastewater treatment and disposal	0.5 Kg CH_4/Kg BOD (Default value)
Methane Correction Factor – Domestic wastewater treatment and discharge	
Anaerobic shallow lagoon	0.2
Septic system	0.5
Latrine	0.7
Organically Biodegradable BOD (Biochemical Oxygen Demand)	*14.6 Kg BOD/yr*

Source: 2006 IPCC Guidelines, Vol 5 Chapt 6, Table 6.2 and 6.3

In the industrial sector, there is no formal registration or estimation of liquid waste generated by the industrial sector but an application form to discharge effluents. This form is overseen by the Department of Environment. The data gap is present as many industries do not submit the quantity of production or discharge. The data that was gathered was calculated from product generated per year and converted to tonnes, entered using the tier one approach in the inventory IPCC software, along with the projected effluent discharge in terms of M³ per tonne of product is calculated.

Table 7-15 Industrial Wastewater treatment and disposal emission factors

Activity	Wastewater generated (m3/t)	Chemical Oxygen Demand (kg COD/m3)	Weighted Emission Factor (kg CH_4/Kg COD)
Alcohol Refining	24	11	0.25
Beer & Malt	6.3	2.9	0.25
Sugar Refining	18	3.2	0.25
Oranges Vegetables, Fruits & Juices – (Orange)	20	5	0.25
Vegetables, Fruits & Juices – (Banana)	20	5	0.25
Fish processing (Shrimp)	*5*	*2.5*	0.25

7.6.3 Uncertainty and time-series consistency of the category

Refer to the Uncertainty Assessment section in Chapter 1, section 1.14.

7.6.4 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

7.6.5 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

7.6.6 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

7.6.7 Description of any flexibility applied to the category

Refer to the Flexibilities applied section in Chapter 1, section 1.17.

7.6.8 Category QA/QC

Compliant with QA/QC plan and implementation as outlined in Chapter 1, Section 1.13.

7.6.9 Category recalculations

Refer to description of inventory recalculations as outlined in Chapter 1, Section 1.10.

7.6.10 Planned improvements for the category

Refer to the planned improvements by sector in the national inventory improvement plan.

8 **Chapter 8**: RECALCULATIONS AND IMPROVEMENTS

8.1 Explanatory information and justification for recalculations

Recalculations of previous inventories were done, where possible, using the old data retrieved from the archives and early inventory reports, however with many data gaps. All available estimates from all sectors were recalculated using the Global Warming Potentials from the IPCC's 5th Assessment report, and all emission factors updated to those reported within this broader report.

Further effort and investigation with sector experts is required to fill in the gaps of the time series 1994 - 2022, notably, those in the energy sector from 1994 – 2012, and the LULUCF sector from 1994 – 1999. This continues to be a priority to enhance the completeness and transparency of future national inventory reports.

8.2 Recalculations done for the LULUCF Sector

As most of the key categories arise from the LULUCF sector, a comparison of previous inventories using different approaches is discussed below.

As inventory capacity and data availability improve the methods used to prepare emissions and removal estimates will likely be update and refine. Such changes or refinement are desirable when the result in more accurate and complete estimate. Both methodological changes and refinements over time are essential part of improving inventory quality.

According to the 2006 IPCC guidelines, it is good practice to change or refine methods when:

- ✓ Available data have change.

- ✓ Previously used method is not consistent with the 2006 IPCC guidelines for a specific category.
- ✓ A category has become key.
- ✓ Previously used method is insufficient to reflect mitigation activities transparently.
- ✓ Capacity for inventory preparation has increased
- ✓ New inventory methods become available.
- ✓ Errors require correction.

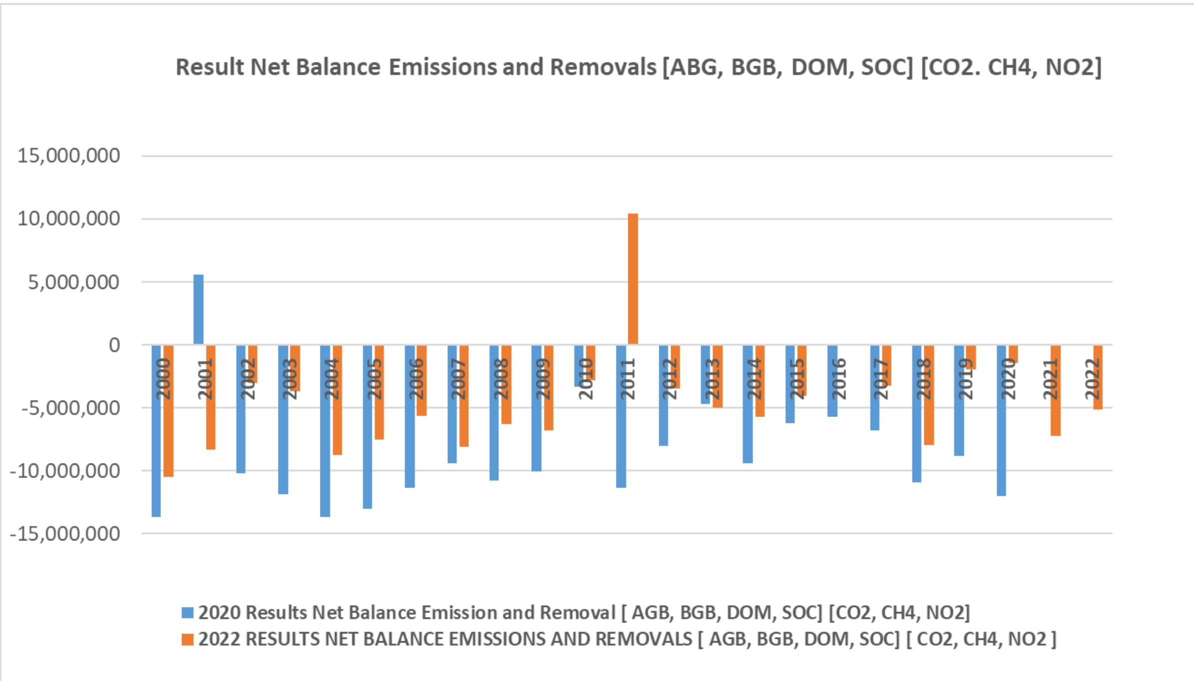


Figure 8-1 Comparison of Net Balance Emissions and Removals for Two Distinct Activity Data Collection Methods.

The graph highlights the emissions and removals captured through two distinct activity data collection methods over different periods. The initial data collection phase, spanning 2000 to 2020, relied on the **Collect Earth Desktop platform**. This method required extensive manual labor and faced several limitations. The survey table used could only record initial and final land use, land-use changes, and one main disturbance. Data from systematically distributed 5% reassessment plots were restricted to one operator per plot, requiring daily downloads and manual concatenation of CSV files. Additionally, the lack of robust satellite imagery hindered detailed assessments.

For this greenhouse gas inventory, emission factors for above-ground biomass included Tier 3 for mature broad-leaf forests, Tier 1 for secondary broad-leaf forests, and Tier 2 for pine, mangrove, and forest plantations. Below-ground biomass emission factors applied Tier 1 uniformly across all ecosystem types.

The second data collection phase, covering 2000 to 2022, introduced significant methodological and technological advancements. The **Collect Earth Online application**, in conjunction with the

Land Use Application (LUA), allowed for the recording of multiple land uses, land-use changes, and disturbances per plot. To enhance data reliability, three operators could review the same plot, reducing uncertainty. Furthermore, over 50% of the operators involved in the initial phase participated in this phase, leveraging their expertise.

The use of high-resolution satellite imagery, complemented by auxiliary shape files, provided operators with a comprehensive understanding of national land-use dynamics. Automation of data archiving and concatenation further streamlined processes. For above-ground biomass, Tier 3 emission factors were employed for mature and secondary broad-leaf forests, with Tier 2 applied to pine, mangrove, and forest plantations. Below-ground biomass emission factors improved to Tier 2 for most ecosystems, while forest plantations retained Tier 1. Notably, Dead Organic Matter (DOM) emission factors advanced from Tier 1 to Tier 3 for secondary broad-leaf and pine forests, and litter stock emission factors for secondary broad-leaf forests also improved to *Tier 3*.

Enhancements to the foundational platform were pivotal in improving efficiency and accuracy. The use of macros automated complex tasks, including formula calculations and color coding for land-use categories and disturbances. This not only reduced human error but also enabled a clearer visual representation of land-use dynamics at the national level.

The **Land Use Assessment application** automatically generated land-use and disturbance codes for each plot, detailing all changes and corresponding years. A transition to equation-based calculations (covering gains, losses, conversions, DOM, SOC, and non-CO_2 emissions) enabled annual assessments of emissions and removals for each plot, regardless of the land use. This approach captured multiple land-use transitions in a single analysis and applied specific equations for each scenario.

The methodology also introduced differentiation of disturbances based on their regeneration potential. Group 1 disturbances, such as agriculture, infrastructure, grazing, and mining, were classified as having no expected regeneration. Group 2 disturbances, including hurricanes, logging, fires, and pests, were categorized based on their varying regeneration potential. Additional advancements included the integration of carbon pools such as DOM and SOC, as well as transfers among pools (e.g., from above-ground biomass to DOM after disturbances like hurricanes). A detailed results sheet provided insights into subcategories of land use and specific disturbance types.

Overall, these enhancements significantly improved the precision, reliability, and scope of greenhouse gas inventory assessments, aligning them with evolving national and international requirements.

8.3 Areas of improvement and/or capacity building in response to the review process

Belize recognizes the importance of a continuous improvement of its inventory over time, whether it is to identify or regularly update, and includes information on areas of improvement as part of its BTR. Improvements to the inventory generally resulted from recommendations from:

(i) team of technical experts (TTE) for the 1BURs and in the future, the TER team of the BTRs;

(ii) Continuous improvements through activities such as consultative studies, QA workshop, peer reviews, QA/QC and verification activities (in accordance with the QA/QC Plan) etc.

(iii) The areas for improvement outlined in this report reflect both ongoing issues from previous reports and new challenges that have been identified. A detailed explanation by sector along with suggested improvement plans and timelines are shown in Table 10-4.

8.4 Belize's National Inventory Improvement Plan

A major area of improvement is the data gaps across sectors. Due to the data gaps, a quantitative Uncertainty Assessment could not be conducted in this report.

The time series data, particularly from 1994-2002 will need to be addressed through backfilling and recalculations using updated methodologies where possible. Smaller sectors like IPPU and Waste also have insufficient subsector data that lead to the use of assumptions and extrapolations. Overall, data reporting is not always consistent. Data on one subsector may be available for previous reports but not available in all reports. In addition, growing populations and industries, particularly the Tourism sector, are generating more emission data that needs to be accounted for in all sectors especially Transport. Data collection protocols and surveying can create more accurate and complete reporting.

In addition to the data gaps, strengthening of technical capacity is needed. Increased financial support through sustainable funding mechanisms, multilateral banks and public-private partnerships along with additional training for technical experts would help improve the efficiency of preparing and executing the GHG inventory cycle. The establishment of standardized protocols and a centralized database would also support more robust data collection and retrieval. A centralized system would also provide cross-sectoral benefits, particularly for sectors such as IPPU and Energy, which sometimes have difficulty accurately allocating emissions between fuel combustion and industrial processes.

Table 10-2.
Summary of areas of improvement identified and how the country addresses them

Sector	Category	Areas of Improvement	Improvements identified	Responsible Entity	Time frame for application	Priority Level
Energy	General	Data gaps from 2000-2009 making time series reporting incomplete	Establish a reliable archival data similar to that of 2012-2022	MPUELE, NCCO	Medium (1-2 years)	Medium

		Need for proper fuel categorization during reporting (e.g. soybean oil, LFO/HFO)	Develop parameters for these fuels not specified by IPCC or create proper matching system that accounts for fuel characteristics within the existing fuel categories	MPUELE, NCCO	Medium (1-2 years)	Low
		Reference and Sectoral Approach were only conducted for 2021 and 2022.	Improvement in energy statistics through availability of updated energy balances	MPUELE, NCCO	Medium (1-2 years)	Medium
	1.A.1. Energy industries	While renewable sources account for 58.6% of in-country generated supply, there's a need for better tracking of emissions from the combined use of petroleum fuels and renewable sources, including from imported electricity from Mexico.	Establish integrated emissions tracking for renewable energy mix	MPUELE, NCCO	Medium (1-2 years)	Medium
	1.A.2. Manufacturing industries and construction	Need heavy-duty construction monitoring protocol	Develop monitoring protocol for heavy-duty construction equipment emissions	MPUELE, NCCO	Medium (1-2 years)	Medium
	1.A.3. Transport	Growing tourism industry has led to expansion in transport sector emissions requiring better monitoring systems. Need for improved tracking of emissions from local maritime ferries and aviation fleet associated with tourism	Conduct comprehensive transport sector survey to quantify fuel consumption for diesel and gasoline, marine transportation and fishing fleet from small skiffs and implement tracking system for marine transport emissions.	MPUELE, NCCO	Immediate (0-12 months)	High
		Previously considered insignificant, the local aviation transport sector now shows increased petroleum fuel usage requiring	Develop tracking system for aviation sector emissions	MPUELE, NCCO	Immediate (0-12 months)	High

		better tracking systems				
		Road transport is a key category. No disaggregated data for vehicle and fuel type, and distance travelled	Improve online vehicle registration system or conduct road transport survey	MPUELE, NCCO	Immediate (0-12 months)	High
	1.B. Fugitive emissions from fuels	Data limitations prevent the estimation of fugitive emissions from natural gas flaring from Belize's small oil and gas industry	Create database for fugitive emissions from oil and gas activities	MPUELE, NCCO	Medium (1-2 years)	Medium
IPPU	General	Slow growth of industrial activities makes comprehensive data collection challenging.	Implement real-time data collection and utilize a centralized database with different stakeholders.	DOE, NCCO	Long (2-3 years)	Medium
	2.A. Mineral industry	Limited data on emissions from road improvement projects, particularly those using imported cement. Also a need for better tracking of emissions from construction activities and material use.	Implement tracking system for construction sector emissions and monitor emissions from road improvement projects.	DOE, NCCO	Medium (1-2 years)	Medium
	2.D. Non-energy products from fuels and solvent use	Difficulty in estimating GHG emissions from non-energy sources and challenges with allocating emissions between fuel combustion and industrial processes (e.g. asphalt)	Create formal reporting system for industrial emissions data and develop a comprehensive industrial processes database.	DOE, NCCO	Medium (1-2 years)	Medium
	2.F. Product uses as substitutes for ODS	Increasing refrigerant use due to growth in tourism industry requiring better monitoring systems. Also need improved tracking of emissions from air conditioning in	Establish data collection protocols for refrigerant use in tourism sector.	DOE, NCCO	Medium (1-2 years)	Medium

		both accommodations and transportation.				
		Activity data on multiple HFC refrigerant gases but only HFC-134a is included in emission calculations.	Investigate the potential of emissions from all refrigerants that were not estimated apart from the HFC-134a.	DOE, NCCO	Long (2-3 years)	Medium
	2.H.2 Food and Beverage Industry	Limited data availability for food and drink processing emissions, including production of liquor, bread (wheat), processed meats, sugar, and animal feeds. Software calculations show negligible or zero emissions for some processes like bread production, requiring verification.	Create monitoring systems for food and beverage production emissions and verify emissions for processes like bread/wheat production.	DOE, NCCO	Medium (1-2 years)	Medium
Waste	5.A. Solid waste disposal	The current report omits previous data from municipalities and landfills. Additionally, the waste per capita metric is currently measured in kg/cap/day, but for more accurate reporting, it should be adjusted to kg/cap/year.	Collaborate with municipal authorities and Belize Solid Waste Management Authority (BSWaMA) to obtain regional waste generation and municipality-specific information (also review types of SWDS in the country). In addition, verify country-specific factors such as waste per capita and waste composition % from previous studies.	BSWaMA, NCCO	Medium (1-2 years)	Medium
	5.C.2. Open burning of waste	Incomplete data on open burning of waste	Establish data collection protocol for open burning emissions	BSWaMA, NCCO	Long (2-3 years)	Medium
	5.D.2. Industrial wastewater	Incomplete data on industrial wastewater volumes	Implement industrial waste monitoring protocols and surveying to track waste water discharge and treatment	BSWaMA, NCCO	Immediate (0-12 months)	High

	5.D. Wastewater treatment and discharge	Insufficient tracking of domestic and commercial wastewater emissions. Data regarding number of connections to the waste (water) treatment systems need to be updated at municipal and village levels for the entire country.	Develop comprehensive wastewater tracking system integrating waste management information systems and advanced emissions monitoring for all waste categories. Particularly, coordinate with Belize Water Services (BWS) to determine the percentages of urban and rural population using different treatment systems.	BSWaMA, NCCO	Immediate (0-12 months)	High
		Need for updated production and waste water generation rates	Develop industry specific values for production and waste water generation rates for improved GHG estimates	BSWaMA, NCCO	Immediate (0-12 months)	High
Agriculture	3.A. Enteric fermentation	Data gaps in livestock for horses, mules and asses	Conduct survey to assess data gaps	MAFSE, NCCO	Medium (1-2 years)	Medium
	3.D. Agricultural soils	Insufficient data on synthetic fertilizers	Analyze the synthetic fertilizers in use and their chemical composition to improve their inclusion in the national inventory.	MAFSE, NCCO	Long (2-3 years)	Medium
	3.F. Field burning of agricultural residues	Data on cropland (sugarcane) burning was included in previous reports but not available in recent data	Establish time series data for sugarcane fields that undergo secondary burning using land area (ha).	MAFSE, NCCO	Immediate (0-12 months)	High
LULUCF	General	Gaps in time series from 1994-2000	Establish time series data for 1994-2000 using current advanced methodology and coordinate with Forestry experts to document process.	Belize Forest Department, NCCO	Immediate (0-12 months)	High
General	**Technical and Financial Capacity Gaps**	Insufficient financial resources for comprehensive monitoring	Establish sustainable funding mechanisms through multilateral development banks and develop public-private partnerships.	NCCO	Medium (1-2 years)	High
		Limited technical capacity and expertise for comprehensive GHG inventory preparation	Implement advanced training modules and implement more frequent process reviews and check ins to ensure continuous progress and preparedness for inventory submission.	NCCO	Medium (1-2 years)	High

		In addition, implement timeline requirements for data submission.			
	Need for improved data collection and management systems across sectors	Establish integrated data management systems, develop centralized data repository, and implement cross-sector data sharing protocols.	NCCO	Medium (1-2 years)	High
Cross-sectoral Gaps	Need for improved coordination between different sectors for data collection and sharing	Establish inter-sector coordination mechanisms and implement cross-sector data sharing protocols.	NCCO	Medium (1-2 years)	High
	Difficulty using UNFCCC ETF tool for generation of CRTs using Json file import from the IPCC Inventory Software	Provide more hands-on support for technical difficulties with support the UNFCCC Technical Support Unit	NCCO	Immediate (0-12 months)	High
Uncertainty Assessment	Need for quantitative data for complete uncertainty assessment	Address gaps in data collection and retrieval for each sector (archival and current years) to conduct a proper evaluation of uncertainty.	NCCO	Immediate (0-12 months)	High

Notes: MPUELE - Minister of Public Utilities, Energy, Logistics & E-Governance (Energy Unit), NCCO – National Climate Change Office, DOE – Department of Energy, BSWaMA – Belize Solid Waste Management Authority

ANNEXES TO THE NATIONAL INVENTORY DOCUMENT

Annex I: Key categories

Description of the approach used for identifying key categories, if different from the IPCC Tier 1 approach

In accordance with the 2006 IPCC Guidelines, Approach 1 was used to identify the key categories using a predetermined cumulative emissions threshold. As inventories had been developed for more than one year, both Level Assessment (Approach 1) and Trend Assessment (Approach 1) were conducted based on the national GHG inventory with LULUCF using equations provided.

Table Annex I - 1 Year 2022 Key Categories Level Assessment with LULUCF

IPCC category code	IPCC Category	Greenhouse gas	Emissions (Gg CO2-eq)	Level assessment (% contribution)	Cumulative value
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-9418.163333	0.5397	0.5397
3.B.2.b	Land Converted to Cropland	CARBON DIOXIDE (CO2)	2214.615333	0.1269	0.6666
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO2)	2054.308667	0.1177	0.7843
4.D	Wastewater Treatment and Discharge	METHANE (CH4)	1574.085428	0.0902	0.8745
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO2)	508.761	0.0292	0.9037
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	472.65909	0.0271	0.9308
3.A.1	Enteric Fermentation	METHANE (CH4)	287.739774	0.0165	0.9473
3.B.1.b	Land Converted to Forest land	CARBON DIOXIDE (CO2)	-253.4572333	0.0145	0.9618
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	197.562388	0.0113	0.9731
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO2)	153.7988	0.0088	0.9819
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO2)	-94	0.0054	0.9873
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO2)	44.22151482	0.0025	0.9898
3.D.1	Harvested Wood Products	CARBON DIOXIDE (CO2)	-42.85350609	0.0025	0.9923
3.B.3.a	Grassland Remaining Grassland	CARBON DIOXIDE (CO2)	-32.362	0.0019	0.9942
3.A.2	Manure Management	METHANE (CH4)	14.68163396	0.0008	0.9950
1.A.3.a	Civil Aviation - Liquid Fuels	CARBON DIOXIDE (CO2)	12.52255	0.0007	0.9957
1.A.3.c	Railways - Liquid Fuels	CARBON DIOXIDE (CO2)	12.1961708	0.0007	0.9964
3.C.4	Direct N2O Emissions from managed soils	NITROUS OXIDE (N2O)	8.980813208	0.0005	0.9969
3.C.7	Rice cultivation	METHANE (CH4)	7.788317046	0.0004	0.9974
3.C.6	Indirect N2O Emissions from manure management	NITROUS OXIDE (N2O)	6.396327098	0.0004	0.9977
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	6.16366415	0.0004	0.9981
1.A.4	Other Sectors - Biomass - solid	METHANE (CH4)	5.64144	0.0003	0.9984
1.A.1	Energy Industries - Biomass - solid	NITROUS OXIDE (N2O)	5.166605581	0.0003	0.9987
3.C.3	Urea application	CARBON DIOXIDE (CO2)	4.822898667	0.0003	0.9990
1.A.1	Energy Industries - Biomass - solid	METHANE (CH4)	4.094291215	0.0002	0.9992
3.C.5	Indirect N2O Emissions from managed soils	NITROUS OXIDE (N2O)	3.816845613	0.0002	0.9994
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH4)	3.66844548	0.0002	0.9997
3.A.2	Manure Management	NITROUS OXIDE (N2O)	1.57417986	0.0001	0.9997
1.A.3.d	Water-borne Navigation - Liquid Fuels	CARBON DIOXIDE (CO2)	1.02564	0.0001	0.9998
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N2O)	0.711896	0.0000	0.9998
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO2)	0.669328	0.0000	0.9999
2.H	Other	CARBON DIOXIDE (CO2)	0.6326621	0.0000	0.9999
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH4)	0.461986	0.0000	0.9999
2.A.2	Lime production	CARBON DIOXIDE (CO2)	0.21225	0.0000	1.0000
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N2O)	0.19369115	0.0000	1.0000
3.C.2	Liming	CARBON DIOXIDE (CO2)	0.12452	0.0000	1.0000
4.A	Solid Waste Disposal	METHANE (CH4)	0.105190643	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N2O)	0.094106369	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	NITROUS OXIDE (N2O)	0.092909	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH4)	0.049716572	0.0000	1.0000

1.A.3.c	Railways - Liquid Fuels	NITROUS OXIDE (N2O)	0.008814505	0.0000	1.0000
1.A.3.d	Water-borne Navigation - Liquid Fuels	NITROUS OXIDE (N2O)	0.007844	0.0000	1.0000
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N2O)	0.004361912	0.0000	1.0000
1.A.3.c	Railways - Liquid Fuels	METHANE (CH4)	0.004233382	0.0000	1.0000
1.A.3.d	Water-borne Navigation - Liquid Fuels	METHANE (CH4)	0.0029008	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	METHANE (CH4)	0.0024542	0.0000	1.0000
1.B.2.b	Natural Gas	CARBON DIOXIDE (CO2)	0.001896718	0.0000	1.0000
1.B.2.b	Natural Gas	METHANE (CH4)	3.33822E-05	0.0000	1.0000
1.B.2.b	Natural Gas	NITROUS OXIDE (N2O)	8.97554E-06	0.0000	1.0000

Table Annex I - 2 Trend Assessment 2012-2022 with LULUCF

IPCC category code	**IPCC Category**	**Greenhouse gas**	**Year 2012 Emissions (Gg CO2-eq)**	**Year 2022 Emissions (Gg CO2-eq)**	**Trend assessment**	**% Contribution to Trend Assessment**	**Cumulative Total**
3.B.2.b	Land Converted to Cropland	CARBON DIOXIDE (CO2)	3971.41	2214.615	0.077	0.345	0.345
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-9994.42	-9418.163	0.071	0.316	0.660
4.D	Wastewater Treatment and Discharge	METHANE (CH4)	1321.12	1574.085	0.019	0.084	0.744
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO2)	184.51	508.761	0.018	0.080	0.824
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO2)	2421.37	2054.309	0.010	0.043	0.868
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	36.71	197.562	0.009	0.039	0.906
3.A.1	Enteric Fermentation	METHANE (CH4)	162.97	287.740	0.007	0.032	0.939
3.B.1.b	Land Converted to Forest land	CARBON DIOXIDE (CO2)	-118.41	-253.46	0.007	0.030	0.969
3.D.1	Harvested Wood Products	CARBON DIOXIDE (CO2)	1.62	-42.85	0.002	0.011	0.979
3.B.3.a	Grassland Remaining Grassland	CARBON DIOXIDE (CO2)	-57.53	-32.36	0.002	0.007	0.986
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	481.59	472.66	0.001	0.007	0.993
3.A.2	Manure Management	METHANE (CH4)	10.23	14.68	0.000	0.001	0.994
1.A.3.c	Railways - Liquid Fuels	CARBON DIOXIDE (CO2)	7.94	12.20	0.000	0.001	0.995
1.A.3.a	Civil Aviation - Liquid Fuels	CARBON DIOXIDE (CO2)	9.29	12.52	0.000	0.001	0.996
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH4)	0.71	3.67	0.000	0.001	0.997
3.C.7	Rice cultivation	METHANE (CH4)	5.20	7.79	0.000	0.001	0.997
3.C.5	Indirect N2O Emissions from managed soils	NITROUS OXIDE (N2O)	1.98	3.82	0.000	0.000	0.998
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO2)	46.35	44.22	0.000	0.000	0.998
2.A.2	Lime production	CARBON DIOXIDE (CO2)	1.59	0.21	0.000	0.000	0.998
1.A.1	Energy Industries - Biomass - solid	NITROUS OXIDE (N2O)	4.38	5.17	0.000	0.000	0.999
1.A.1	Energy Industries - Biomass - solid	METHANE (CH4)	3.47	4.09	0.000	0.000	0.999
3.C.4	Direct N2O Emissions from managed soils	NITROUS OXIDE (N2O)	8.77	8.98	0.000	0.000	0.999

3.C.6	Indirect N2O Emissions from manure management	NITROUS OXIDE (N2O)	6.11	6.40	0.000	0.000	0.999
3.C.2	Liming	CARBON DIOXIDE (CO2)	0.94	0.12	0.000	0.000	0.999
3.C.3	Urea application	CARBON DIOXIDE (CO2)	4.47	4.82	0.000	0.000	1.000
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO2)	1.35	0.67	0.000	0.000	1.000
2.H	Other	CARBON DIOXIDE (CO2)	1.09	0.63	0.000	0.000	1.000
1.A.4	Other Sectors - Biomass - solid	METHANE (CH4)	5.90	5.64	0.000	0.000	1.000
3.A.2	Manure Management	NITROUS OXIDE (N2O)	1.50	1.57	0.000	0.000	1.000
4.A	Solid Waste Disposal	METHANE (CH4)	0.04	0.105	0.000	0.000	1.000
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	6.72	6.164	0.000	0.000	1.000
1.A.3.a	Civil Aviation - Liquid Fuels	NITROUS OXIDE (N2O)	0.07	0.093	0.000	0.000	1.000
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N2O)	0.07	0.094	0.000	0.000	1.000
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N2O)	0.74	0.712	0.000	0.000	1.000
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH4)	0.04	0.050	0.000	0.000	1.000
1.A.3.c	Railways - Liquid Fuels	NITROUS OXIDE (N2O)	0.01	0.009	0.000	0.000	1.000
1.A.3.c	Railways - Liquid Fuels	METHANE (CH4)	0.00	0.004	0.000	0.000	1.000
1.A.3.a	Civil Aviation - Liquid Fuels	METHANE (CH4)	0.00	0.002	0.000	0.000	1.000
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N2O)	0.00	0.004	0.000	0.000	1.000
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO2)	0.00	-94.00	0.000	0.000	1.000
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO2)	0.00	153.80	0.000	0.000	1.000
1.A.3.d	Water-borne Navigation - Liquid Fuels	CARBON DIOXIDE (CO2)	0.00	1.026	0.000	0.000	1.000
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH4)	0.00	0.462	0.000	0.000	1.000
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N2O)	0.00	0.194	0.000	0.000	1.000
1.A.3.d	Water-borne Navigation - Liquid Fuels	NITROUS OXIDE (N2O)	0.00	0.008	0.000	0.000	1.000
1.A.3.d	Water-borne Navigation - Liquid Fuels	METHANE (CH4)	0.00	0.003	0.000	0.000	1.000
1.B.2.b	Natural Gas	CARBON DIOXIDE (CO2)	0.00	0.002	0.000	0.000	1.000
1.B.2.b	Natural Gas	METHANE (CH4)	0.00	3.33822E-05	0.000	0.000	1.000
1.B.2.b	Natural Gas	NITROUS OXIDE (N2O)	0.00	8.97554E-06	0.000	0.000	1.000

Annex II: Uncertainty assessment

Please see Chapter 1, section 1.14 on General Uncertainty Assessment.

Annex III: Detailed description of the reference approach

The following tables show the results in comparing reference approach with sectoral approach of fuels consumed and emissions in the energy sector for 2021 and 2022. These years had reliable energy statistics data to be able to make this assessment.

Table Annex I - 3 Comparison of reference and sectoral approach of fuels consumed in the energy sector for 2021

	Reference Approach				Sectoral Approach		Difference	
Fuel	**Apparent Consumption (TJ)**	**Excluded consumption (TJ)**	**Apparent Consumption (excluding non-energy use and feedstock) (TJ)**	**CO2 Emissions (Gg)**	**Energy Consumption (TJ)**	**CO2 Emissions (Gg)**	**Energy Consumption (%)**	**CO2 Emissions (%)**
Aviation Gasoline	33.2	0	33.2	2.325106667	9.1	0.637	264.8351648	265.0088959
Bitumen	0	0	0	0	119.0322	9.6019308	-100	-100
Crude Oil	897.9	0	897.9	65.846	897.9259144	65.81796953	-0.002886029	0.042587875
Gas/Diesel Oil	3009.7	0	3009.7	222.9184467	3009.651442	223.0151719	0.001613406	-0.043371575
Jet Kerosene	776.4	0	776.4	55.5126	127.6	9.1234	508.4639498	508.4639498
Liquefied Petroleum Gases	1211.2	0	1211.2	76.38634667	1211.2	76.42672	0	-0.052826202
Motor Gasoline	3270.1	0	3270.1	226.61793	3270.1	226.61793	0	-1.25417E-14
Other Kerosene	627.1	0	627.1	45.06758667	627.1	45.08849	0	-0.046360686
Residual Fuel Oil	392.7	0	392.7	30.38189	392.6784616	30.39331293	0.005484997	-0.037583688
Natural Gas (Dry)	28.7	0	28.7	1.61007			100	100

Table Annex I - 4Comparison of reference and sectoral approach of fuels consumed in the energy sector for 2022

	Reference Approach				Sectoral Approach		Difference	
Fuel	**Apparent Consumption (TJ)**	**Excluded consumption (TJ)**	**Apparent Consumption (excluding non-energy use and feedstocks) (TJ)**	**CO2 Emissions (Gg)**	**Energy Consumption (TJ)**	**CO2 Emissions (Gg)**	**Energy Consumption (%)**	**CO2 Emissions (%)**
Aviation Gasoline	19.8	0	19.8	1.38666	7.6	0.532	160.5263158	160.6503759
Bitumen	0	0	0	0	151.1922	12.1961708	-100	-100
Crude Oil	811.7	0	811.7	59.52466667	811.7324814	13.63618088	-0.004001488	336.5200724
Gas/Diesel Oil	3247.2	0	3247.2	240.50928	3247.209797	240.6182459	-0.000301692	-0.045285812
Jet Kerosene	1170.6	0	1170.6	83.6979	167.7	11.99055	598.0322004	598.0322004
Liquefied Petroleum Gases	0	0	0	0	1295.3	81.73343	-100	-100
Motor Gasoline	3633	0	3633	251.7669	3630.8	251.61444	0.060592707	0.060592707
Natural Gas Liquids	46.9	0	46.9	3.009416667			100	100
Other Kerosene	1002.3	0	1002.3	72.03196	1002.3	72.06537	0	-0.046360686
Residual Fuel Oil	155.5	0	155.5	12.03051667	155.5216797	12.03737801	-0.013939986	-0.057000304
Natural Gas (Dry)	1295.3	0	1295.3	72.66633			100	100

Annex IV: Quality assurance and quality control

Please see Chapter 1, section 1.13 on QA/QC plan and implementation.

Annex V: Common reporting tables (CRT)

Common reporting tables have been submitted electronically in the UNFCCC portal.

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