National Inventory Report (NIR) of Fiji

September 2023

NATIONAL GHG INVENTORY REPORT OF FIJI

Report details

National Inventory Report (NIR): National Inventory Report (NIR) of Fiji

Presented by

Gauss International Consulting

Contact author(s)

Coordinator	Pepa López	pepa.lopez@gauss-int.com
Coordinator	Juan Luis Martin Ortega	jlm@gauss-int.com
Energy Sector	Javier Chornet	javier.chornet@gauss-int.com
IPPU Sector	Sander Akkermans	sander.akkermans@gauss-int.com
AFOLU Sector	Théo Rouhette	theo.rouhette@gauss-int.com
Waste Sector	Daniela Da Costa	daniela@gauss-int.com

Date

26 September 2023

Table of Content

List of Figures

List of Tables

Foreword

In 1993, Fiji ratified the United Nations Framework Convention on Climate Change (UNFCCC). In conformity with Articles 4(1)(a) and 12(1)(a) of the Convention, the non-Annex I Parties shall report to the Conference of the Parties (COP) data on emissions (by types of sources) and sinks (by types of storage) of all greenhouse gases (GHG) that do not fall under the Montreal Protocol.

Fiji has already submitted three national communications, with the latest Third National Communication (TNC) submission occurring on 28 April 2020 in fulfilment of Fiji's obligations to the UNFCCC under Articles 4 and 12.

The Convention stipulates that GHG emissions shall be monitored through the application of a set of methodologies and guidelines developed by the Intergovernmental Panel on Climate Change (IPCC) and approved by the UNFCCC. These guidelines describe how to assess GHG emissions ensuring quality attributes such as Transparency, Accuracy, Completeness, Consistency and Comparability of the GHG inventory.

The Convention also obliges its Parties to the continuous improvement of the quality of national GHG inventories.

Fiji has voluntarily prepared a standalone National Inventory Report (NIR). The NIR is to accompany the submission of the First Biennial Update Report to the UNFCCC. The NIR reflects the efforts made by the Climate Change Division team of the OPM during 2020-2021.

Fiji's national inventory system continues to improve. During the preparation of this GHG inventory, we have introduced a number of improvements aimed at sharpening the functionality of the national system. Key among them is the establishment of sectoral working groups and the entrenchment of the institutionalisation process for regular reporting of the GHG inventories the Climate Change Act, 2021.

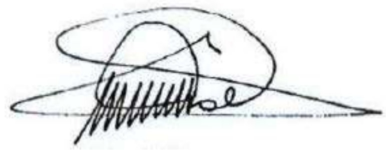
The NIR covers 25 years full time-series, from 1994 to 2019, for the four main IPCC sectors: Energy, Industrial Process and Product Use (IPPU), Agriculture, Forestry and Other Land Uses (AFOLU) and Waste. The inventory has been prepared using the 2006 IPCC Guidelines covering main four Greenhouse Gases (GHGs) (Carbon dioxide, Methane, Nitrous oxide and Hydrofluorocarbons) and some Precursor gases (Non-methane Volatile Organic Compounds).

For the 25 years' time series, recalculations have been carried on the 1994-2011 estimates and new estimates for 2012 to 2019.

Besides the GHG inventory results, the NIR contains the analysis of recent trends in GHG emissions and sinks in Fiji, the analysis of key categories, an uncertainty assessment, sectoral data sources and methodologies used in GHG emission inventory preparation, description of the activities related to inventory quality control and quality assurance and improvement plans and a comparison with the previous GHG inventories presented in the National Communications.

The Fijian national GHG inventory estimates aim to provide a tool to aid climate mitigation planning, facilitate building the foundation for the regular tracking of impacts of mitigation actions; and assess whether policy and national determined contributions (NDC) targets are being met, and which policies need further retooling.

The NIR provides an outstanding basis for identifying, developing and prioritising climate mitigation actions and targets at sectors that have high emission reduction potential and benefits to the broader sustainable development goals. It also provides an action plan by sector to improve activity data availability and quality and reduce the uncertainties for future inventory preparation for the achievement of the ultimate objective of the Convention.



Pita Wise
Permanent Secretary- Office of the Prime Minister

List of Contributors and Reviewers

The following Government Ministries contributed and reviewed the present 1994-2019 edition of the National GHG Inventory of Fiji.

- Department of Environment;
- Ministry of Public Works, Meteorological Services and Transport (Departments of Energy and Transport);
- Ministry of Agriculture and Waterways;
- Ministry of Forestry;
- Ministry of Land and Mineral Resources;
- Ministry of Local Government;
- Ministry of Health;
- Ministry of Finance, Strategic Planning, National Development and Statistic;
- Ministry of Civil Service and Public Enterprise; and
- Office of the Solicitor- General.

The following table presents the list of the international technical experts from Gauss International Consulting that contributed to the 1994-2019 edition of the National GHG Inventory of Fiji.

Coordinators		Pepa López Juan Luis Martin Ortega
Authors		
Executive Summary		Daniela Da Costa
Chapter 1	Background to the National GHG Inventory	Daniela Da Costa
Chapter 2	Fijian GHG Emissions Inventory	Sander Akkermans
Chapter 3	Energy Sector	Sander Akkermans Javier Chornet
Chapter 4	IPPU Sector	Sander Akkermans
Chapter 5	Agriculture Sector	Théo Rouhette Ingrid Aguirre
Chapter 6	FOLU Sector	Théo Rouhette Ingrid Aguirre
Chapter 7	Waste Sector	Daniela Da Costa
Reviewers		
Cross-cutting chapters		Pepa López Juan Luis Martin Ortega
Energy		Pepa López Juan Luis Martin Ortega

IPPU	Pepa López
AFOLU	Ioannis Sempos
Waste	Juan Luis Martin Ortega

Acknowledgements

The Climate Change Division of OPM gratefully acknowledges individuals and organisations who contributed significantly to the successful completion of Fiji's National Greenhouse Gas Inventory.

Special thanks go to United Nations Environment Programme (UNEP) for funding the whole greenhouse gas inventory exercise.

Mention specifically has to be made of institutions that provided various forms of support to the inventory process such as data collection and validation. These institutions provided most of the data, which was very crucial for the inventory.

It is also worthy of acknowledging the immense support received from the sectoral Working Groups that were part of the inventory process from start to end. The Climate Change Division is pleased with the tireless efforts and wealth of knowledge they brought on board to enrich the quality of the report. Our utmost appreciation also goes to the various private data generators/owners, individuals and entities who provided the critical activity data for the inventory.

Finally, the Climate Change Division is immensely thankful to the various international experts from Gauss International for their hard work, which was demonstrated in the preparation and finalisation of this report. We also wish to express our profound gratitude to all the institutions and international partners who reviewed the inventory and made invaluable comments and suggestions, which added significant value to the entire report.

Abbreviations, Acronyms and Units

Abbreviations

AD - Activity Data
AFOLU - Agriculture, Forestry and Other Land Use
AR - Assessment Report
BOD - Biological Oxygen Demand
BUR - Biennial Update Report
CCICD - Climate Change and International Cooperation Division
CCD - Climate Change Division
CMA - Certified Management Accountant
COP - Conference of Parties
EF - Emission Factor
EFL - Energy Fiji Limited
ETF - Enhanced Transparency Framework
FAO - Food and Agriculture Organization
FEA - Fiji Energy Authority
FOLU - Forestry and Other Land Use
FRL - Forest Reference Level
FRSC - Fiji Revenue & Custom Services
FSC - Fiji Sugar Corporation
GDP - Gross Domestic Product
GHG - Greenhouse gases
GWP - Global Warming Potentials
IPCC - Intergovernmental Panel on Climate Change
IPPU - Industrial Processes and Product Use
JICA - Japan International Cooperation Agency
KCA - Key category analysis
LEDS - Low Emission Development Strategy
LTA - Land Transport Authority
FOLU - Land use, land use change, and forestry
MPG - modalities, procedures and guidelines
MRV - monitoring, reporting and verification
NCCP - National Climate Change Policy
NDC - National Determined Contributions
NIR - National Inventory Report

QA - Quality Assurance

QC - Quality Control

SIDS - Small Island Developing States

SNC - Second National Communication

TACCC - Transparency, Accuracy, Completeness, Consistency and Comparability

TNC - Third National Communication

UNCED - United Nations Conference on Environment and Development

UNFCCC - United Nations Framework Convention on Climate Change

Units and Chemical Compounds

CFCs - Chlorofluorocarbons

CH_4 - Methane

CO_2 - Carbon dioxide

CO - Carbon monoxide

CO_{2eq} - Carbon dioxide equivalent

F-Gases - Fluorinated Gases

Gg - Gigagrams

HFCs - Hydrofluorocarbons

N_2O - Nitrous oxide

NF_3 - Nitrogen trifluoride

NMVOC - Non-Methane Volatile Organic Compounds

NO_x - Nitrous oxides

PFCs - Perfluorocarbons

SF_6 - Sulphur hexafluoride

SO_2 - Sulphur dioxide

Executive Summary

As a Small Island Developing State (SIDS), the Republic of Fiji advocates urgent action to strengthen its response to the imminent challenge posed by climate change. Fiji ratified the Paris Agreement on 22 April 2016, committing to raising the ambition for reducing GHG emissions to help limit global warming below 1.5 ºC through the development, adoption, and implementation of policies and measures to mitigate the adverse effects of climate change and adapt to these changes.

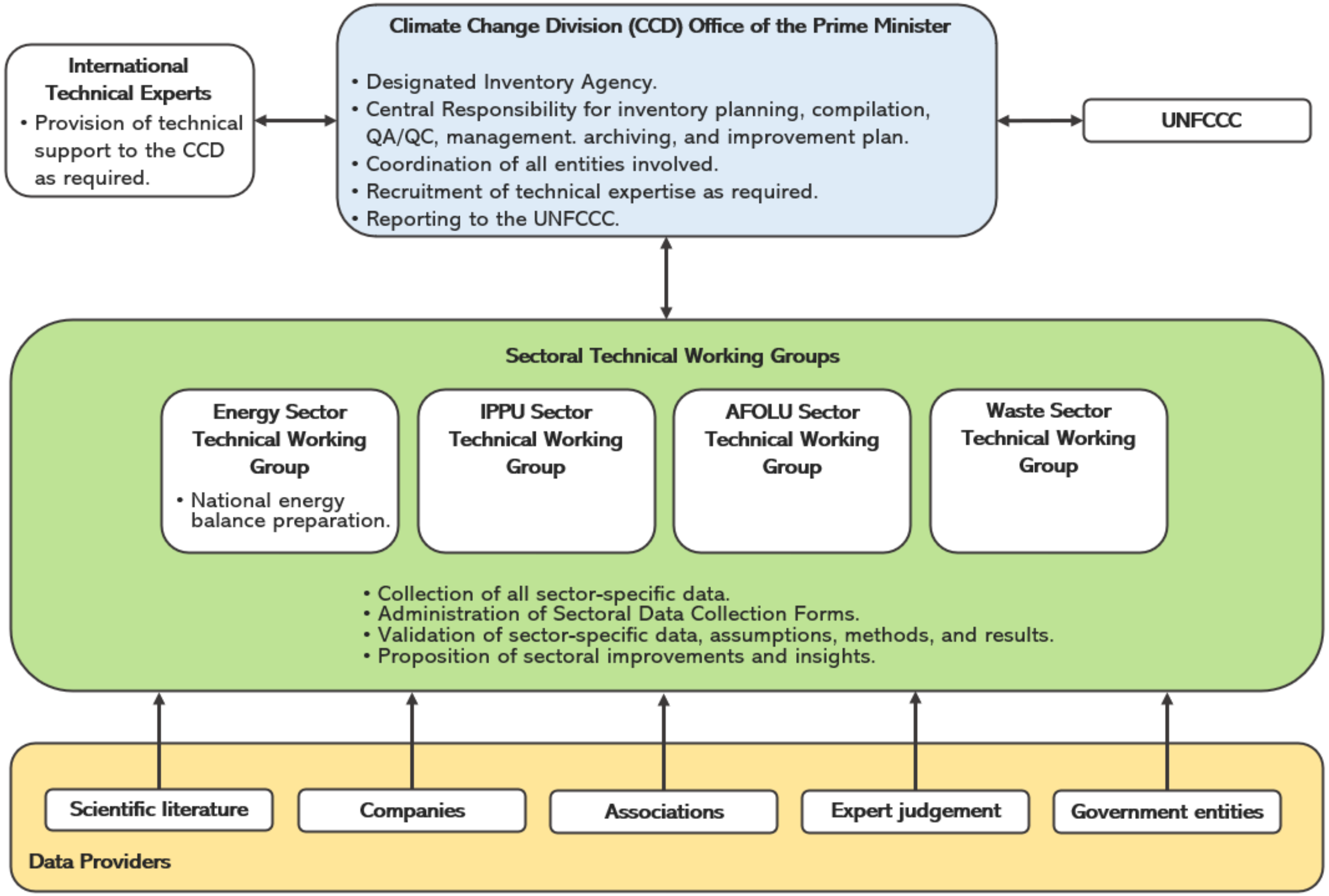
In that regard, Fiji submitted its first Nationally Determined Contribution (NDC) on 22 April 2016 and its subsequent update on 31 December 2020. The updated NDC of Fiji includes a reaffirmation of Fiji's 2030 target consisting of a 30% reduction in CO_2 emissions from the Energy Sector by 2030 compared to the Business as Usual (BAU) scenario, of which 10% are unconditional and 20% are conditional to international support.

Under the UNFCCC, Parties must present a **National Inventory Report** (NIR) of anthropogenic emissions by sources and removals by sinks of greenhouse gases. National GHG inventories are one of the most important chapters of both NCs and BURs and are the basis to assess mitigation efforts for meeting the commitments established under NDCs.

To this end, the NIR of Fiji has been developed along with the GHG inventory of the national GHG emissions. The present edition of the National Inventory of Fiji adopts the definitions and methodologies of the GHG inventory principles provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The five sectors encompassed by the inventory are (i) Energy, (ii) Industrial processes and product use (IPPU), (iii) Agriculture, (iv) Forestry and Other Land Uses, (FOLU), and (v) Waste. It has been elaborated using the most recent information available in the country and provides recommendations for further and continuous improvements of the GHG inventory of Fiji.

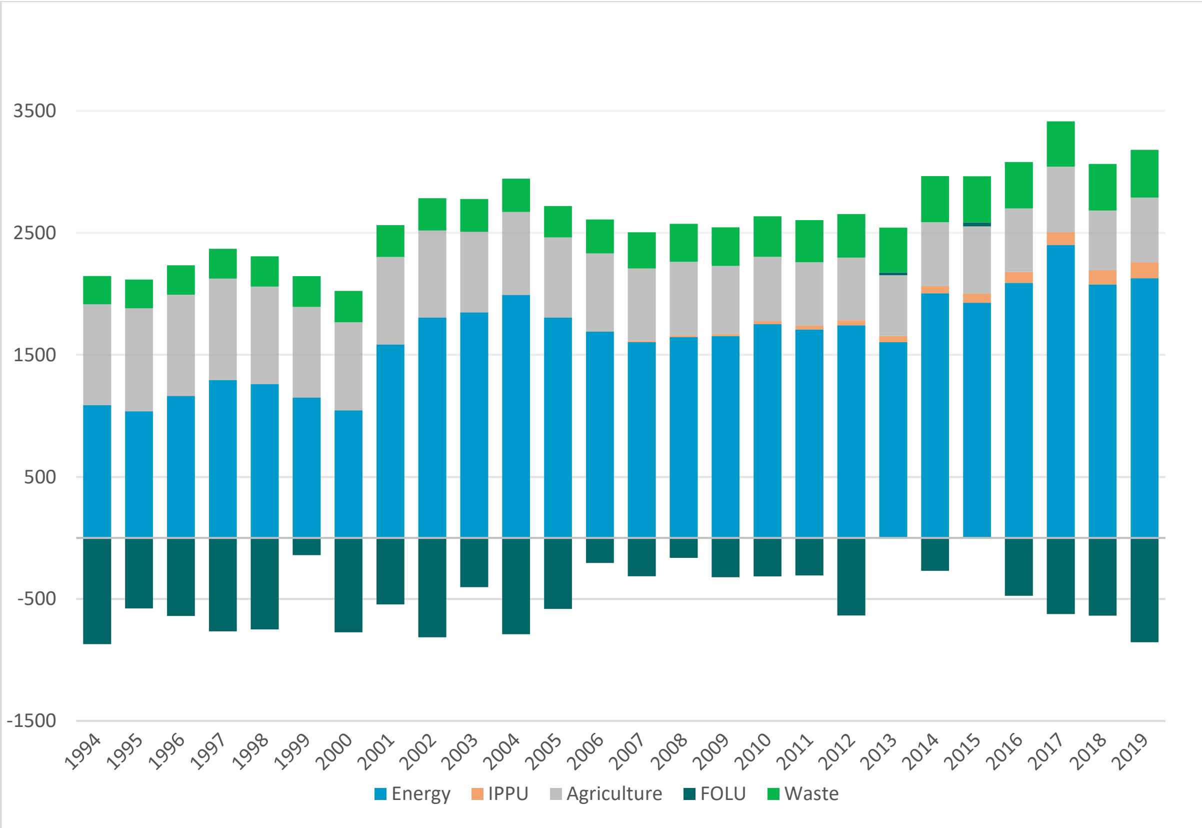
The national territory of Fiji covered by the GHG inventory corresponds to a total land size of 18,272 km^2. The inventory time period spans a total of 25 years, beginning with 1994 and ending with the year 2019 but using as the base year 2013. Fiji´s NDC establishes 2013 as the base year as a reference point for evaluating its GHG emission reduction targets until the year 2030, for which this inventory, by adopting the same base year, will serve as a mechanism for the country to track its progress towards meeting its NDC commitments.

The preparation of the present edition of the national GHG inventory of Fiji has been conducted under the centralized leadership and coordination of the Climate Change Division (CCD) under the Office of the Prime Minister (OPM), as the focal point to the UNFCCC. The institutional arrangements and information flow followed for the preparation of the 1994-2019 National GHG inventory of Fiji are presented below.



Institutional arrangements for the Fiji national inventory preparation.

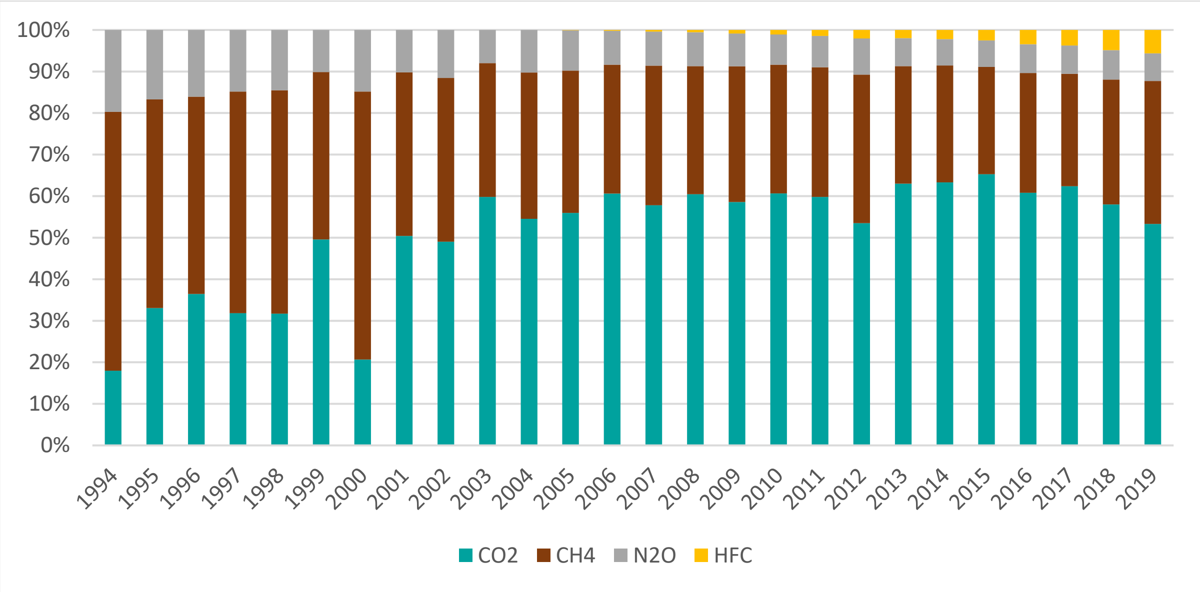
The results demonstrate that the national GHG emissions show an increasing trend in Fiji for all sectors and gases. In 2019, the emissions of the energy sector have the largest contribution to national total emissions (52.74 per cent), followed by Forestry and Other Land Use (21.18 per cent[1]) and Agriculture (13.14 per cent). Industrial Processes (3.24 per cent) and Waste sector (9.70 per cent) have a minor contribution. Fiji´s emission profile is a consequence of the economic structure of the country and its national characteristics. Emission trends have changed significantly since the first inventoried year, as shown in following figure.



Fiji GHG emissions 1994-2019 (Gg CO_2-eq).

The most influential gas in national total GHG emission trends is CO_2, as shows in the figure below. However, the evolution and changes in the economic activity of the country have substantially modified the gas contribution of national total emissions.

[1] These percentages are calculated in absolute levels, meaning that removals from the FOLU sector have been converted into absolute terms before calculating the percentage contribution by sector.



Trends in gas contribution to total GHG emissions.

The table below presents the key category analysis for the year 2019. A key category (KC) is defined as a prioritised category within the national inventory system because its estimate has a significant influence on a country's total inventory. The GHG emissions from road transport (Category 1A3b) ranks as the most emitting category of the Fiji inventory in 2019, followed by the GHG emissions from Forestland remaining Forestland (Category 3B1a) and Land converted to Grassland (Category 3B3b, deforestation).

Key category analysis with FOLU – Trend Assessment for the period 2013-2019.

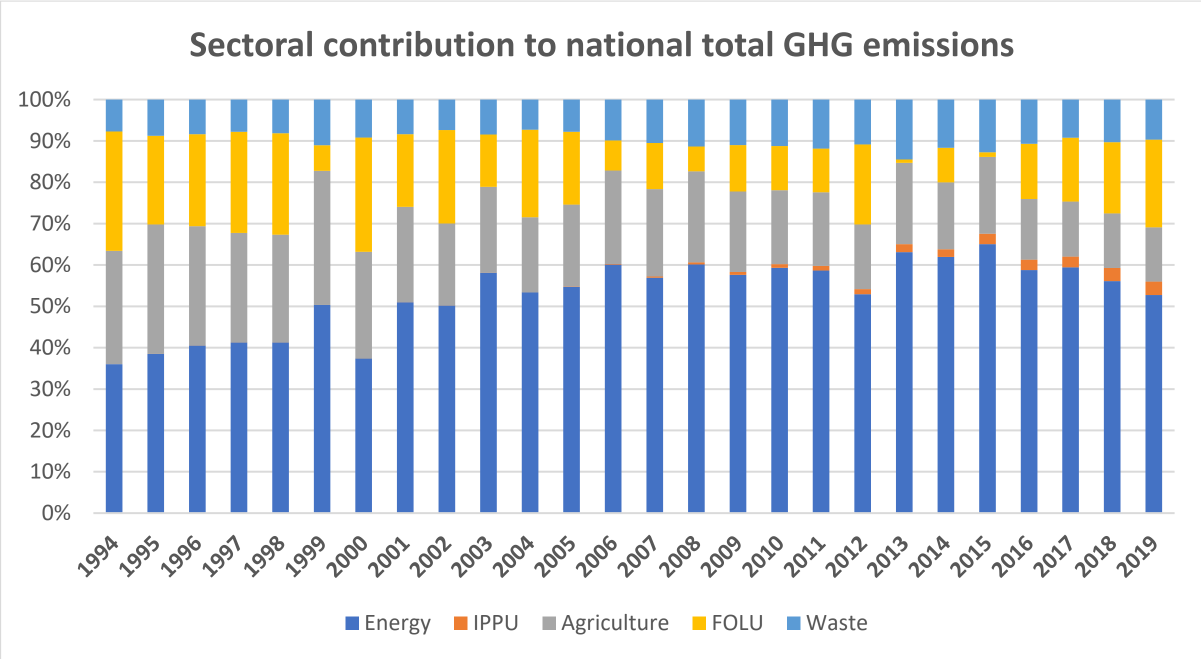
IPCC Category	Name	Gas	Emissions year 2019 (Gg CO_{2e})*	Absolute value of emissions year 2019 (Gg CO_{2e})	Contribution for year 2019 (%)	Cumulative contribution total for year 2019 (%)	KCA order 2019
1A3b - liquid	Road transport - liquid fuels	CO_2	1438.60	1438.60	0.345	0.345	**1**
3B1a	Forest land remaining forest land	CO_2	-504.47	504.47	0.121	0.466	**2**
3B1b	Land converted to forest land	CO_2	-416.63	416.63	0.100	0.566	**3**
1A1 - liquid	Energy industries - liquid fuels	CO_2	333.95	333.95	0.080	0.646	**4**
3A1	Enteric Fermentation	CH_4	326.27	326.27	0.078	0.725	**5**
4A	Solid waste disposal	CH_4	241.32	241.32	0.058	0.783	**6**
1A4 - liquid	Other sectors - liquid fuels	CO_2	134.52	134.52	0.032	0.815	**7**
2F1	Refrigeration and air conditioning	HFC	130.78	130.78	0.031	0.846	**8**

IPCC Category	Name	Gas	Emissions year 2019 (Gg CO_{2e})*	Absolute value of emissions year 2019 (Gg CO_{2e})	Contribution for year 2019 (%)	Cumulative contribution total for year 2019 (%)	KCA order 2019
4D	Wastewater treatment and discharge	CH_4	112.62	112.62	0.027	0.873	**9**
3C4	Direct N_2O Emissions from managed soils	N_2O	85.67	85.67	0.021	0.894	**10**
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	85.63	85.63	0.021	0.914	**11**
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	70.30	70.30	0.017	0.931	**12**
3B3b	Land converted to grassland	CO_2	66.43	66.43	0.016	0.947	**13**
3A2	Manure Management	CH_4	65.88	65.88	0.016	0.963	**14**

*Positive values correspond to emissions, while negative values correspond to removals.

Beyond key category analysis, the uncertainty assessments are an essential element of the national GHG inventory through the identification of the most significant sources of uncertainties. It aims to prioritise data collection efforts and guide methodological selection. For the set of sectors of the National Inventory, the uncertainty on the level has been estimated for the base year (2013) and the last inventory year (2019). The results of the uncertainty quantification for the National Inventory were a total of 27.34% for the inventory year (2019) and a trend uncertainty of 25.66%.

The relative contributions of sectoral emissions from the GHG inventory of Fiji are summarized in the following figure.



Energy Sector. The Energy sector GHG emissions for the year 2019 are 2127.65 Gg CO_2-eq, representing 52.74% of national total GHG emissions[2] for this year. Energy is the main contributor to national total GHG emissions, followed by AFOLU, Waste, and IPPU. Transport (1A3) and Energy Industries (1A1) are the major emission sources within the Energy Sector, accounting for 73.35 percent and 15.75 percent of the sectoral emissions in 2019 and constituting two of the national key categories. From the base year (2013), GHG emissions of the energy sector have grown 32.63 percent. In the same period, the main driver of energy emissions (economic activity represented by GDP) grew a 53.89 percent.

Industrial Processes and Product Use. The IPPU sector represented approximately 3.24% of national total GHG emissions of Fiji in 2019. It is the smallest sector in Fiji in terms of total GHG emission but does play an important role as it is the only source of HFCs and PFCs emissions, which have high global warming potentials (GWPs). Consequently, the IPPU sector only accounts for 0.00039% of total CO_2 emissions in 2019. The total GHG emissions from the IPPU sector were 0.13079 $MtCO_2eq$ in 2019 and 0.04988 $MtCO_2eq$ in 2013, representing an increase of 162.21% on total sectoral emissions recorded from 2013 to 2019. HFC was the most important GHG in the IPPU sector in 2019.

Agriculture, Forestry and Other Land Uses. The AFOLU sector was responsible for 34.32% of the total national GHG emissions of Fiji in 2019. The Agriculture and FOLU Sectors represented approximately 13.14% and 21.18% respectively. The contribution of the AFOLU sector to the national totals has increased from 20.50% in 2013 to 34.32% to 2019, due to a significant increase in removals in those 6 years. The total GHG emissions from the Agriculture sector were 499.20 Gg CO_2-eq in 2013 and 529.99 Gg CO_2-eq in 2019, illustrating the stability of the total

[2] Considering the contribution by sector in absolute terms

emissions from agriculture recorded from 2013 to 2019. The total GHG emissions from the FOLU sector were 21.15 Gg CO_2-eq in 2013 and -854.68 Gg CO_2-eq in 2019, due to a constant increase in the carbon removals from forests and the reduced rates of annual deforestation between 2016 and 2019.

Waste Sector. The Waste Sector represented 9.70% of total GHG emissions of Fiji in 2019. Being the third major source of GHG emissions, following the Energy and Agriculture, Forestry and Other Land Use Sectors, the Waste Sector is an important source of methane (CH_4) and nitrous oxide (N_2O) emissions. The Waste Sector accounts for 46.11% of the total national CH_4 emissions, 9.84% of the total national N_2O emissions, and only 0.56% of the total national CO_2 emissions. The following figure shows the trends of the GHG emissions of the Waste Sector Compared to the national total.

For cross-cutting issues and for each sector, the National Inventory Report includes an Inventory Improvement Plan which draws upon the corrective actions and/or areas of improvement identified during the elaboration of the Fijian GHG inventory. The national priority for inventory improvement involves increasing the availability and the quality of the data used for inventory preparation. Since the National Inventory System of Fiji is not formally institutionalized, the adoption of the Climate Change Act, 2021 to formally establish the governance structure and procedures for the Measurement, Reporting and Verification of Emissions and Emissions Reductions in Fiji, including the establishment of the sector-based collection of data, figures among the short-term cross-cutting task that will contribute to improving the quality of future GHG inventories in Fiji.

CHAPTER 1: BACKGROUND TO THE NATIONAL GHG INVENTORY OF FIJI

1.1. Outline of the National Inventory Report

This section presents the structure of this document through all its chapters to provide an overview of its contents.

The **Foreword** is presented at the first part of the document, which consists of the wording of Fiji's commitments derived from the ratification of the Kyoto Protocol and the Paris Agreement and the declaration of the present report. This is followed by the **list of contributors** and **reviewers and** the pertinent **acknowledgements**, which is a list of the participants in the preparation of this report and the inventory, as well as the sectoral stakeholders and the consultancy team with which the project has collaborated. In addition, a **list of abbreviations, acronyms and units** are presented to facilitate the reading of the document.

The **Executive summary** brings an overview of the whole findings, reasoning and results that summarize the current situation in Fiji regarding GHG emissions.

Chapter 1 of the NIR, comprising sections 1 to 9, contains background information about Fiji and its commitments and all the information relevant to the development of the greenhouse gas inventory.

Section 2 provides a general overview of commitments and characteristics as a Party to the convention as a result of the ratification of the UNFCCC and its Kyoto Protocol and the Paris Agreement, as well as its current status in terms of submitted reports and subsequent documents.

Section 3 and 4 present information about the definitions and characteristics of the national GHG inventory, along with all the institutional arrangements and procedures associated with the structure of organization and the monitoring, reporting and verification of national greenhouse gas emissions.

Section 5 explains the structure and methodology followed for all inventory categories and sectors, as well as the status of the estimated categories, data sources and the documentation of the data used for the GHG inventory compilation.

Section 6 through 8 provides the methodology followed and the results obtained in the calculation of the key category analysis and the uncertainty assessment, as well as the quality control and quality assurance procedures to ensure the quality of the inventory throughout the compilation, estimation and reporting process.

Section 9 gives the structure of the sectoral improvement plan planned on the basis of the issues and findings that have been carried out during the inventory.

Chapter 2 of the NIR, comprising sections 1 to 6, provides a general overview of development of emissions of direct and indirect greenhouse gases and of removals of carbon dioxide in sinks.

Sections 1 and 2 present the country's emission profile, which are the most emitting categories and the reasoning behind these results, considering the country's own circumstances. In addition to the trends of these emissions by themselves, indicators such as emissions per capita and GDP are presented and assessed.

Sections 3 through 5 provides a general overview of the emission trends by sector and by each of the main GHG that must be reported following the 2006 IPCC Guidelines.

Section 6 gives a comparison of this GHG emissions inventory with inventories presented in previous National Communications, giving the reasoning behind the differences in the whole timeseries due to the changes in methodology and data sources, in addition to the change from the 1996 IPCC Guidelines to the 2006 IPCC Guidelines.

Chapters 3 through 6 of the NIR present information about the resulting estimates by sector (Energy, IPPU, AFOLU and Waste) starting with an overview of the sector and descriptions and information relative to the methods and data used and finalizing with the planned improvements for relevant source and sink categories.

1.2. Commitments on Climate Change in Fiji

As a Small Island Developing State (SIDS), the Republic of Fiji advocates urgent action to strengthen its response to the imminent challenge posed by climate change, in consideration of its unique social, economic, and environmental vulnerabilities. Fiji is thus recognized as a special case for their environment and development at the United Nations Conference on Environment and Development (UNCED).

In 1993, the Republic of Fiji joined the majority of countries within the international community in ratifying the United Nations Framework Convention on Climate Change (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and coping with the associated impacts. Later, on 17 September 1998, Fiji signed and ratified the Kyoto Protocol for the first commitment period from 2008 to 2012 and the second commitment period from 2013 to 2020 through the ratification of the Doha Amendment in 2017. The Kyoto Protocol legally binds developed country Parties to greenhouse gas (GHG) emission reduction targets.

In doing so, Fiji committed itself to submit to the Conference of the Parties (COP) national reports on the implementation of the Convention to inform on the progress of activities relating to climate change. Developing country Parties are required to submit National Communications (NCs) every four years containing anthropogenic GHG emissions by sources and removals by sinks, national mitigation and adaptation measures, and any other relevant information on achievements towards the objective of the Convention. Fiji has already submitted three national communications, with the latest Third National Communication (TNC) submission occurring on 28 April 2020 in fulfilment of Fiji's obligations to the UNFCCC under Articles 4 and 12. The TNC followed the UNFCCC guidelines and included information on Fiji's Greenhouse Gas Inventory for the 2006 to 2011 reporting period. The document also reported on the country's vulnerability to climate change and measures to address and adapt to these vulnerabilities, alongside options for climate change mitigation.

Until the year 2024, Biennial Update Reports (BURs) must also be submitted every two years containing updates of national GHG inventories, including information on mitigation actions and the needs and support received to combat climate change. As a Small Island Developing State (SIDS), Fiji has the flexibility to submit both NCs and BURs at its discretion. Fiji is currently in the process of preparing its first BUR, with an intended submission timeframe of 2023. This document is prepared following the BUR guidelines for developing countries according to paragraphs 39 to 42 of Decision 2/CP.17 and its Annex III paragraphs 4 - 10. Fiji´s first BUR provides an overview of the relevant national circumstances regarding climate change and a summary of the results of the inventory of anthropogenic emissions by sources and removals by sinks for the years extending from 2012 to 2019 and constructing time-series for the period 1994-2019 by applying the 2006 IPCC Guidelines, including recalculations of the estimates of the period 1994-2012. It also presents information related to identified mitigation actions, constraints, and gaps; the financial support received regarding climate change related activities and related capacity, technical and financial needs; information on institutional arrangements relevant to the preparation of national communications and BURs on a continuous basis and information on domestic MRV (measurement, reporting and verification).

Furthermore, Fiji ratified the Paris Agreement on 22 April 2016, committing to raising the ambition for reducing GHG emissions to help limit global warming below 1.5 °C through the development, adoption, and implementation of policies and measures to mitigate the adverse effects of Climate Change and adapt to these changes. In that regard, Fiji submitted its first Nationally Determined Contribution (NDC) on 22 April 2016 and its subsequent update on 31 December 2020. The updated NDC of Fiji includes:

- A reaffirmation of Fiji's 2030 target consisting of a 30% reduction in CO_2 emissions from the Energy Sector by 2030 compared to the Business as Usual (BAU) scenario, of which 10% are unconditional and 20% are conditional to international support;
- A commitment to achieve met zero greenhouse gas emissions by 2050;
- A commitment to increase clarity, transparency and understanding;
- A commitment to enact the Climate Change Act by 2021;
- A commitment to operationalise its National Adaptation Plan.

Furthermore, the starting point of the NDC implements a base year of 2013 and it is estimated that Fiji´s emissions peak will be demonstrated in the timeseries of 1990 to 2019 reported under the present National Inventory Report.

With the aim of fortifying Fiji´s commitment to mitigate global warming, in 2018 the Fiji Low Emission Development Strategy (LEDS) up to the year 2050 was developed under the guidance of the CCD of the OPM with the support from the Global Green Growth Institute. The LEDS 2018-2050 is an economy-wide decarbonisation plan which identifies mitigation options for major sectors of the economy including an implementation cost assessment to inform the development of sectoral plans and future NDCs. Fiji will operationalise its decarbonisation ambitions by implementing its NDC Investment Plan targeting the creation of a strong business case for mobilising new and additional climate finance.

Under the UNFCCC, Parties must present a **national inventory report** (NIR) of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change (IPCC).

National GHG inventories are one of the most important chapters of both NCs and BURs and are the basis to assess mitigation efforts for meeting the commitments established under NDCs.

This NIR has been developed to enhance the accuracy, completeness, consistency, comparability, and transparency of the Fijian GHG inventory. It has been elaborated using the most recent information available in the country and provides recommendations for further and continuous improvements of the GHG inventory of Fiji.

1.3. Definitions, Coverage, Metrics and Quality Attributes

A National Greenhouse Gas Inventory can be defined as a comprehensive account of the annual anthropogenic GHG emissions by sources and GHG removals by sink within the national territory over a specified time period (a year), whereby:

- Anthropogenic GHG emissions refer to the release of greenhouse gases into the atmosphere from specific sources each year as a result of human activity.
- Anthropogenic GHG removals refer to the removal of greenhouse gases from the atmosphere through specific sinks each year as a result of human activity.
- The national territory covers the mainland territory and the offshore areas over which the country has jurisdiction.
- The time series refers to the specified period of time over which the national GHG inventory accounts emissions and removals annually, starting from the base year.

The present edition of the National Inventory of Fiji adopts the definitions and methodologies of the GHG inventory principles provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the 2006 IPCC Guidelines and available at https://www.ipcc-nggip.iges.or.jp/public/2006gl/).

1.3.1 Scope

A National GHG Inventory estimates and reports a total of seven (7) gases emitted and CO_2 removed from five (5) sectors occurring throughout the entirety of the National territory over the inventory time period.

The seven gases covered by the inventory are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)
- Nitrogen trifluoride (NF_3)

The five sectors encompassed by the inventory, are (i) Energy, (ii) Industrial Processes and Product Use (IPPU), (iii) Agriculture, (iv) Land Use, Land Use Change, and Forestry (FOLU), and (v) Waste.

The associated emissions and removals are calculated over four sectors as per the 2006 IPCC Guidelines as follows:

- **Sector 1: Energy:** This sector includes all GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are not included here (only for information purposes in the reference approach) but reported under Industrial Processes and Product Use.

- **Sector 2: Industrial Processes and Product Use (IPPU):** This sector includes all GHG emissions from industrial processes that chemically or physically transform materials, as well as the consumption of products such as refrigerants, solvents and fuels, excluding those related to energy combustion.
- **Sector 3: Agriculture, Forestry and Other Land Use (AFOLU):** This sector encompasses emissions and removals from managed forest land, cropland, grassland, wetlands, settlements, and other lands. It also includes emissions from livestock and manure management, emissions from managed soils, and emissions from liming and urea application.
- **Sector 4: Waste:** This sector includes the emissions from the anaerobic microbial decomposition of organic matter in both solid waste and wastewater, as well as the incineration and open burning of wastes.

These sectors (designated with a number) are further subdivided into categories (capital letter), sub-categories (number) and emissions sources (small letter) whose GHG emissions and removal are calculated to the lowest possible level of disaggregation on a category-by-category basis as data availability permits.

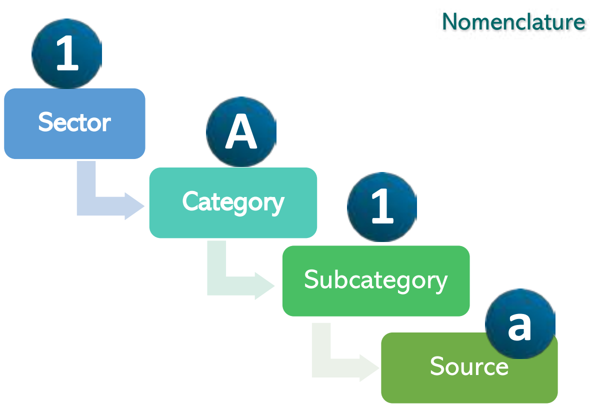


Figure 1. Nomenclature of the 2006 IPCC Guidelines.

The National territory of Fiji covered by the GHG inventory corresponds to a total land size of 18,272 km² distributed over a series of 322 volcanic islands and 522 islets, of which about 106 are permanently inhabited. The inventory time period spans a total of 25 years, beginning with 1994 and ending with the year 2019 but using as the base year 2013 as it is the base year of Fijian NDC. Fiji´s NDC establishes 2013 as the base year as a reference point for evaluating its GHG emission reduction targets until the year 2030, for which this inventory, by adopting the same base year, will serve as a mechanism for the country to track its progress towards meeting its NDC commitments.

The following table presents the greenhouse gases covered under each of the four principal categories covered by the inventory.

Table 1. Gases and sectors covered by the national GHG inventory.

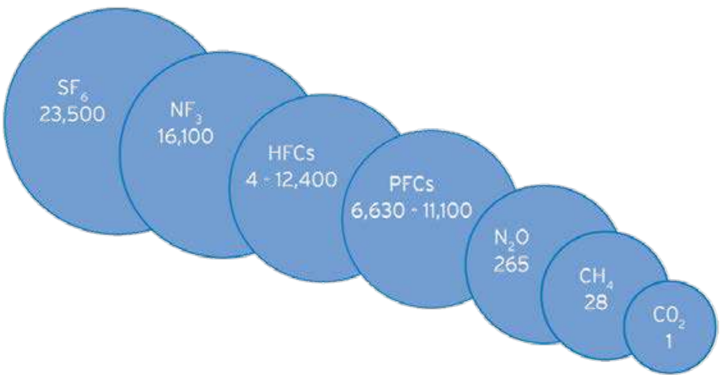
Sector		GHG						
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
1	Energy	X	X	X				
2	IPPU	X	X	X	X	X	X	X
3	AFOLU	X	X	X				
4	Waste	X	X	X				

1.3.2 Global Warming Potential

Each greenhouse gas has a different contribution to atmospheric warming as a function of:

- Their ability to absorb energy (radiative forcing); and
- The period over which they remain in the atmosphere (lifetime).

In order to sum and compare emissions estimates of different gases through the compilation of the national GHG inventory, it is necessary to have a common unit of measure. With this aim, the Global Warming Potential (GWP) allows the comparison of the global warming impacts of different GHGs and provides a common unit of measure, the CO_2 equivalent. By definition, a GWP compares the radiative forcing of one kilogramme of greenhouse gas emitted to the atmosphere to the radiative forcing of one kilogramme of CO_2 over a fixed period of time, typically 100 years. For instance, the GWP of N_2O is 265 times that of CO_2, with an average residence time of 100 years.



GHG	GWP (AR5)
CO_2	1
CH_4	28
N_2O	265
HFC	4 -12.400
SF_6	23.500
PFCs	6.630 – 11.100
NF_3	16.100

Figure 2. Examples of Global Warming Potentials (GWP) and their comparative size.

This inventory implements the last published GWPs for a period of 100 years reported under the IPCC Fifth Assessment Report (AR5). As an example, the following table illustrates the GWP adopted in this inventory from the IPCC AR5 for the estimated direct GHGs and four species of HFCs.

Table 2. AR5 Global Warming Potentials (GWP).

Gas	GWP
CO_2	1
CH_4	28
N_2O	265
HFC134a	1300
HFC125	3170
HFC143a	4800
HFC32	677

The selection of the AR5 GWP for the current edition of the Fijian inventory is in line with the adopted decision under the MPGs for the Enhanced Transparency Framework established under the Paris Agreement, which states:

Article II-D: Decision 18/CMA.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement

Each Party shall use the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report, or 100-year time-horizon GWP values from a subsequent IPCC assessment report as agreed upon by the CMA, to report aggregate emissions and removals of GHGs, expressed in CO_{2eq}.

Furthermore, the inventory aims to increase comparability with Fiji´s Low Emission Development Strategy (LEDS) for the period 2018-2050, which also uses the GWP of the IPCC Fifth Assessment Report in the calculation of GHG emissions projections until the year 2050.

1.3.3 Quality Principles

The measurement, reporting and verification (MRV) processes of the national inventory of Fiji, as well as the institutional arrangements within the national inventory system, have as a guiding principle the improvement of inventory quality over time. With this aim, the inventory adopts the 2006 IPCC Guidelines TACCC Principles to ensure the promotion of transparency, accuracy, completeness, consistency, and comparability of GHG emissions and removals reporting.

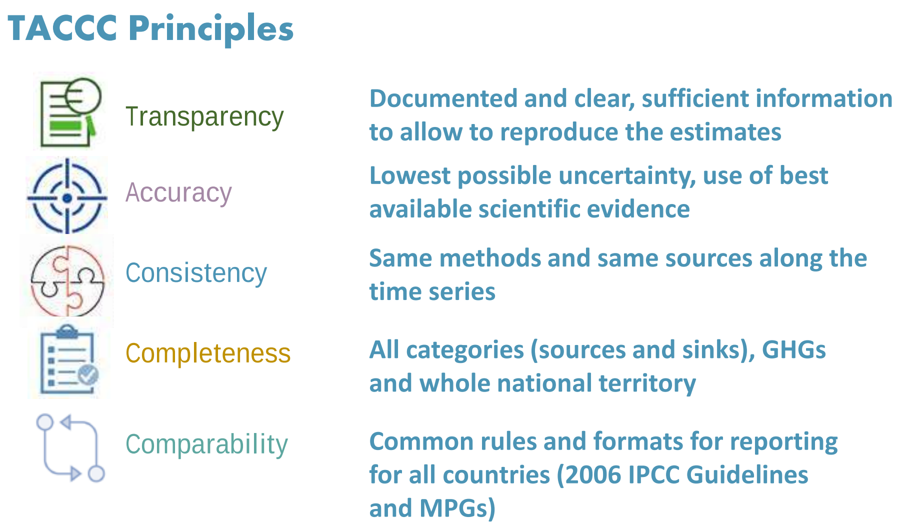


Figure 3. 2006 IPCC Guidelines TACCC Principles.

In that regard, the following five (5) quality attributes have been followed:

- **Transparency:** Sufficient and clear documentation is provided to understand how the inventory is compiled. All assumptions, methodologies, and expert judgment for data provision, treatment and emissions calculations are clearly explained and documented to facilitate replication of the estimates and demonstrate that good practice requirements and quality are met.
- **Accuracy:** Estimates of GHG emissions and removals are as exact and representative of national circumstances as possible while reducing uncertainties as far as practicable using the most recent available and cross-checked information. As far as can be judged according to the available information, estimates have not been neither over- nor under-estimated.
- **Completeness:** All greenhouse gas emissions and removals from all sources and sinks encompassed within the full geographical scope of the inventory are accounted for when information was available, and methodologies provided in the 2006 IPCC Guidelines.
- **Consistency:** Estimates for different inventory years, gases and categories were made using the same method and data sources for the base year and all subsequent years such that trends reflect the real annual fluctuations in emissions and removals and are not subject to changes resulting from methodological differences. Estimates from 1994 to 2011 were recalculated to ensure the consistency of the time series.
- **Comparability:** The national GHG inventory of Fiji is reported in a way that allows it to be compared with the national GHG inventories for other countries through the application of agreed methodologies, formats, and categories of the 2006 IPCC Guidelines.

1.4. Institutional Arrangements for Inventory Preparation

The National Inventory System of Fiji pertains to all the institutional arrangements and procedures associated with the monitoring, reporting, and verification (MRV) of national greenhouse gas emissions and removal.

Currently, Fiji does not dispose of a legal instrument that formally establishes the National Inventory System or the associated processes, roles, and responsibilities for GHG inventory compilation, reporting, and verification, however, is in the process of establishing this as part of the Climate Change Act, 2021.

Nevertheless, the Republic of Fiji National Climate Change Policy (NCCP) for the period 2018-2030 serves as the basis that anchors Fiji´s national climate change response and nationally determined commitment under the Paris Agreement within national policy and planning processes, establishing the basic framework for national GHG inventory compilation and reporting.

Under the NCCP, the former Climate Change and International Cooperation Division (CCICD) under the Ministry of Economy, now the Climate Change Division (CCD) of the Office of the Prime Minister (OPM) is established as the focal point to the UNFCCC and the head institution responsible for:

- Coordinating Fiji´s international engagement with the UNFCCC.
- Reporting to the UNFCCC.
- Ensuring "transparency, integrity, and consistency" of reporting to the UNFCCC.

Under the NCCP, the CCD is also responsible for "recruiting specific monitoring and evaluation expertise as required" to support the MRV of GHG emissions in Fiji.

Under this context, the preparation of the present edition of the national GHG inventory of Fiji has been conducted under the centralized leadership and coordination of the CCD using a sector-based approach for the collection of emissions and removal data.

As such, the CCD has established four Sectoral Technical Working Groups covering the energy, IPPU, AFOLU, and waste sectors. These Working Groups operate through formal Terms of Reference Documents and are responsible for the collection of data, as well as the validation of assumptions, methodologies, and final results. All the necessary data for the preparation of the inventory was collected through four standardized sectoral data collection forms in Excel format administered by the corresponding Sectoral Technical Working Group. These data collection forms compile activity data and input on emission factors and other parameters from diverse raw data providers comprising of statistical institutes, academia, non-governmental associations, private enterprises, and associations, among others.

The CCD has also recruited international technical expertise provided by Gauss International Consulting for the treatment of data, estimation of emissions, and execution of quality assurance and quality control procedures.

A validation workshop was organised in October 2021 where all leading members of each Sectoral Working Group, the CCD, and the international technical experts met to discuss the GHG inventory compilation process, emissions results, key focus areas and improvement opportunities.

After November 2021, a dedicated period was allocated for refining data through additional consultations with stakeholders. This effort led to further enhancements in the 1994-2019 edition of the Fiji GHG inventory. Subsequently, a final validation workshop with a broader group of stakeholders representing government officials, private sector, and non-governmental organisations (NGOs) was convened on July 7, 2023, to validate the national GHG emissions data.

This validation process is vital for ensuring the robustness and credibility of the inventory and plays a critical role in strengthening Fiji's GHG emission inventory foundation for informed decision-making, policy formulation, and climate action planning.

It is of fundamental importance that these procedures, roles, and responsibilities be institutionalized to ensure the long-term continuous improvement of the GHG inventory system, as well as the timely provision of transparent, accurate, consistent, complete, and coherent information.

To this end, the Climate Change Act, 2021 is currently under the final stages of development. Part 7 – Measurement, Reporting, and Verification of Emissions and Emissions Reductions will formally establish the Fiji GHG Inventory under the centralized responsibility of the CCD of the OPM through a sector-based data collection approach similar to the inventory preparation procedures followed in the preparation of the current 1994-2019 inventory edition. The aim of such Act is to formalize all MRV processes and enhance the national capacity to prepare and submit biennial inventories as per the MPGs under the Enhanced Transparency Framework of the Paris Agreement. It is highly recommended that the Technical Working Groups be formally incorporated and institutionalized in the Climate Change Act, 2021.

1.4.1 Governance Structure

The institutional arrangements and information flow followed for the preparation of the 1994-2019 National GHG inventory of Fiji is presented in the following figure, with a description of the roles and responsibilities of each entity involved further elaborated below.

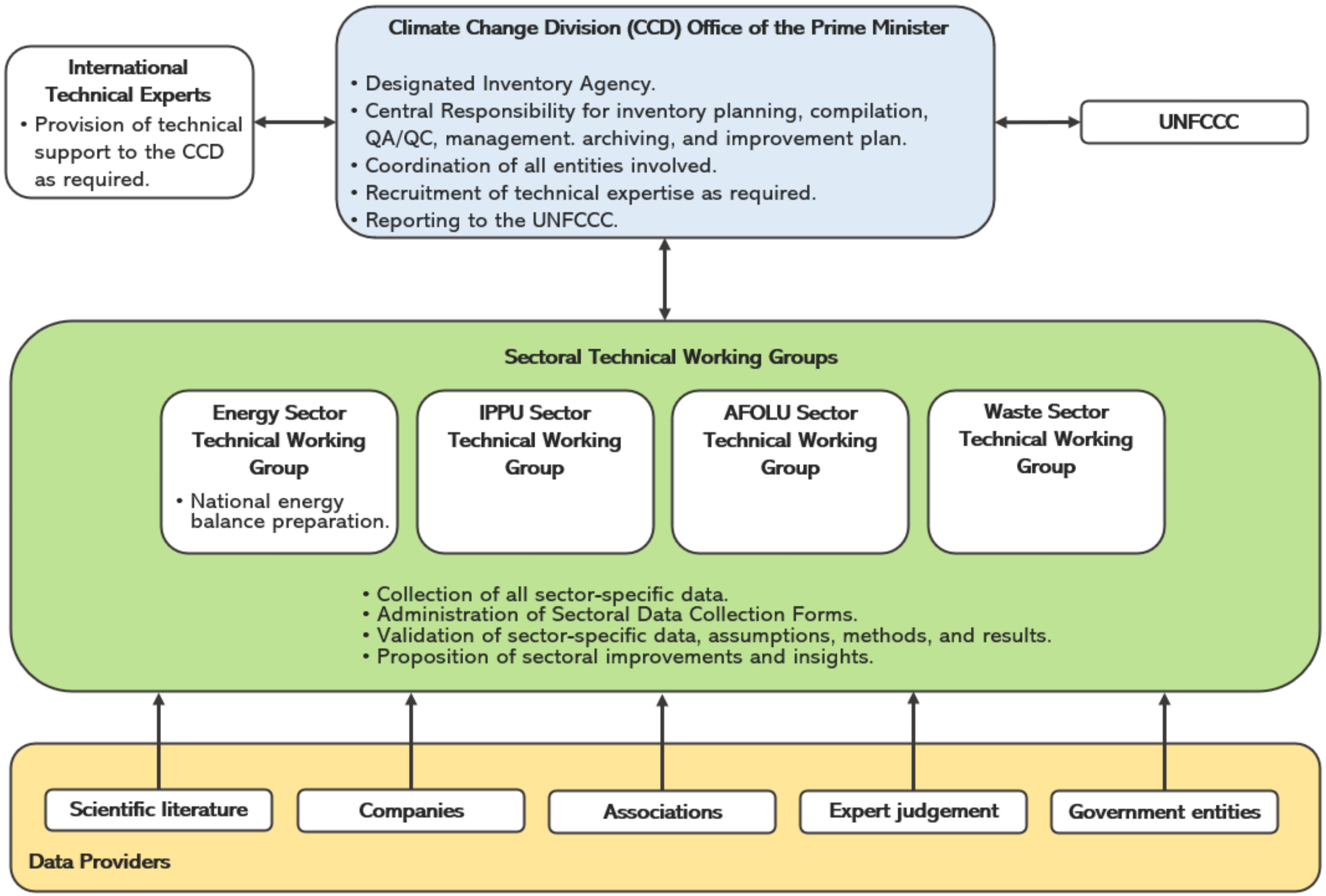


Figure 4. Institutional arrangements for the Fiji national inventory preparation.

Office of the Prime Minister - Climate Change Division

The Climate Change Division (CCD) under the OPM is the Designated Inventory Agency and Focal Point to the UNFCCC. It has the overall responsibility of the National Inventory System of Fiji, including the compilation, reporting and verification of the Fiji GHG inventory in accordance with the guidelines and methodologies established under the UNFCCC, the Paris Agreement, and the IPCC. It is also the permanent coordination authority between all entities involved in the preparation of the Fiji GHG inventory. The aim of the CCD is to ensure the monitoring, reporting, and verification of GHG emissions in a transparent, accurate, consistent, comparable, and complete manner, avoiding omissions or double counting while promoting the continuous improvement of Fiji's GHG inventory.

In particular, the responsibilities of the CCD include:

- Planning the inventory preparation processes.
- Recruiting the necessary technical expertise for inventory compilation.
- Convening the Sectoral Working Groups.
- Coordinating all entities involved in the collection of data, estimation of emissions, and verification of assumptions/methodologies/results.
- Ensuring the quality of the inventory and ensuring the TACCC principles are upheld in all GHG inventory preparation processes.
- Ensuring the emissions estimates are calculated as per the guidelines and methodologies established under the UNFCCC, the Paris Agreement, and the IPCC.
- Reporting to the UNFCCC the national GHG emissions and removals under the correct reporting formats and deadlines.
- Preparing and implementing the inventory improvement plan.
- Managing the national GHG inventory archiving system.
- Organizing a final validation workshop with the Sectoral technical Working Groups.

Within the CCD, an Inventory Coordinator, an Archive Manager, and a QA/QC coordinator have been appointed to lead in overall coordination processes, archiving procedures, and verification procedures, respectively.

Sectoral Technical Working Groups

The National Inventory System of Fiji implements a sector-based approach for the collection of emissions and removal data aiming to increase the quality and availability of sector-specific activity data and other parameters. In that regard, four Sectoral Technical Working Groups are convened to facilitate data collection and validation processes:

- Energy Sector Technical Working Group
- IPPU Sector Technical Working Group
- AFOLU Sector Technical Working Group
- Waste Sector Technical Working Group

The operation of each Working Group is dictated by a Terms of Reference document, which establishes its purpose, duration, membership, roles and responsibilities, as well as coordination and data-sharing arrangements. The key responsibilities of the Sectoral Technical Working Groups are to:

- Collect sector-specific data through the administration of Sectoral Data Collection forms and liaising with sectoral experts.
- Provide advice to technical experts to ensure the representation of national contexts.
- Provide insights and propose recommendations covering further aspects of data generation, collection, institutional arrangements, and verification practices.
- Propose additional sources of information, data, or expertise.
- Validate the estimated results.
- Provide input for the development of the inventory improvement plan.

Each Working Group is convened at the beginning of each GHG inventory reporting period and remains effective until the culmination of said period. The Working Group is regenerated at the beginning of each reporting period, and the Terms of Reference document is reviewed and updated for each reporting period if appropriate. For example, for the present 1994-2019 edition of the Fiji National Inventory, the Sectoral Working Groups were convened for the first time on October 16, 2020, remaining in operation until the inventory is officially submitted to the UNFCCC.

The membership of each Sectoral Technical Working Group includes relevant members from line ministries, regulative bodies, sectoral experts, city and town councils, private enterprises and/or private enterprise associations, non-governmental organizations, national statistical institutes, and academia. Each Working Group is headed by a Sectoral Lead as follows:

- Energy Technical Working Group: Energy Sectoral Lead
- IPPU Technical Working Group: Industrial Processes Lead
- AFOLU Technical Working Group: Agriculture Sector Lead and FOLU Sector Lead
- Waste technical Working Group: Waste Sector Lead

International Technical Experts

As per the NCCP, the CCD may recruit specific international technical expertise to support the CCD in the execution of its monitoring, reporting, and verification responsibilities. For the 1994-2019 edition of the Fiji National Inventory, international technical experts from Gauss International Consulting were recruited to provide support with:

- Determining gaps in previous national GHG inventories in Fiji.
- Assessing the quality of the data currently available and identifying further data needs for GHG inventory compilation in Fiji.
- Developing the standardized Sectoral Data Collection Forms.
- Conduct the emissions calculations and quality control procedures.
- Participating in validation activities conducted by the Sectoral Technical Working Groups.

Overview of the Current Inventory Management Team

Following the governance structure described above, the present 1994-2019 edition of the Fiji National Inventory was composed of the inventory management team presented in the following table.

Table 3. Inventory management team for the 1994-2019 edition of the Fiji national GHG inventory

Entity	Role	Name	Organization
Climate Change Division	Designated Inventory Agency	Mr. Pita Wise, Permanent Secretary	Office of Prime Minister
		Mr. Prashant Chandra, Acting Director	CCD
	Inventory Coordinating Team	Ms. Ranjila Singh	CCD
		Ms. Deepitika Chand	CCD
		Ms. Namisha Nikita	CCD
		Mr. Ravneeth K. Dewan	CCD
		Ms. Jeanette Mani	CCD
		Ms. Aradhana Singh	CCD
Sectoral Technical Working Groups	Energy Sector Lead	Mr. Mikaele Belana	Department of Energy
	Industrial Processes Lead	Ms. Teupola Lui	Fiji Revenue Customs Service
	Agriculture Sector Lead	Mohammed Abdullah Bin Shorab	Ministry of Forestry
	FOLU Sector Lead	Mohammed Abdullah Bin Shorab	Ministry of Forestry
	Waste Sector Lead	Deepitika Chand	Mitigation Team of the CCD
International Technical Experts	Responsible for estimating emissions from energy sector	Javier Chornet	Gauss International Consulting
	Responsible for estimating emissions from IPPU sector	Sander Akkermans Juan Luis Martin	Gauss International Consulting

	Responsible for estimating emissions from FOLU sector	Théo Rouhette Ioannis Sempos	Gauss International Consulting
	Responsible for estimating emissions from waste sector	Daniela Da Costa	Gauss International Consulting
	Responsible for internal coordination of emissions estimates and verification	Juan Luis Martin Ortega	Gauss International Consulting
	Responsible for coordination with the CCD and verification	Pepa Lopez	Gauss International Consulting

1.4.2 MRV Procedures

The inventory preparation is executed through a comprehensive Measurement, Reporting, and Verification (MRV) cycle. For the 1994-2019 edition of the Fiji GHG inventory, the preparation and development of the GHG inventory began on September 1, 2020, and culminated on November 30, 2021, consisting of 11 steps as indicated in the following chronogram. It is important to highlight the sectoral-based approach which encompassed both data collection, emissions estimation, and verification procedures.

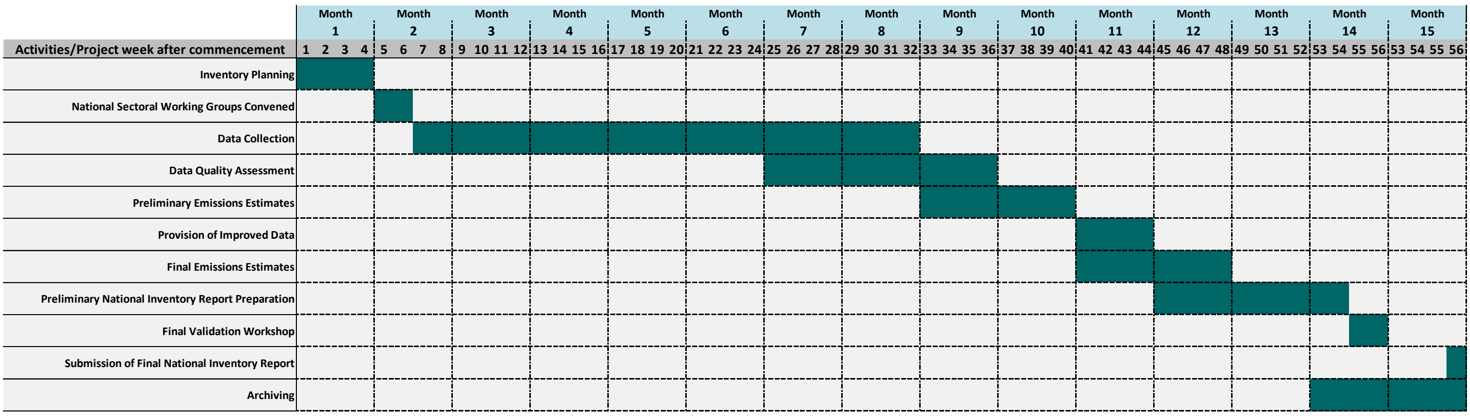


Figure 5. Chronogram of the MRV cycle for GHG emissions in the 1994-2019 edition of the Fiji national GHG inventory.

After November 2021, a dedicated period was allocated for refining data through additional consultations with stakeholders. This effort led to further enhancements in the 1994-2019 edition of the Fiji GHG inventory. Subsequently, a final validation workshop was convened on July 7, 2023, to validate the national GHG emissions data.

Inventory Planning

The CCD of the OPM is responsible for the planning of the GHG inventory, including the recruitment of the necessary technical expertise to execute its roles in the planning, monitoring, reporting, and verification of GHG emissions in Fiji. In this stage, an evaluation of the previous editions of the GHG inventory of Fiji was conducted with the aim of identifying gaps and further data needs, feeding the development of the Excel-based Sectoral Data Collection Forms.

Data Collection

Terms of Reference documents were prepared for the four Sectoral Technical Working Groups, which were convened for the first time on October 16, 2020. During the data collection phase, the Sectoral Leads of each Working Group administered the Excel-based Sectoral Data Collection Forms and collected additional relevant information from individual data providers. The completed forms were then provided to the CCD and forwarded to the international technical experts for data treatment and emissions calculations.

Data Quality Assessment

The National Inventory System of Fiji recognizes the fundamental importance of the availability of high-quality activity data, as all downstream treatment and estimation processes ultimately depend on the quality of the initial data and its ability to fully represent the national context. In that regard, following data-collection, all information was assessed in terms of data availability and quality. The aim of the assessment is to identify existing data gaps and identify immediate, short-term, and long-term corrective actions and/or areas of improvement for each sector. Under the responsibility/supervision of the CCD, the sectoral data quality assessment was performed by international technical experts.

Preliminary Emissions Estimates

Under the responsibility/supervision of the CCD, international technical experts performed preliminary emissions estimations from the original collected data, including key category analysis and uncertainty evaluation as per the 2006 IPCC Guidelines. Further details on emissions estimations methodologies and data sources are provided in Chapter 1 - Section 6. Meetings with the Sectoral Technical Working Group leads were held throughout this process to validate any assumptions undertaken or clarify additional questions.

Provision of Improved Data and Final Emissions Estimates

In response to the immediate and short-term corrective actions identified through the sectoral data quality assessments, the Sectoral Working Groups provided additional/improved data as available, which was used by the international technical experts to update and finalize the emissions estimates. At this stage, quality control and quality assurance procedures were implemented, as further elaborated in Chapter 1 - Section 7.

Preparation of Draft National Inventory Report

The international technical experts, under the responsibility/supervision of the CCD, proceeded to write the national inventory report as per the UNFCCC reporting requirements.

Final Validation Workshops and Preparation of Final National Inventory Report

A validation workshop was organised in October 2021, led by the CCD with key members from the Sectoral Technical Working Groups to verify the data sources, assumptions, methodologies, and results of the inventory. Any issues/comments/improvements arising from the workshop were then incorporated into the National Inventory Report by November 30, 2021.

Remaining issues from the initial Data Quality Assessment and the validation workshop in October 2021 were incorporated into the national inventory improvement plan, which lists and prioritizes a set of sectoral and cross-cutting improvement activities to be implemented in the short-, medium- and long- term.

After November 2021, a dedicated period was allocated for refining data through additional consultations with stakeholders. This effort led to further enhancements in the 1994-2019 edition of the Fiji GHG inventory. Subsequently, a final validation workshop was convened on July 7, 2023, to validate the national GHG emissions data.

Archiving

A robust archiving system is a crucial component of any national inventory system. Systematic documentation and archiving of information will enhance the transparency and long-term sustainability of the MRV process, aiming to:

- Ensure credibility of reported results and encourage donor confidence.
- Facilitate access to previous records upon inquiry and future verification procedures.
- Safeguard against information loss.

Under the National Inventory System of Fiji, archiving is performed under the responsibility of the CCD as per good practice procedures for internal documentation and archiving recommended by the 2006 IPCC Guidelines. The national archiving systems consists of a series of Excel files and Word documents organized by sector that encompass the following information:

- Institutional arrangements and procedures of the National Inventory System.
- Assumptions and criteria for the selection of activity data and emission factors.
- Emission factors and other estimation parameters used, including references to the IPCC document for default factors.
- All raw activity data and data processing.
- Information on the uncertainty associated with activity data and emission factors.
- Rationale for choice of methods.
- Identification of individuals providing expert judgement.
- Worksheets and interim calculations for category estimates, and aggregated estimates and any recalculations of previous estimates.
- Final inventory report
- Quality control checklists.

1.5. Description of Methodologies, Data Sources and Data Documentation

The National Inventory of Fiji is structured to match the reporting requirements of the UNFCCC and prepared in accordance with the 2006 IPCC Guidelines.

The estimates of emissions and removals – in its simplest form - correspond to a direct relation between an emission factor (emission rate by unit of activity) and the activity data which represents the corresponding level of activity. The activity data (AD) describes the annual magnitude of one activity. The emission factor (EF) is the amount of gas emitted by unit of activity. Default emission factors are provided by the 2006 IPCC Guidelines for the direct GHGs emissions.

The basic equation for estimating the emission of one category is the following:

$$Emissions_{c,g,t} = AD_{c,t} \cdot EF_{c,g,t}$$

Where:

$Emissions_{c,g,t} = Emissions\ of\ category\ c, gas\ g\ and\ year\ t$

$AD_{c,t} = Activity\ data\ of\ category\ c, year\ t$

$EF_{c,g,t} = Emission\ factor\ of\ emissions\ of\ category\ c, gas\ g\ and\ year\ t$

In many cases, the activity data available do not correspond to the default (D) emission factor (EF) available or used. In these cases, the data need to be converted using conversion factors. In such cases, the equation is the following:

$$Emissions_{c,g,t} = AD_{c,t} \cdot EF_{c,g,t} \cdot Conversion\ factor$$

All the equations require a statistical value which needs to be obtained from the entities which regularly collect the data.

For each category, the IPCC methodology is divided into various tiers, based on the level of complexity, detail, and accuracy to which the emissions and removals can be calculated, depending on the availability of activity data, emission factors, and other parameters. Generally, higher tiers are more detailed methodology and more accurate. Tier 1 represents the minimum or default methodology. If sufficient country-specific data is available, a party can also try to apply a higher tier. Tiers 2 and 3 involve more elaborated methods, which could be either source category-specific or technology-based. These methods require more detailed and country-specific data and/or measurements for their application. The following figure provides an overview of the methodological tiers provided by the 2006 IPCC Guidelines.

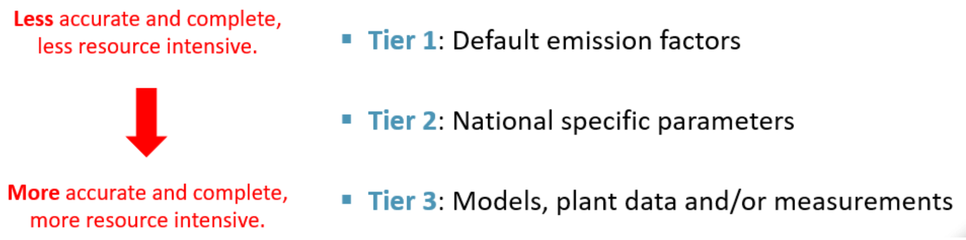


Figure 6. Methodological levels provided by the 2006 IPCC Guidelines.

The 1994-2019 edition of the National Inventory of Fiji was prepared based primarily on Tier 1 methods, although certain sub-categories were prepared based on a Tier 2 approach. All emission factors used were default values selected from the appropriate ranges recommended by the 2006 IPCC guidelines, whereas the activity data used was derived from a combination of country-specific and default values. Table 4 presents a breakdown of the methodological tiers applied for each category in the present edition of the inventory.

All emission and removal estimates were calculated by sector in a series of Excel files prepared specifically for the national context of Fiji and were cross-checked with results obtained from the application of the latest version of the IPCC Inventory Software[3]. The purpose of this software is to implement Tier 1 and Tier 2 methodologies for the preparation of national GHG inventories according to 2006 IPCC Guidelines. The primary target groups of users include inventory compilers who wish to apply default 2006 IPCC Guidelines methods and Parties not included in Annex I of the UNFCCC having limited resources for their inventory systems. However, the national GHG inventory of Fiji has been prepared by developing an Excel country-specific database in order to better understand and document every step in the compilation of the GHG inventory.

As one of the guiding quality attributes of the National Inventory System of Fiji, completeness means that inventory estimates have been prepared for all categories and gases occurring in the national territory. In this section, information is provided for all emissions sources/sinks and gases occurring in Fiji. When actual emission and removal quantities were not estimated or could not be reported for specific categories and/or gases, then the following notation keys were adopted:

- **NE: Not Estimated:** emissions and/or removals occur but have not been estimated or reported. Explanations are then provided on the reason for the NE values.
- **IE: Included Elsewhere:** emissions and/or removals for this activity or category are estimated and included in the inventory but not presented separately for this category, Explanations are then provided on the category where these emissions and removals are included.
- **C: Confidential information:** emissions and/or removals are aggregated and included elsewhere in the inventory because reporting at a disaggregated level could lead to the disclosure of confidential information. This has not been the case for this edition of the Fijian GHG inventory.

[3] Available at: https://www.ipcc-nggip.iges.or.jp/software/index.html

- **NA: Not Applicable:** the activity of category exists, but relevant emissions and removals are considered never to occur.
- **NO: Not Occurring:** the activity or process does not exist within the country.

The following tables provide the used 2006 IPCC Guidelines methodology and corresponding emission factors by sources and sinks categories in the 1994-2019 edition of the Fiji national GHG inventory.

Table 4. Methodological tiers used in the preparation of the 1994-2019 edition of the national GHG inventory of Fiji.

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
1. Energy	T1, T2	D	T1, T2	D	T1, T2	D								
A. Fuel combustion activities (sectoral approach)	T1, T2	D	T1, T2	D	T1, T2	D								
1. Energy industries	T1	D	T1	D	T1	D								
a. Public electricity and heat production	T1	D	T1	D	T1	D								
i. Electricity Generation	T1	D	T1	D	T1	D								
ii. Combined Heat and Power Generation (CHP)	T1	D	T1	D	T1	D								
b. Petroleum refining	NO	NO	NO	NO	NO	NO								
c. Manufacture of solid fuels and other energy industries	NO	NO	NO	NO	NO	NO								
2. Manufacturing industries and construction	T1	D	T1	D	T1	D								
3. Transport	T1, T2	D	T1, T2	D	T1, T2	D								
a. Domestic aviation	T1/T2	D	T1/T2	D	T1/T2	D								
b. Road transportation	T1	D	T1	D	T1	D								
c. Railways	T1	D	T1	D	T1	D								
d. Domestic navigation	T1	D	T1	D	T1	D								
e. Other transportation	NO	NO	NO	NO	NO	NO								
4. Other sectors	T1	D	T1	D	T1	D								
a. Commercial/institutional	T1	D	T1	D	T1	D								
b. Residential	T1	D	T1	D	T1	D								
c. Agriculture/forestry/fishing	T1	D	T1	D	T1	D								
5. Other	NO	NO	NO	NO	NO	NO								
B. Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE								
C. CO_2 Transport and storage	NO	NO												

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
2. Industrial Processes and Product Use	T1	D	NA, NO	NA, NO	NA, NO	NA	T1	D	NA, NE, NO	D	NO, NE	NO, NE	NA, NO	NA, NO
A. Mineral Industry	NO	NO	NO	NO	NO	NO								
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use	T1	D	NA, NO	NA, NO	NA, NO	NA, NO								
1. Lubricant Use	T1	D												
2. Paraffin Wax Use	NO	NO	NO	NO	NO	NO								
3. Solvent Use														
4. Other	NO	NO	NO	NO	NO	NO								
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances	NA, NO	NA, NO	NO	NO	NO	NO	T1	D	NA, NE	NA, NE			NA	NA
1. Refrigeration and Air Conditioning	NA	NA					T1	D	NA	NA			NA	NA
2. Foam Blowing Agents	NA	NA					NE	NE	NE	NE			NA	NA
3. Fire Protection	NA	NA					NE	NE	NE	NE			NA	NA
4. Aerosols							NE	NE	NA	NA			NA	NA
5. Solvents							NE	NE	NE	NE			NA	NA
6. Other Applications	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA			NA	NA
G. Other Product Manufacture and Use	NA	NA	NA	NA	NE	NE	NA	NA	NA	NA	NE	NE	NA	NA
H. Other	NA	NA	NA	NA	NA	NA								

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
3. Agriculture, Forestry, and Other Land Use	T1	D	T1	D	T1	D								
A. Livestock			T1	D	T1	D								
1. Enteric Fermentation			T1	D										
2. Manure Management			T1	D	T1	D								
B. Land	T1	D	NA, NO	NA, NO	NA, NO	NA, NO								
1. Forest Land	T1	D	NA	NA	NA	NA								
2. Cropland	T1	D	NA	NA	NA	NA								
3. Grassland	T1	D	NA	NA	NA	NA								
4. Wetlands	NO	NO	NO	NO	NO	NO								
5. Settlements	NO	NO	NO	NO	NO	NO								
6. Other Land	NO	NO	NO	NO	NO	NO								
C. Aggregate sources and non-CO2 emissions sources on Land	T1	D	T1	D	T1	D								
1. Emissions from biomass burning	NE	NE	T1	D	T1	D								
2. Liming	T1	D												
3. Urea Application	T1	D												
4. Direct N_2O Emissions from managed soils					T1	D								
5. Indirect N_2O emissions from managed soils					T1	D								
6. Indirect N_2O Emissions from manure management					T1	D								
7. Rice cultivations			T1	D	NA	NA								
8. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other	NO	NO	NO	NO	NO	NO								
1. Harvested Wood Products	NE	NE												
2. Other	NO	NO	NO	NO	NO	NO								

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
4. Waste	T1, T2a	D	T1	D	T1	D								
A. Solid Waste Disposal			T1	D	NE	NE								
1. Managed Waste Disposal Sites			T1	D	NE	NE								
2. Unmanaged Waste Disposal Sites			T1	D	NE	NE								
3. Uncategorized Waste Disposal Sites			T1	D	NE	NE								
B. Biological Treatment of Solid Waste			T1	D	T1	D								
C. Incineration and Open Burning of Waste	T1, T2a	D	T1	D	T1	D								
1. Waste Incineration	T1, T2a	D	T1	D	T1	D								
2. Open Burning of Waste	T1	D	T1	D	T1	D								
D. Wastewater Treatment and Discharge			T1	D	T1	D								
1. Domestic Wastewater Treatment and Discharge			T1	D	T1	D								
2. Industrial Wastewater Treatment and Discharge			IE	IE	IE	IE								
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: (1)	T1, T2	D	T1, T2	D	T1, T2	D								
International bunkers	T1, T2	D	T1, T2	D	T1, T2	D								
Aviation	T1/T2	D	T1/T2	D	T1/T2	D								
Navigation	T1	D	T1	D	T1	D								
Multilateral operations	NE	NE	NE	NE	NE	NE								
CO_2 emissions from biomass	T1	D												
CO_2 captured	NO	NO												
For domestic storage	NO	NO												
For storage in other countries	NO	NO												

Abbreviations: T1 - Tier 1 method; T2 - Tier 2 method; D - Default Use; IE - Included Elsewhere; NA - Not Applicable; NE - Not Estimates; NO - Not Occurring

Explanation for the use of Notation Key NE:

- CO_2, CH_4, and N_2O Emissions from Category 1B. Fugitive emissions from charcoal production were not estimated due to lack of data. Minor production levels expected.
- CO_2, CH_4, and N_2O Emissions from Category 1A3e - Other Transportation were Not Estimated due to the lack of data for this category.
- HFCs emissions from 2.F2. Foam Blowing Agents, 2F.3. Fire Protection and 2.F.4. Aerosols were Not Estimated due to the lack of data for these categories.
- SF_6 Emissions from Category 2.G. Other Product Manufacture and Use from electrical equipment were Not Estimated due to the lack of data for this category.
- N_2O Emissions from Category 2.G. Other Product Manufacture and Use from the use of N_2O as anaesthesia were Not Estimated due to the lack of data for this category.
- CO_2 Emissions from Category 3C1 – Emissions from Biomass Burning were not calculated due to lack of data about fires or other burning.
- N_2O Emissions from Category 4A – Solid Waste Disposal were Not Estimated given that no methodologies are provided in the IPCC Guidelines for estimating these emissions and the IPCC FOD model does not calculate these emissions.
- CO_2, CH_4, and N_2O Emissions from Memo Item – Multilateral Operations were Not Estimated due to the lack of data for this category.

Explanation for the use of Notation Key IE:

- CH_4, and N_2O Emissions from Category 4D2 – Industrial Wastewater Treatment and Discharge were not calculated due to the lack of data on on-site industrial wastewater treatment practices in Fiji. Instead, methane emissions from industrial wastewater are included under Category 4D1 – Domestic Wastewater Treatment and Discharge through the use of the correction factor I.

To the extent possible, the activity data used in the elaboration of the national inventory is based on country-specific collected and officially published data, complemented by default values from the 2006 IPCC Guidelines when such information is not available. The principal data sources of information used for each sector are described in the following table.

Table 5. Principal data sources of the 1994-2019 edition of the national GHG inventory of Fiji.

Sector	Data Source	Data Provided
Cross-cutting matters	Fiji Bureau of Statistics	Population Statistics, GDP
	Fiji Meteorological Services	Weather conditions and temperature
Energy Sector	Department of Energy	Energy Balance Survey with information for the reference and sectoral approach for various categories, covering stationary and mobile combustion, with data from Fiji Revenue & Custom Services, Energy Fiji Limited (EFL), Vatukoula Gold Mines Limited and Fiji Sugar Corporation (FSC).
	CCD, OPM	Additional fuel consumption for different purposes coming from companies such as Fiji Sugar Corporation (FSC), Fiji Revenue & Custom Services, Land Transport Authority and Energy Fiji Limited, different oil and gas companies, and production companies.
IPPU Sector	Fiji Revenue & Custom Services (FRSC)	Information on consumption of carbonates, lubricants, solvents, refrigeration and air conditioning imported and the agro-food industry production.
AFOLU Sector	Agricultural Official Census	Livestock data between 2006 and 2020
	FAO Statistics	Livestock data between 1994 and 2005, urea application, rice cultivation practices
	Forest Reference Level (FRL) and Emission Reduction - Monitoring Report (ER-MR) provided by the Ministry of Forestry	Information pertaining to the monitoring of different land uses and land use change, including deforestation and afforestation/reforestation
Waste Sector	JICA 2009 Waste Minimization and Recycling Promotion Project in the Republic of the Fiji Islands.	Solid waste generation rates, solid waste composition, solid waste management streams.
	Water Authority of Fiji	Biological Oxygen Demand of wastewater, number of connections to each wastewater treatment plant, types of technologies implemented at each wastewater treatment plant.
	Central Board of health	Clinical waste incineration records.
	Biosecurity Authority of Fiji	Quarantine waste incineration records.

Initial technical and quality evaluation of the data was done before transmission to the sectoral working groups. The quality of the collected data was assessed, and quality assessment reports prepared for each sector. All the details on the acquired data were documented and stored in the excel database for proper documentation, archiving and retrieval.

1.6. Key Category Analysis

As per the 2006 IPCC Guidelines, a key category (KC) is defined as "one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sinks categories."

As far as possible, key categories receive special consideration in terms of three important inventory aspects:

- **Efficient use of resources:** The identification of key categories enables the limited resources available for preparing inventories to be prioritised towards improving the quality of those categories that have the greatest contribution to the inventory magnitude, trend, and uncertainty.
- **Methodological selection:** Generally, inventory uncertainty is lower when emissions and removals are estimated using the most rigorous methods available, but this may not be feasible for all categories covered by the inventory. More detailed, higher tier methods should therefore be selected for key categories.
- **Verification procedures:** It is good practice to give additional attention to key categories with respect to quality assurance and quality control (QA/QC).

1.6.1 Methodology

The general approach undertaken for identifying the key categories of the National GHG Inventory of Fiji in a systematic and objective manner consists of performing a quantitative analysis of the contribution of each source or sink category to the level and the trend of the total national emissions and removals. The 2006 IPCC Approach 1 has been used to conduct the key category analysis (KCA) for both the level and the trend, considering the base year of 2013 and the latest inventory year of 2019. Furthermore, key categories were identified both including and excluding emissions and removals from Forestry and Other Land Use (FOLU). The following two figures illustrate the procedure for undertaking the level and trend assessments.

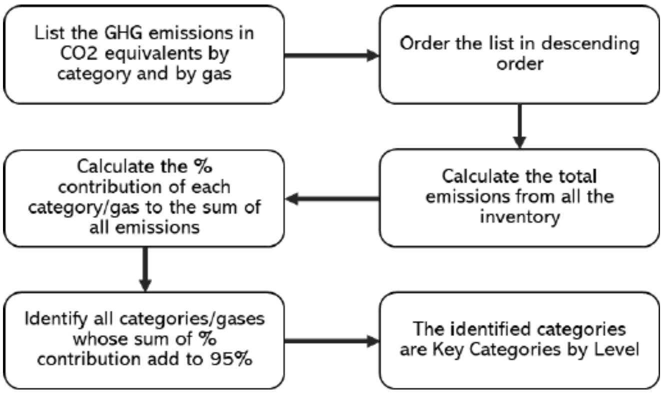


Figure 7. KCA methodological steps under the Approach 1 Level Assessment.

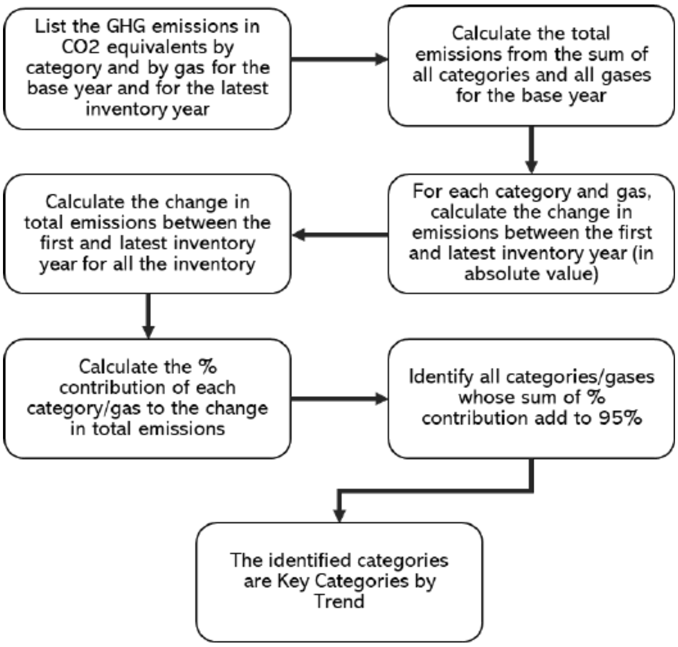


Figure 8. KCA methodological steps under the Approach 1 Trend Assessment.

Level Assessment

The contribution of each source or sink category to the total national inventory level is calculated according to the following equation:

$$L_{x,t} = \frac{|E_{x,t}|}{\sum_y |E_{y,t}|}$$

Where:

$L_{x,t} = \text{level assessment for source or sink } x \text{ in latest inventory year}$

$|E_{x,t}| = \text{absolute value of emission or removal estimate of source or sink category } x \text{ in year } t$

$\sum_y |E_{y,t}| = \text{total contribution in year } t \text{ (sum of the absolute values of emissions and removals)}$

Under the level assessment, key categories are therefore those that, when summed together in descending order of magnitude, add up to 95% of the total contribution of all sources and sinks categories to the national total inventory level.

Trend Assessment

The contribution of the trends of each source or sink category to the total national inventory trends is calculated according to the following equation:

$$T_{x,t} = \frac{|E_{x,0}|}{\sum_y |E_{y,0}|} \cdot \left| \frac{|E_{x,t} - E_{x,0}|}{|E_{x,0}|} - \frac{\left(\sum_y E_{y,t} - \sum_y E_{y,0}\right)}{|\sum_y E_{y,0}|} \right|$$

Where:

$T_{x,t}$ = *trend assessment for source or sink x in year t as compared to the base year (year 0)*

$|E_{x,0}|$ = *absolute value of emission or removal estimate of source or sink category x in base year*

$E_{x,t}$ and $E_{x,0}$ = *real values of estimate of source or sink category X in years t and base year, respectively.*

$\sum_y E_{y,t}$ and $\sum_y E_{y,0}$ = *total inventory estimates in years t and base year, respectively.*

It is important to note that both increasing and decreasing trends are taken into consideration. Under the trends assessment, key categories are therefore those that, when summed together in descending order of magnitude, add up to 95% of the total contribution of all sources and sink categories to the national total inventory trend.

Disaggregation Level

The results of the key category identification will be most useful if the analysis is done at the appropriate disaggregation level of categories. The assessment performed has followed, as far as possible, the suggested aggregation level for Approach 1 provided by the 2006 IPCC Guidelines.

1.6.2 Results

Table 6 on the following page presents an overview of all the key categories identified under the level and trend assessments for the base year 2013 and the latest inventory year 2019, both including and excluding FOLU.

Table 6. Summary of key categories identified by the KCA.

IPCC category	Name	Gas	With FOLU			Without FOLU		
			L2019	L2013	Trend	L2019	L2013	Trend
1A1 - liquid	Energy industries - liquid fuels	CO_2	X	X	X	X	X	X
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	X	X		X	X	X
1A3a - liquid	Civil aviation - liquid fuels	CO_2						X
1A3b - liquid	Road transport - liquid fuels	CO_2	X	X	X	X	X	X
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	X	X	X	X	X	X
1A4 - liquid	Other sectors - liquid fuels	CO_2	X	X	X	X	X	X
2F1	Refrigeration and air conditioning	HFC	X	X	X	X	X	X
3A1	Enteric Fermentation	CH_4	X	X	X	X	X	X
3A2	Manure Management	CH_4	X	X	X	X	X	X
3B1a	Forest land remaining forest land	CO_2	X	X	X			
3B1b	Land converted to forest land	CO_2	X	X	X			
3B3b	Land converted to grassland	CO_2	X	X	X			
3C1	Emissions from biomass burning	CH_4						X
3C4	Direct N_2O Emissions from managed soils	N_2O	X	X		X	X	X
3C5	Indirect N_2O Emissions from managed soils	N_2O					X	X
4A	Solid waste disposal	CH_4	X	X	X	X	X	
4D	Wastewater treatment and discharge	CH_4	X	X		X	X	X

Key Category Analysis Including the Contribution of FOLU

The following three tables present further details of the KCA performed for the level and trend assessments, including the contributions of Forestry and Other Land Use.

Table 7. Key category analysis with FOLU – Level Assessment for the year 2019.

IPCC Category	Name	Gas	Emissions year 2019 (Gg CO_{2e})*	Absolute value of emissions year 2019 (Gg CO_{2e})	Contribution for year 2019 (%)	Cumulative contribution total for year 2019 (%)	KCA order 2019
1A3b - liquid	Road transport - liquid fuels	CO_2	1438.60	1438.60	0.345	0.345	**1**
3B1a	Forest land remaining forest land	CO_2	-504.47	504.47	0.121	0.466	**2**
3B1b	Land converted to forest land	CO_2	-416.63	416.63	0.100	0.566	**3**
1A1 - liquid	Energy industries - liquid fuels	CO_2	333.95	333.95	0.080	0.646	**4**
3A1	Enteric Fermentation	CH_4	326.27	326.27	0.078	0.725	**5**
4A	Solid waste disposal	CH_4	241.32	241.32	0.058	0.783	**6**
1A4 - liquid	Other sectors - liquid fuels	CO_2	134.52	134.52	0.032	0.815	**7**
2F1	Refrigeration and air conditioning	HFC	130.78	130.78	0.031	0.846	**8**
4D	Wastewater treatment and discharge	CH_4	112.62	112.62	0.027	0.873	**9**
3C4	Direct N_2O Emissions from managed soils	N_2O	85.67	85.67	0.021	0.894	**10**
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	85.63	85.63	0.021	0.914	**11**
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	70.30	70.30	0.017	0.931	**12**
3B3b	Land converted to grassland	CO_2	66.43	66.43	0.016	0.947	**13**
3A2	Manure Management	CH_4	65.88	65.88	0.016	0.963	**14**
*Positive values correspond to emissions, while negative values correspond to removals.							

Table 8. Key category analysis with FOLU – Level Assessment for the base year 2013.

IPCC Category	Name	Gas	Emissions year 2013 (Gg CO_{2e})*	Absolute value of emissions year 2013 (Gg CO_{2e})	Contribution for year 2013 (%)	Cumulative contribution total for year 2013 (%)	KCA order 2013
3B3b	Land converted to grassland	CO_2	1084.88	1084.88	0.330	0.330	1
3B3b	Land converted to grassland	CO_2	394.26	394.26	0.120	0.450	2
3A1	Enteric Fermentation	CH_4	295.43	295.43	0.090	0.540	3
3B1b	Land converted to forest land	CO_2	-290.85	290.85	0.088	0.628	4
1A1 - liquid	Energy industries - liquid fuels	CO_2	248.82	248.82	0.076	0.704	5
4A	Solid waste disposal	CH_4	190.77	190.77	0.058	0.762	6
4D	Wastewater treatment and discharge	CH_4	141.42	141.42	0.043	0.805	7
3C4	Direct N_2O Emissions from managed soils	N_2O	102.45	102.45	0.031	0.836	8
1A4 - liquid	Other sectors - liquid fuels	CO_2	101.92	101.92	0.031	0.867	9
3B1a	Forest land remaining forest land	CO_2	-82.27	82.27	0.025	0.892	10
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	77.89	77.89	0.024	0.915	11
2F1	Refrigeration and air conditioning	HFC	49.86	49.86	0.015	0.931	12
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	45.03	45.03	0.014	0.944	13
3A2	Manure Management	CH_4	41.42	41.42	0.013	0.957	14

*Positive values correspond to emissions, while negative values correspond to removals.

Table 9. Key category analysis with FOLU – Trend Assessment for the period 2013-2019.

IPCC Category	Name	Gas	Trend assessment	Contribution to the trend (%)	Total cumulative trend contribution (%)	KCA order Trend
1A3b - Liquid	Road transport - liquid fuels	CO_2	0.136	0.257	0.257	1
3B1a	Forest land remaining forest land	CO_2	0.126	0.239	0.495	2
3B3b	Land converted to grassland	CO_2	0.089	0.169	0.664	3
1A1 - liquid	Energy industries - liquid fuels	CO_2	0.032	0.061	0.726	4
3B1b	Land converted to forest land	CO_2	0.031	0.058	0.784	5
2F1	Refrigeration and air conditioning	HFC	0.026	0.049	0.833	6
4A	Solid waste disposal	CH_4	0.020	0.038	0.871	7
3A1	Enteric Fermentation	CH_4	0.017	0.032	0.903	8
1A4 - liquid	Other sectors - liquid fuels	CO_2	0.013	0.024	0.927	9
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	0.009	0.017	0.944	10
3A2	Manure Management	CH_4	0.009	0.016	0.960	11

Key Category Analysis Excluding the Contribution of FOLU

The following three tables present further details of the KCA performed for the level and trend assessments, excluding the contributions of Forestry and Other Land Use.

Table 10. Key category analysis without FOLU – Level Assessment for the year 2019.

IPCC Category	Name	Gas	Emissions year 2019 (Gg CO_{2e})*	Absolute value of emissions year 2019 (Gg CO_{2e})	Contribution for year 2019 (%)	Cumulative contribution total for year 2019 (%)	KCA order 2019
1A3b - Liquid	Road transport - liquid fuels	CO_2	1438.60	1438.60	0.452	0.452	1
1A1 - liquid	Energy industries - liquid fuels	CO_2	333.95	333.95	0.105	0.557	2
3A1	Enteric Fermentation	CH_4	326.27	326.27	0.103	0.660	3
4A	Solid waste disposal	CH_4	241.32	241.32	0.076	0.736	4
1A4 - liquid	Other sectors - liquid fuels	CO_2	134.52	134.52	0.042	0.778	5
2F1	Refrigeration and air conditioning	HFC	130.78	130.78	0.041	0.819	6
4D	Wastewater treatment and discharge	CH_4	112.62	112.62	0.035	0.855	7
3C4	Direct N_2O Emissions from managed soils	N_2O	85.67	85.67	0.027	0.882	8
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	85.63	85.63	0.027	0.909	9
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	70.30	70.30	0.022	0.931	10
3A2	Manure Management	CH_4	65.88	65.88	0.021	0.952	11

Table 11. Key category analysis without FOLU – Level Assessment for the base year 2013.

IPCC Category	Name	Gas	Emissions year 2013 (Gg CO_{2e})*	Absolute value of emissions year 2013 (Gg CO_{2e})	Contribution for year 2013 (%)	Cumulative contribution total for year 2013 (%)	KCA order 2013
1A3b - Liquid	Road transport - liquid fuels	CO_2	1084.88	1084.88	0.430	0.430	**1**
3A1	Enteric Fermentation	CH_4	295.43	295.43	0.117	0.547	**2**
1A1 - liquid	Energy industries - liquid fuels	CO_2	248.82	248.82	0.099	0.646	**3**
4A	Solid waste disposal	CH_4	190.77	190.77	0.076	0.722	**4**
4D	Wastewater treatment and discharge	CH_4	141.42	141.42	0.056	0.778	**5**
3C4	Direct N_2O Emissions from managed soils	N_2O	102.45	102.45	0.041	0.818	**6**
1A4 - liquid	Other sectors - liquid fuels	CO_2	101.92	101.92	0.040	0.859	**7**
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	77.89	77.89	0.031	0.890	**8**
2F1	Refrigeration and air conditioning	HFC	49.86	49.86	0.020	0.910	**9**
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	45.03	45.03	0.018	0.927	**10**
3A2	Manure Management	CH_4	41.42	41.42	0.016	0.944	**11**
3C5	Indirect N_2O Emissions from managed soils	N_2O	26.59	26.59	0.011	0.954	**12**

Table 12. Key category analysis without FOLU – Trend Assessment for the period 2013-2019.

IPCC Category	Name	Gas	Trend assessment	Contribution to the trend (%)	Total cumulative trend contribution (%)	KCA order Trend
1A3b - Liquid	Road transport - liquid fuels	CO_2	0.028	0.176	0.176	1
2F1	Refrigeration and air conditioning	HFC	0.027	0.169	0.344	2
4D	Wastewater treatment and discharge	CH_4	0.026	0.163	0.508	3
3A1	Enteric Fermentation	CH_4	0.018	0.115	0.623	4
3C4	Direct N_2O Emissions from managed soils	N_2O	0.017	0.108	0.731	5
1A1 - liquid	Energy industries - liquid fuels	CO_2	0.008	0.050	0.782	6
3A2	Manure Management	CH_4	0.005	0.034	0.815	7
1A3d - liquid	Waterborne navigation - liquid fuels	CO_2	0.005	0.034	0.849	8
1A2 - Liquid	Manufacturing industries and construction - Liquid fuels	CO_2	0.005	0.031	0.880	9
3C5	Indirect N_2O Emissions from managed soils	N_2O	0.005	0.030	0.910	10
3C1	Emissions from biomass burning	CH_4	0.003	0.018	0.928	11
1A4 - liquid	Other sectors - liquid fuels	CO_2	0.002	0.015	0.943	12

1.7. Quality Assurance/Quality Control Procedures

Verification activities are an integral part of the inventory preparation process in Fiji, aiming to ensure the quality attributes of transparency, consistency, comparability, completeness, and accuracy are met in a practical and cost-effective manner within a system of long-term continuous inventory improvement.

Verification is defined as the collection of activities and procedures conducted during the planning, development, and posterior utilisation of the GHG inventory in order to establish its reliability. Verification involves the establishment and application of a Quality Control and Quality Assurance (QA/QC) Plan.

Quality control (QC) and quality assurance (QA) are defined by the 2006 IPCC Guidelines as:

Quality Control (QC): A system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled, performed by personnel compiling the inventory. QC activities are designed to (i) provide routine and consistent checks to ensure data integrity, correctness, and completeness, (ii) identify and address errors and omissions, and (iii) document and archive inventory material and record all QC activities. QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods.

Quality Assurance (QA): A planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon a completed inventory following the implementation of QC procedures. Reviews verify that measurable objectives were met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme.

The QA/QC Plan for the National Inventory of Fiji is comprised of the following elements:

- Quality objectives
- Definition of roles/responsibilities for executing the QA/QC Plan
- General QC procedures and category-specific QC procedures
- QA procedures
- Archiving procedures

The results of the QA/QC activities serve as the main input for the development of the inventory improvement plan.

The QA/QC Procedures are illustrated in the following figure.

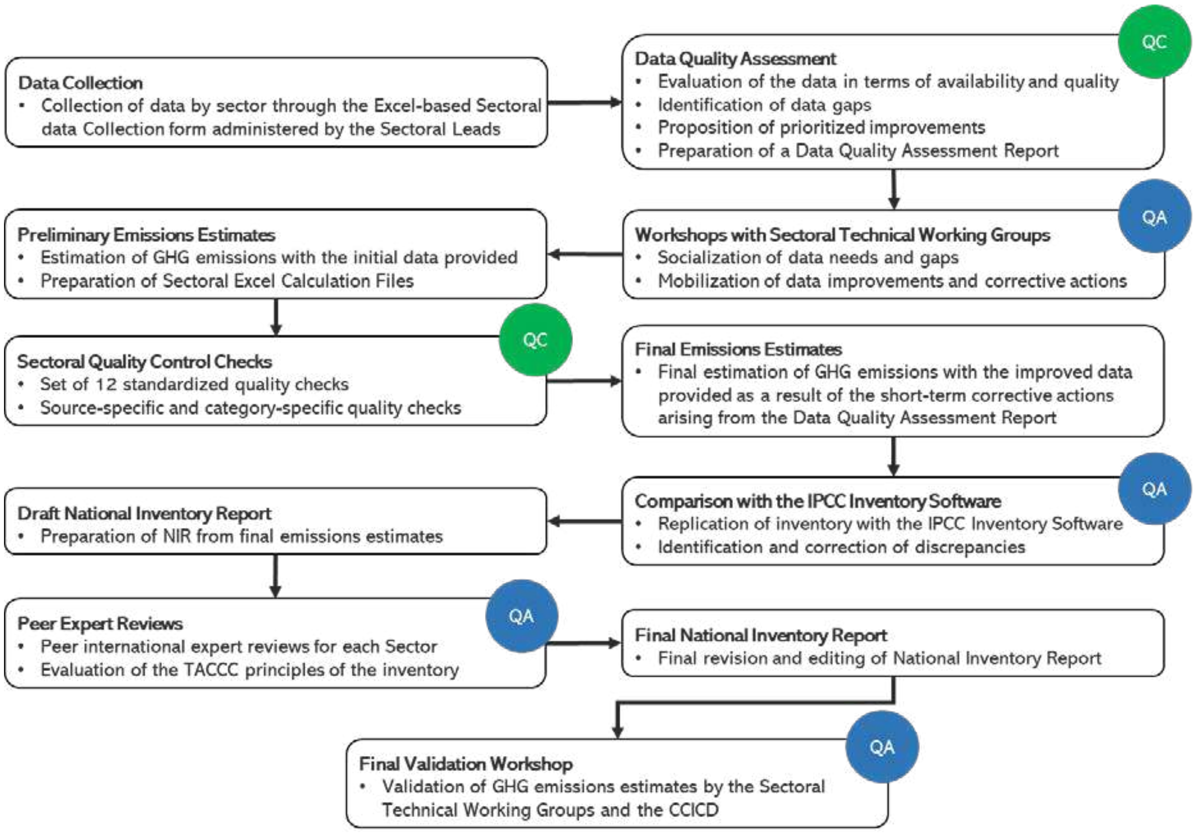


Figure 9. QA/QC procedures flow chart.

1.7.1. Quality Objectives

The QA/QC Plan establishes the following quality objectives for the national inventory of Fiji and the national inventory system:

- **Transparency:** Ensuring all data, assumptions, expert judgement, supporting documentation, calculations, assessments, and QA/QC activities are adequately documented, reported, and archived in order to increase the credibility of emissions results, facilitate verification processes and meet reporting requirements.
- **Accuracy:** Reducing uncertainties as far as practicable, considering the scientific knowledge available, while ensuring the national circumstances are adequately reflected.
- **Completeness:** Covering all GHG sources and sinks occurring within the national territory.
- **Consistency:** Ensuring methodologies and data sources are applied in a consistent matter over the entire time series in order to adequately evaluate changing trends as a response to changing national conditions.
- **Comparability:** Ensuring 2006 IPCC Guidelines are followed throughout all processes of inventory compilation and ensuring the national inventory system of Fiji and its outputs meet international requirements under the UNFCCC and agreements thereunder.
- **Improvement:** Ensuring the quality of the inventory is continuously improved by addressing gaps in data, assumptions, and methodologies in a prioritized manner for effective allocation of resources.

The QA/QC Plan places of utmost importance on the quality and availability of raw data used for compiling the GHG inventory, acknowledging that the quality of all downstream processes is ultimately determined by the quality of the raw data available. As a result, the QA/QC plan places a strong emphasis on the assessment of existing data sources, their reliability, and potential data gaps, aiming to improve data quality and propose the incorporation of new data sources if needed.

1.7.2. QA/QC Roles and Responsibilities

All QA/QC activities are conducted under the responsibility of the QA/QC Coordinator within the Climate Change Division (CCD) of the OPM, executed by the international technical experts responsible for the elaboration of the inventory, in conjunction with the Sectoral Technical Working Groups.

The international technical experts are responsible for the implementation of QA/QC procedures on a sectoral basis related to data collection, handling, processing, documentation, archiving, and necessary reporting procedures related to the inventory.

Each entity/organization contributing data to the development of the Fiji inventory is responsible for the quality of its own data in response to feedback and petitions of the Sectoral Technical Working Groups.

The Sectoral Leads have an important role in the implementation of QA/QC activities since they are responsible for providing validation of all processes related to inventory preparation, as well as the derived results. Given that the Sectoral Technical Working Groups are the entities responsible for data collection, they are also responsible for addressing data gaps and implementing data quality corrective actions.

The roles and responsibilities of each entity involved as it pertains to the inventory QA/QC Plan are illustrated in the following figure.

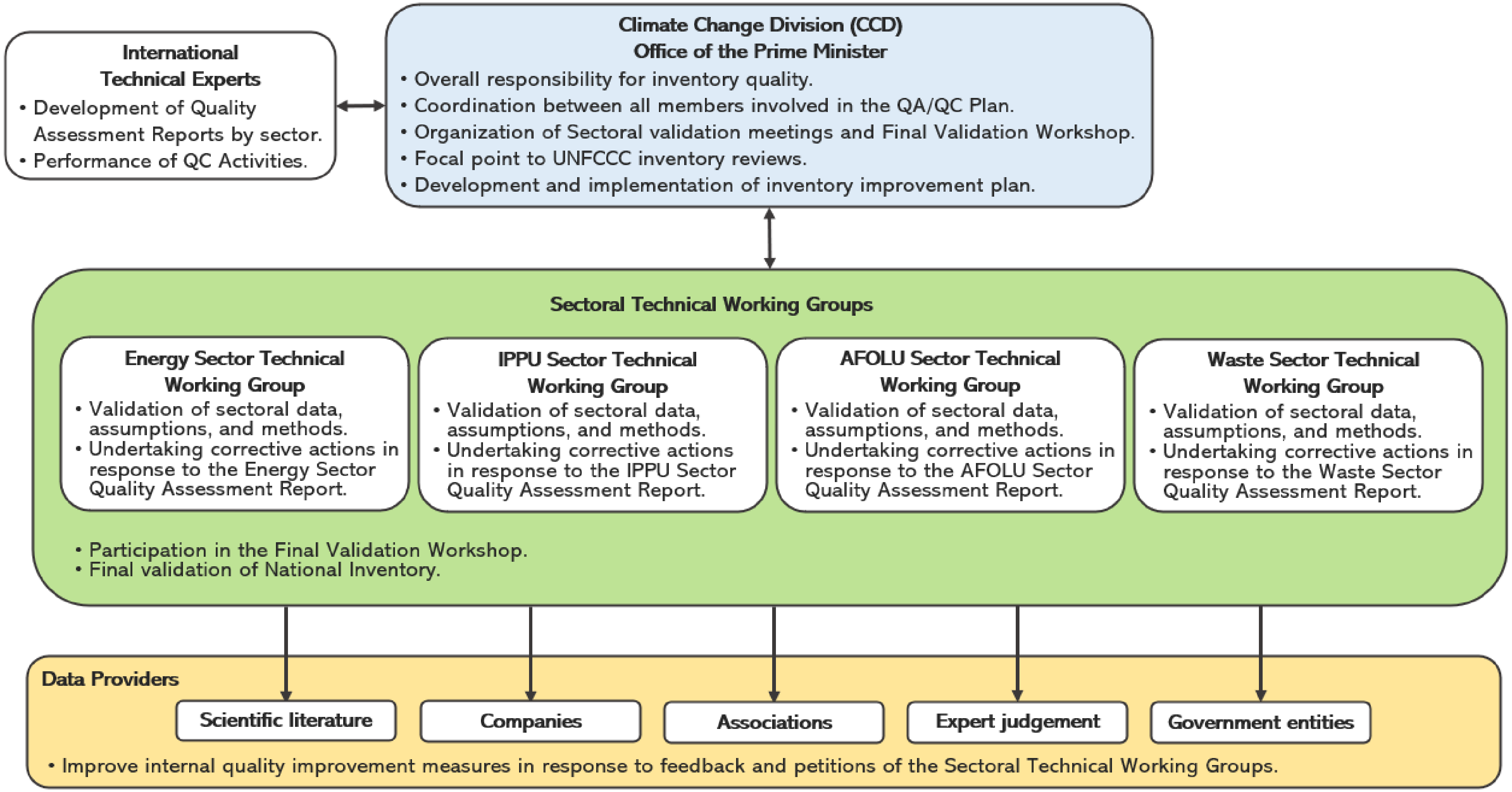


Figure 10. Roles and responsibilities of the inventory A/QC plan.

1.7.3. Quality Control Procedures

QC procedures are performed in two steps by the personnel directly involved in the preparation of the inventory: (i) Data quality assessment, and (ii) general and sector-specific QC checklists.

Data Quality Assessment

Following data collection, all information provided by the Sectoral Technical Working Groups is assessed in terms of data availability and quality before preliminary GHG emissions and removal estimates are conducted. The aim of the assessment is to identify existing data gaps and identify immediate, short-term, and long-term corrective actions and/or areas of improvement for each sector. A Data Quality Assessment Report is prepared for each sector and provided to the corresponding Working Groups. A sectoral workshop is then organized with each Working Groups in order to present results of the Data Quality Assessment Report and to address questions and provide feedback on assumptions and/or gap-filling, if needed. The Data Quality Assessment Report provides the Working Groups with the opportunity to undertake the necessary actions to address the immediate and short-term data gaps prior to finalizing the GHG emissions and removals estimates with improved data.

General and Sector-Specific QC Checklists

QC checks are performed by sector during the estimation of GHG emissions and removals of each sector to minimize errors during the final selection of data, emission factors, and other parameters; unit conversion; selection of methodological tiers; preparation of computation files; evaluation of trends; and documentation of inventory processes. The following Table 13 presents the QC Checklist that is followed for all sectors, based on the recommended QC procedures in Table 6.1, chapter 6, Volume 1 of the 2006 IPCC Guidelines. This Checklist comprises of 12 QC activities, further broken down into QC procedures. Additional sector-specific quality control checks are performed as needed on a case-by-case basis in response to the data availability and nature of GHG sources and sinks occurring in Fiji. Further source-specific QC procedures are be applied on a case-by-case basis for key categories and categories where there has been a significant revision of the methodology and data used, as well as for new data sources. In all cases, the individual responsible for performing each QC check, the date it was performed, and any corrective actions undertaken are documented.

QC Activity Number 3 – "Check that emissions and removals are calculated correctly" is an element of particular importance within the QA/QC Plan of Fiji, given that all calculations are performed in a series of Excel files developed specifically for the national context of Fiji. This QC Activity therefore consists of reproducing all emissions and removals calculations through the introduction of the final selected data into the latest version of the IPCC Inventory Software[4,5]. If emissions and

[4] The purpose of this software is to implement Tier 1 and Tie r2 methodologies for the preparation of national GHG inventories according to 2006 IPCC Guidelines. The primary target groups of users include inventory compilers who wish to apply default 2006 IPCC Guidelines methods, and Parties not included in Annex I of the Convention having limited resources for their inventory systems.
[5] Available at: https://www.ipcc-nggip.iges.or.jp/software/index.html

removals are calculated correctly, then the results obtained from the national Excel inventory calculation files should agree with the results obtained from the IPCC Inventory Software.

Table 13. QC checklist for all sectors.

	QC Activity	QC Procedure
1	Check that assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters are documented.	Cross-check descriptions of activity data and ensure that these are properly recorded and archived.
		Cross-check descriptions of emission factors and ensure that these are properly recorded and archived.
		Cross-check descriptions of other estimation parameters and ensure that these are properly recorded and archived.
2	Check for transcription errors in data input and references.	Confirm that bibliographical data references are properly cited in the internal documentation.
		Cross-check a sample of input data for transcription errors.
3	Check that emissions and removals are calculated correctly.	Reproduce a set of emissions and removals calculations.
		Use a simple approximation method that gives similar results to the original and more complex calculation to ensure that there is no data input error or calculation error.
4	Check that parameters and units are correctly recorded and that appropriate conversion factors are used.	Check that units are properly labelled in calculation sheets.
		Check that units are correctly carried through from beginning to end of calculations.
		Check that the relation between the activity data and emission factors is correct.
		Check that conversion factors are correct.
		Check that temporal and spatial adjustment factors are used correctly.
5	Check the integrity of database files.	Confirm that the appropriate data processing steps are correctly represented in the database.
		Confirm that data relationships are correctly represented in the database.
		Ensure that data fields are properly labelled and have the correct design specifications.
		Ensure that adequate documentation of database and model structure and operation are archived.
6	Check for consistency in data between categories.	Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations.
7	Check that the movement of inventory data among processing steps is correct.	Check that emissions and removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing the results tables.
		Check that emissions and removals data are correctly transcribed between different intermediate products.
8	Check that uncertainties in emissions and removals are estimated and calculated correctly.	Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate.
		Check that qualifications, assumptions and expert judgements are recorded.
		Check that uncertainties are complete and calculated correctly.
		If necessary, duplicate uncertainty calculations on a small sample using uncertainty calculations according to Approach 1.
9		Check for temporal consistency in time series input data.

QC Activity		QC Procedure
	Check time series consistency.	Check for consistency in the algorithm/method used for calculations throughout the time series.
		Check methodological and data changes resulting in recalculations.
		Check that the effects of mitigation activities have been appropriately reflected in time series calculations.
10	Check completeness.	Confirm that estimates are reported for all categories and for all years from the appropriate base year to the period of the current inventory.
		Confirm that entire category is being covered.
		Provide clear definition of ‘Other’ type categories.
		Check that known data gaps that result in incomplete estimates are documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions.
11	Trend checks.	Compare current estimates to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any differences.
		Check value of implied emission factors (aggregate emissions divided by activity data) across time series.
		Check if there are any unusual and unexplained trends noticed for activity data or other parameters across the time series.
12	Review of internal documentation and archiving.	Check that there is detailed internal documentation to support the estimates and enable reproduction of the emission, removal and uncertainty estimates.
		Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.
		Check that the archive is closed and retained in secure place following completion of the inventory.
		Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.

1.7.4. Quality Assurance Procedures

QA procedures consists of the validation of all data sources, assumptions, methodologies used to compile the national GHG inventory of Fiji, as well as the accuracy of the results and trends in representing the national context.

Validation has been undertaken at three levels:

- By an international team of experts who are also UNFCCC lead reviewers of Annex I GHG inventories submitted to the UNFCCC annually as well as co-leads of the technical team of experts undertaking the technical analysis of BURs.
- Using the last version of the IPCC software to cross-check that the same results are obtained.
- At national level.

QA at international level

In the international team a peer reviewer expert was assigned by sector to undertake checks, propose improvements, and ensure the quality of the inventory.

Table 14. International QA roles.

International QA roles	
Peer reviewer experts	Sectors
Pepa López	Cross-cutting, energy and IPPU
Juan Luis Martin Ortega	Cross-cutting, energy and waste
Ioannis Sempos	AFOLU

The international peer reviewers checked the five quality principles at various levels in the data compilation and reporting processes as presented in the table below.

Table 15. QA procedures for the Fiji national GHG inventory.

QA procedures	
Principle	Procedures
Transparency means clear documentation and reporting at a level of disaggregation that sufficiently allows individuals other than the compiler of the inventory to understand how the inventory was compiled. The transparency of emission reporting is fundamental to the effective use, review and continuous improvement of the inventory.	Check if documentation within the spreadsheets shows data inputs, calculations, and outputs. Check if the chapters and sections within the NIR provide the activity data and emission factors with the sources used, explain the methods used and summarise the data set.
Consistency means that estimates for any different inventory years, gases and source categories are made in such a way that differences in the results between years and source categories reflect real differences in emissions. Annual emissions, as far as possible, should be calculated using the same method and data sources for all years, and resultant trends should reflect real fluctuations in emissions and not the changes resulting from methodological differences.	Check if the same methods and the same data sources are used for the whole time series.
Comparability means that the national inventory is reported in such a way that allows it to be compared with national inventories of other Parties. This can be achieved by using accepted methodologies and by using the reporting templates such as those provided in the 2006 IPCC Guidelines.	Check if the same IPCC guidelines for the methodologies and reporting templates have been used for the whole inventory and for the same group of gases (GHG or precursors).
Completeness means that estimates are reported for all gases, all relevant source categories and all years and for the entire territorial areas of Parties covered by the reporting requirements set forth in the provisions of the Convention and its protocols.	Check if estimates are provided for all gases, all source categories existing in the country and the whole national territory under Fiji jurisdiction. Check if emissions from international transport are not part of the totals but provided as memo items.

QA procedures	
Principle	Procedures
Accuracy means that emissions are neither overestimated nor underestimated, as far as can be judged and with uncertainties reduced as far as practicable. This implies that Parties will endeavour to remove bias from the inventory estimates and minimize uncertainty.	Check if uncertainty analysis is undertaken and improvement plans proposed. Check if the most appropriate and up to date data sources and methods are used.

These checks were designed to verify the transparency, accuracy, consistency, comparability and completeness of the information submitted and included:

- an assessment whether all emission source categories and gases are reported;
- an assessment whether emissions data time series are consistent;
- an assessment whether implied emission factors are comparable to the emissions factors of other countries with similar national circumstances and also taking the IPCC default emission factors into account;
- an assessment of the use of 'Not Estimated' notation keys where IPCC tier 1 methodologies exist;
- an analysis of recalculations performed compared to the inventories presented in previous national communications;
- a comparison of the national data using both different national data sources and international data sources when available;
- a comparison of the results of the reference approach with the sectoral approach for the energy sector; and
- an assessment whether there were potential overestimations or underestimations relating to a key category in the inventory.

In particular, the peer reviewers checked if the international team in charge of the inventory compilation had implemented the following activities:

- Source data received are traceable back to their source in the compilation system. The mechanisms for this are spreadsheet notes, and a common system of data referencing of activity data and emission factors in each sector.
- Checks are undertaken at each stage of the inventory compilation – on receipt of the data, after each calculation step and at the end of the process before dissemination.
- Calculations are also checked, and the checks applied are described.
- Checks are made on the inventory comparing the emissions of the whole time series and looking for explanations of the trend to ensure that large inter-annual variations have been investigated.
- Compare the reference and the sectoral approach in the energy sector and look for explanations in case of large discrepancies (the total emissions by fuel, must be consistent with the total emissions by source).
- All spreadsheets are subject to second person checking.
- As an additional quality check, the national emission estimates were also prepared via the IPCC software by introducing the activity data and emission factors.

- The national report provides full details of inventory estimation methodologies by source category. The report includes summaries of key data sources and significant revisions to methods and historic data, where appropriate. It also describes the assumptions used in the compilation.
- The uncertainty analysis and the key category analysis for the greenhouse gas inventory is detailed within the National Inventory Report.
- The national report includes a programme of continuous improvement.
- At the end of each reporting cycle, it is planned that all the database files, spreadsheets, electronic source data, paper source data, output files, etc., are in effect frozen and archived.

QA/QC using the IPCC software

The activity data used for calculating the GHG emission inventory has been populated into the IPCC software as an additional QC procedure of the national GHG emission inventory. This was made for all the energy, IPPU and waste sectors (i.e., the AFOLU sector was not included in this exercise for the limitations of the software regarding the estimation of these emissions). The only issue identified in this exercise related the emissions of refrigeration and air conditioning, for which the IPCC template provided together 2006 IPCC guidelines provided different results to the IPCC software. The inventory compilation team ascertained there were no errors in the calculations, as the issue was due to a calculation bug in the excel file provided by IPCC. The results from the IPCC software were used as the final emissions in category 2F1 Refrigeration and air conditioning.

QA at national level

National validation is provided by the Sectoral Technical Working Groups through a series of workshops and meetings held throughout the inventory preparation processes, the two principal QA/validation workshops/meetings are:

- Sectoral Meetings with the Sectoral Technical Working Groups scheduled following the elaboration of the Quality Assessment Report: The aim of these sectoral meetings is to provide clarification, feedback, and approval on assumptions and selected data sources for the preparation of preliminary GHG emissions and removal estimates.
- Validation Workshop: A Validation Workshop was held in October 2021 with key members of all Sectoral Technical Working Groups and the CCD involved in the inventory preparation after the initial GHG inventory is compiled and the draft national inventory report is prepared. The aim of the Validation Workshop is to ensure that the final GHG inventory of Fiji adequately reflects the national context and meets the set attributes/objectives.
- Final Validation Workshop: Following a period of further refining data through additional consultations with stakeholders and enhancement of the 1994-2019 edition of the Fiji GHG inventory, a final validation workshop was organised on 7 July 2023 to validate the national GHG emissions data.

QA at sectoral level

To estimate emissions for category 2F1 – Refrigeration and Air Conditioning, data was available from the Fiji Revenue Customs Service (FRCS) on the quantity of refrigeration and air conditioning units imported in Fiji in the period 2016-2020. However, when applying the tier 2 approach from the 2006 IPCC Guidelines, which estimates emissions according to the number of units by sub-application, the results were unusually high (e.g., higher emissions than the entire Energy sector). Data on the usage of HFCs in metric tonnes in Fiji for the period 2016-2020 was also available from the FRCS. Because the provided data on the quantities of refrigeration and air conditioning units imported could not be verified, HFC emissions were therefore estimated according to a tier 1 approach using the data on the amount of blends imported in the country.

Furthermore, data was provided on the consumption of carbonates for clinker production in the period 1994-2019. When assessing this data, it was found to be related to clinker imports with the values showing very strong correlations with clinker import data. Further research indicated that Fiji does not produce any clinker in the country and that it imports all clinker which is subsequently used to produce cement. Therefore, emissions for category 2A1 – Cement production were not included in the national totals. Archiving Procedures.

All documents and files used to conduct the inventory are stored electronically. Archiving processes as it pertains to the QA/QC Plans include checks to ensure that all information related to the planning, preparation and management of inventory activities are documented and archived. The extent and availability of this information should aim to enhance transparency and credibility while enabling the reproduction of the inventory in the event of future inquiry. While archiving and documentation is an on-going process that is executed as data is collected and the inventory is compiled, at the end of the inventory, QA/QC procedures for archiving are performed to ensure that all archived information is adequately stored in a secure and centralized location, including:

- Responsibilities, institutional arrangements, and procedures for the planning, preparation, QA/QC, and management of the inventory process.
- Assumptions and criteria for the selection of activity data and emission factors.
- Emission factors and other estimation parameters used, including references to the IPCC.
- Activity data.
- Information on the uncertainty associated with activity data and emission factors.
- Rationale for choice of methods.
- Methods used.
- Changes in data inputs or methods from previous inventories (recalculations).
- Expert judgement, including the identification of the experts, the rationale for the judgement, and all supporting documentation.
- Electronic databases or software used in the production of the inventory.
- Worksheets for category estimates calculation.
- Inventory reports and any analysis of trends.
- QA/QC results, including QA
- Inventory Improvement Plan

1.8. Uncertainty Assessment

Uncertainty assessments are an essential element for improving the accuracy of the national GHG inventory through the identification of the most significant sources of uncertainties with the aim to prioritise data collection efforts and guide methodological selection.

While the 1994-2019 edition of the National Inventory of Fiji has been prepared with the highest possible accuracy considering the current availability of country-specific data, uncertainties are associated to a varying degree due to the following reasons:

- Lack of high-quality data leading to interpolation, extrapolation, and the use of assumptions.
- Model approximations which simplify real systems and are therefore not exact.
- Measurement and statistical random sampling errors.

Further analysis of the causes of uncertainties for each Sector is provided in Chapters 3 through 6, as well as the identification of improvement methods to reduce these uncertainties, which have been incorporated into the Inventory Improvement Plan (Chapter 1 - Section 9). It is worth mentioning that the national priority for reducing uncertainties is focused on improving the extent and periodicity of the collection of more specific high-quality activity data.

1.8.1 Methodology

The 2006 IPCC Approach 1 – Propagation of Error has been followed to conduct the uncertainty assessment. In line with the 2006 IPCC Guidelines, the uncertainty of the national GHG inventory is determined for individual categories and for the inventory as a whole, as well as the trends between the latest inventory year (2019) and the base year (2013). The uncertainty assessment is performed on the basis of the uncertainties in the activity data, emission factors, and other estimation parameters for each category.

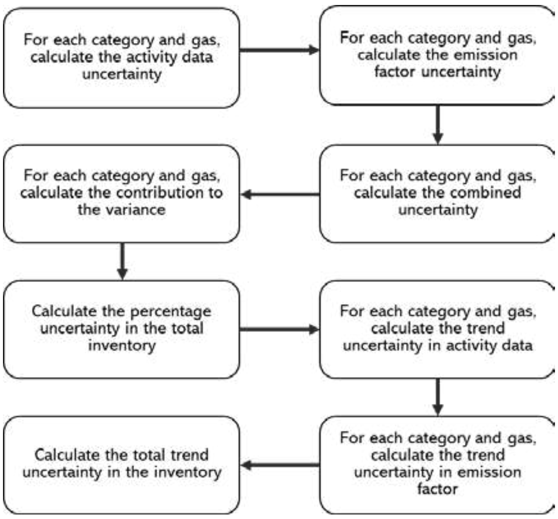


Figure 11. Uncertainty assessment under Approach 1.

A description of the main equations used is as follows:

Uncertainty in the Total Level of the Emissions of the Inventory

Combined Uncertainty:

The combined uncertainty is utilized to provide uncertainty estimates of a source or sink based on the combination of the uncertainties of the activity data and emissions factors.

$$U_x = \sqrt{U_{AD,x}^2 + U_{EF,x}^2}$$

Where:
$U_x =$ *Combined uncertainty for source or sink x*
$U_{AD,x} =$ *Uncertainty of the activity data for source or sink x*
$U_{EF,X} =$ *Uncertainty of the emission factor for source or sink x*

Total Level Uncertainty in the Inventory:

Type B sensitivity arises from uncertainties that affect emissions or removals in the current year only.

$$U = \sqrt{\sum_x V_x} \text{ , where } V_x = \frac{(U_x \cdot E_{x,t})^2}{(\sum_y E_{y,t})^2}$$

Where:
$V_x =$ *Contribution to variance by category x in year t*
$U_x =$ *Combined uncertainty for source or sink x*
$E_{x,t} =$ *Emission or removal estimate of source or sink x in year t*
$\sum_y E_{y,t} =$ *Total inventory estimates in year t*
$U =$ *Uncertainty in the total level of the emissions of the inventory*

Uncertainty Introduced into the Trend in Total National Emissions

Type A Sensitivity:

The Type A Sensitivity arises from uncertainties that affect emissions or removals in the base year and the current year equally.

$$S_{A,x} = \left| \frac{0.01 \cdot E_{x,t} + \sum_y E_{y,t} - (0.01E_{x,0} + \sum_y E_{y,0})}{(0.01E_{x,0} + \sum_y E_{y,0})} \cdot 100 - \frac{\sum_y E_{y,t,} - \sum_y E_{y,0}}{\sum_y E_{y,0}} \cdot 100 \right|$$

Where:
$S_{A,x} =$ *Type A sensitivity for source or sink x*
$E_{x,t}$ and $E_{x,0} =$ *Emission or removal estimate of source or sink x in year t and year 0, respectively*

$\sum_y E_{y,t}$ and $\sum_y E_{y,0}$ $= Total\ inventory\ estimates\ in\ year\ t\ and\ 0,\ respectively$

Type B Sensitivity:

Type B sensitivity arises from uncertainties that affect emissions or removals in the current year only.

$$S_{B,x} = \left|\frac{E_{x,t}}{\sum_y E_{y,0}}\right|$$

Where:
$S_{B,x} = Type\ B\ sensitivity\ for\ source\ or\ sink\ x$
$E_{x,t} = Emission\ or\ removal\ estimate\ of\ source\ or\ sink\ x\ in\ year\ t$
$\sum_y E_{y,0} = Total\ inventory\ estimates\ in\ year\ 0$

Total Trend Uncertainty in the Inventory:

$$U_{trend} = \sqrt{\sum_x U_{trend,x}},$$

where: $U_{trend,EF,x} = S_{A,x} \cdot U_{EF,x}$, $U_{trend,AD,x} = S_{B,x} \cdot U_{AD,x} \cdot \sqrt{2}$, and $U_{trend,x} = {U_{trend,AD,x}}^2 + {U_{trend,EF,x}}^2$

Where:
$U_{trend,EF,x} = Uncertainty\ in\ trend\ in\ national\ emissions\ introduced\ by\ emission\ factor\ uncertainty$
$S_{A,x} = Type\ A\ sensitivity\ for\ source\ or\ sink\ x$
$S_{B,x} = Type\ B\ sensitivity\ for\ source\ or\ sink\ x$
$U_{EF,x} = Emission\ factor\ uncertainty$
$U_{AD,x} = Activity\ data\ uncertainty$
$U_{trend,AD,x} = Uncertainty\ in\ trend\ in\ national\ emissions\ introduced\ by\ activity\ data\ uncertainty$
$U_{trend,x} = Uncertainty\ introduced\ into\ the\ trend\ in\ total\ national\ emissions\ by\ category\ x$
$U_{trend} = Trend\ uncertainty$

1.8.2 Results

For the set of sectors of the National Inventory, the uncertainty on the level has been estimated for the base year (2013) and the last inventory year (2019). The results of the uncertainty quantification for the National Inventory were a total of 55.08% for the inventory year (2019) and a trend uncertainty of 42.25%.

The following tables present the uncertainty calculations performed for the inventory as a whole and for each sector. The source of all the uncertainty values are the default 2006 IPCC uncertainty values selected among the ranges provided by the IPCC 2006, for which the selection criteria has been based on the conservative principle, using the upper values of the ranges by default.

Table 16. Uncertainty of the 1994-2019 national GHG inventory of Fiji.

IPCC category	Gas	Base year emissions (2013)	2019 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Contribution to variance by category in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend by EF	Uncertainty in trend by AD	Uncertainty introduced into the trend in total national emissions
		Gg of CO2-eq		%	%	%		%	%	%	%	
1A1 – Energy industries – Liquid	CO2	248.82	333.95	2	7	7	1.093	0.042	0.131	0.293	0.263	0.155
1A1 – Energy industries – Liquid	CH4	0.28	0.37	2	100	100	0.000	0.000	0.000	0.005	0.000	0.000
1A1 – Energy industries – Liquid	N2O	0.52	0.69	2	100	100	0.001	0.000	0.000	0.009	0.001	0.000
1A2 – Manufacturing industries and construction - Biomass	CH4	2.59	3.81	30	100	104	0.029	0.001	0.002	0.057	0.045	0.005
1A2 – Manufacturing industries and construction – Biomass	N2O	3.27	3.80	30	100	104	0.029	0.000	0.001	0.032	0.045	0.003
1A2 – Manufacturing industries – Liquid	CO2	77.89	85.63	15	7	17	0.372	0.006	0.034	0.040	0.505	0.257
1A2 – Manufacturing industries – Liquid	CH4	0.08	0.08	15	100	101	0.000	0.000	0.000	0.000	0.000	0.000
1A2 – Manufacturing industries – Liquid	N2O	0.14	0.14	15	100	101	0.000	0.000	0.000	0.000	0.001	0.000
1A3a – Domestic aviation – Liquid	CO2	14.76	22.27	15	7	17	0.025	0.003	0.009	0.024	0.131	0.018
1A3a – Domestic aviation – Liquid	CH4	0.02	0.02	15	100	101	0.000	0.000	0.000	0.000	0.000	0.000
1A3a – Domestic aviation – Liquid	N2O	0.13	0.19	15	100	101	0.000	0.000	0.000	0.003	0.001	0.000

IPCC category	Gas	Base year emissions (2013)	2019 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Contribution to variance by category in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend by EF	Uncertainty in trend by AD	Uncertainty introduced into the trend in total national emissions
		Gg of CO2-eq		%	%	%		%	%	%	%	
1A3b – Road transport – Liquid	CO2	1084.88	1438.60	15	7	17	104.898	0.175	0.566	1.224	8.487	73.522
1A3b – Road transport – Liquid	CH4	4.78	8.96	15	100	101	0.152	0.002	0.004	0.181	0.053	0.035
1A3b – Road transport – Liquid	N2O	14.33	18.33	15	100	101	0.636	0.002	0.007	0.206	0.108	0.054
1A3c – Railways - Liquid	CO2	0.34	1.14	15	7	17	0.000	0.000	0.000	0.002	0.007	0.000
1A3c – Railways – Liquid	CH4	0.00	0.00	15	100	101	0.000	0.000	0.000	0.000	0.000	0.000
1A3c – Railways – Liquid	N2O	0.03	0.12	15	100	101	0.000	0.000	0.000	0.003	0.001	0.000
1A3d – Waterborne navigation – Liquid	CO2	45.03	70.30	15	7	17	0.251	0.011	0.028	0.080	0.415	0.178
1A3d – Waterborne navigation – Liquid	CH4	0.12	0.19	15	100	101	0.000	0.000	0.000	0.003	0.001	0.000
1A3d – Waterborne navigation – Liquid	N2O	0.34	0.52	15	100	101	0.001	0.000	0.000	0.009	0.003	0.000
1A4 – Other sectors – Liquid	CO2	101.92	134.52	15	7	17	0.917	0.016	0.053	0.114	0.794	0.643
1A4 – Other sectors – Liquid	CH4	0.29	0.36	15	100	101	0.000	0.000	0.000	0.004	0.002	0.000
1A4 – Other sectors – Liquid	N2O	2.26	2.58	15	100	101	0.013	0.000	0.001	0.020	0.015	0.001
1A4 – Other sectors – Biomass	CH4	0.60	0.47	30	100	104	0.000	0.000	0.000	0.003	0.005	0.000
1A4 – Other sectors – Biomass	N2O	0.76	0.59	30	100	104	0.001	0.000	0.000	0.004	0.007	0.000
2D - Lubricants	CO2	0.02	0.01	3	50	50	0.000	0.000	0.000	0.000	0.000	0.000
2F1 - F-gases	HFC	49.86	130.78	100	100	141	63.278	0.033	0.051	3.350	5.143	37.674

IPCC category	Gas	Base year emissions (2013)	2019 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Contribution to variance by category in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend by EF	Uncertainty in trend by AD	Uncertainty introduced into the trend in total national emissions
		Gg of CO2-eq		%	%	%		%	%	%	%	
3A1 - Enteric Fermentation	CH4	295.43	326.27	20.00	40	45	39.384	0.022	0.128	0.882	2.566	7.364
3A2 - Manure Management	CH4	41.42	65.88	20.00	30	36	1.044	0.011	0.026	0.330	0.518	0.378
3A2 - Manure Management	N2O	0.18	0.16	53.85	116	128	0.000	0.000	0.000	0.000	0.003	0.000
3B1a - Forest remaining Forest	CO2	-82.27	-504.47	28.00	233	235	2.593	0.169	-0.198	39.347	-5.555	1.579.055
3B1b - Land converted to Forest	CO2	-290.85	-416.63	15.00	43	46	67	0.059	-0.164	2.551	-2.458	12.549
3B3b - Land Converted to Grassland	CO2	394.26	66.43	15.00	53	55	2	0.115	0.026	6.120	0.392	37.612
3C1 - Emissions from biomass burning	CH4	20.50	18.60	100.00	50	112	0.800	0.000	0.007	0.003	0.732	0.535
3C1 - Emissions from biomass burning	N2O	5.71	5.18	100.00	50	112	0.062	0.000	0.002	0.001	0.204	0.041
3C3 - Urea application	CO2	0.32	0.39	50.00	5	50	0.000	0.000	0.000	0.000	0.008	0.000
3C4 - Direct N2O Emissions from managed soils	N2O	102.45	85.67	20.00	200	201	54.850	0.003	0.034	0.630	0.674	0.851
3C5 - Indirect N2O Emissions from managed soils	N2O	26.59	21.62	20.00	463	463	18.563	0.001	0.009	0.490	0.170	0.269
3C6 - Indirect N2O Emissions from manure management	N2O	0.01	0.01	53.85	313	318	0.000	0.000	0.000	0.000	0.000	0.000
3C7 - Rice cultivations	CH4	6.60	6.22	10.00	83	84	0.050	0.000	0.002	0.006	0.024	0.001

IPCC category	Gas	Base year emissions (2013)	2019 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Contribution to variance by category in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend by EF	Uncertainty in trend by AD	Uncertainty introduced into the trend in total national emissions
		Gg of CO2-eq		%	%	%		%	%	%	%	
4A - Solid waste disposal	CH4	190.77	241.32	51.96	56	77	63.188	0.026	0.095	1.479	4.931	26.506
4B - Biological treatment of solid waste	CH4	2.36	2.58	30.00	100	104	0.013	0.000	0.001	0.016	0.030	0.001
4B - Biological treatment of solid waste	N2O	1.34	1.46	30.00	113	116	0.005	0.000	0.001	0.010	0.017	0.000
4C1 - Incineration of waste	CO2	0.25	0.26	100.00	40	108	0.000	0.000	0.000	0.000	0.010	0.000
4C1 - Incineration of waste	CH4	0.00	0.00	100.00	100	141	0.000	0.000	0.000	0.000	0.000	0.000
4C1 - Incineration of waste	N2O	0.00	0.00	100.00	100	141	0.000	0.000	0.000	0.000	0.000	0.000
4C2 - Open burning	CO2	6.57	6.74	30.00	40	50	0.021	0.000	0.003	0.011	0.080	0.006
4C2 - Open burning	CH4	12.23	12.54	30.00	100	104	0.317	0.001	0.005	0.053	0.148	0.025
4C2 - Open burning	N2O	1.92	1.97	58.31	100	116	0.010	0.000	0.001	0.008	0.045	0.002
4D1 - Domestic wastewater	CH4	141.42	112.62	59.64	54	80	15.134	0.007	0.044	0.353	2.641	7.102
4D1 - Domestic wastewater	N2O	11.44	11.81	33	500	501	6.482	0.001	0.005	0.267	0.153	0.094

National total emissions	2542,70	2325.05	**Year uncertainty**	55.08	**Trend uncertainty**	42.25

Table 17. Uncertainty in the energy sector.

IPCC category	Gas	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
1A1 – Energy industries – Liquid	CO_2	2	7	7
1A1 – Energy industries – Liquid	CH_4	2	100	100
1A1 – Energy industries – Liquid	N_2O	2	100	100
1A2 – Manufacturing industries – Biomass	CH_4	30	100	104
1A2 – Manufacturing industries – Biomass	N_2O	30	100	104
1A2 – Manufacturing industries – Liquid	CO_2	15	7	17
1A2 – Manufacturing industries – Liquid	CH_4	15	100	101
1A2 – Manufacturing industries – Liquid	N_2O	15	100	101
1A3a – Domestic aviation – Liquid	CO_2	15	7	17
1A3a – Domestic aviation – Liquid	CH_4	15	100	101
1A3a – Domestic aviation – Liquid	N_2O	15	100	101
1A3b – Road transport - Liquid	CO_2	15	7	17
1A3b – Road transport – Liquid	CH_4	15	100	101
1A3b – Road transport – Liquid	N_2O	15	100	101
1A3c – Railways - Liquid	CO_2	15	7	17
1A3c – Railways – Liquid	CH_4	15	100	101
1A3c – Railways – Liquid	N_2O	15	100	101
1A3d – Waterborne navigation – Liquid	CO_2	15	7	17
1A3d – Waterborne navigation – Liquid	CH_4	15	100	101
1A3d – Waterborne navigation – Liquid	N_2O	15	100	101
1A4 – Other sectors – Liquid	CO_2	15	7	17
1A4 – Other sectors – Liquid	CH_4	15	100	101
1A4 – Other sectors – Liquid	N_2O	15	100	101
1A4 – Other sectors – Biomass	CH_4	30	100	104
1A4 – Other sectors – Biomass	N_2O	30	100	104

The source of all the uncertainty values for the energy sector is the default values from the ranges provided in the 2006 IPCC Guidelines, whereby a conservative principle has been applied by selecting the upper values of the default uncertainty ranges.

Table 18. Uncertainty in the IPPU sector.

IPCC category	Gas	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
2D - Lubricants	CO_2	3	50	50
2F1 - F-gases	HFCs	100	100	141

The uncertainty values allocated in the IPPU sector are mainly based on expert judgment (based on 2006 IPCC guidance) rather than default values. The reason for that is the limited guidance provided by the 2006 IPCC Guidelines.

Table 19. Uncertainty in the AFOLU sector.

IPCC category	Gas	Activity data uncertainty (%)	Emission factor Uncertainty (%)	Combined uncertainty (%)
3A1 - Enteric fermentation	CH_4	20	40	45
3A2 - Manure management	CH_4	20	30	36
3A2 - Manure management	N_2O	54	116	128
3B - Land	CO_2	100	0	100
3C1 - Emissions from biomass burning	CH_4	100	50	112
3C1 - Emissions from biomass burning	N_2O	100	50	112
3C3 - Urea application	CO_2	50	5	50
3C4 - Direct N_2O emissions from managed soils	N_2O	20	200	201
3C5 - Indirect N_2O emissions from managed soils	N_2O	20	463	463
3C6 - Indirect N_2O emissions from manure management	N_2O	54	313	318
3C7 - Rice cultivations	CH_4	10	83	84

The source of all the uncertainty values for categories included within 3A Livestock is IPCC 2006. For the selection of the uncertainty among those provided by IPCC 2006, the criteria have been based on the conservative principle, using the upper values of the ranges by default. Conversely, the uncertainty values allocated in 3B Land and 3C Aggregate sources and non-CO_2 emissions sources on land are mainly based on expert judgment (based on 2006 IPCC guidance) rather than default values. The reason for that is the limited guidance provided by the 2006 IPCC Guidelines.

Table 20. Uncertainty in the waste sector.

IPCC category	Gas	Activity data uncertainty (%)	Emission factor Uncertainty (%)	Combined uncertainty (%)
4A - Solid waste disposal	CH_4	52	56	77
4B – Biological treatment of solid waste	CH_4	30	100	104
4B – Biological treatment of solid waste	N_2O	30	113	116
4C1 - Incineration of waste	CO_2	100	40	108
4C1 - Incineration of waste	CH_4	100	100	141
4C1 - Incineration of waste	N_2O	100	100	141
4C2 - Open burning	CO_2	30	40	50
4C2 - Open burning	CH_4	30	100	104
4C2 - Open burning	N_2O	58	100	116
4D1 – Domestic wastewater	CH_4	60	54	80
4D1 – Domestic wastewater	N_2O	33	500	501

The uncertainty values allocated in the waste sector are mainly based on the selection from the default uncertainty values from the 2006 IPCC guidelines.

1.9. Overview of the Inventory Improvement Plan

The elaboration of the Inventory Improvement Plan takes place at the end of each inventory MRV cycle, under the overarching responsibility of the Climate Change Division (CCD) within the OPM. The national priority for inventory improvement involves increasing the availability and the quality of the data used for inventory preparation.

The Inventory Improvement Plan draws upon the corrective actions and/or areas of improvement identified through the Sectoral Data Quality Assessment Reports, Meetings with the Sectoral Technical Working Groups, and the Final Validation Workshop.

Each improvement activity identified is prioritized and assigned a deadline and a responsible entity for its execution. This information is organized into sectoral and cross-cutting tables incorporated into the Inventory Improvement Plan. The prioritization of improvement areas is aimed at achieving practicality, acceptability, cost-effectiveness, and the incorporation of existing experience. The prioritization criteria therefore include:

- **Key categories:** Key categories should be prioritized as they contribute the most to the national GHG emission and removal totals and trends, as well as the level of uncertainty of the inventory. Priority should be given to key categories as their improvement will significantly increase the quality of the inventory overall while maximizing cost-effectiveness.
- **Technical viability:** Improvement areas for which the required technology and capacity already exist in the country should be prioritized, as the mobilization of resources can be simplified, improvement implementation periods can be shortened, and existing experience can be incorporated.
- **Budget:** Cost-effectiveness of inventory implementation may be reached by prioritizing simple actions that have a significant impact on quality.
- **Required time for execution**: Short-term actions that can be implemented immediately and/or by the next inventory cycle should be prioritized as they can increase the inventory quality within a reduced period of time.
- **Length of time the improvement has been overdue from previous inventory cycles:** It is of fundamental importance that inventory improvement recommendations not only be identified but also implemented for effective refinement of inventory quality. Improvement actions that are overdue from previous inventory cycles should therefore be given priority.

Based on these criteria, actions are classified as:

- **Immediate:** Corrective action should be undertaken before the finalization of the current inventory cycle.
- **Short-term:** Corrective action should be undertaken by the next inventory cycle.
- **Medium-term:** Improvement measures should be undertaken within the next 2-5 years.
- **Long-term:** Improvement measures should be undertaken within the next 5 years or longer, as per resource availability and evaluation of national priorities.

The following tables present the inventory improvement plan elaborated for the present 1994-2019 edition of the National Inventory of Fiji.

It should be noted that in the beginning of the year 2021, the Government of Fiji has partnered with the Initiative for Climate Action Transparency (ICAT) to help build the country's institutional monitoring, reporting and verification (MRV) capacity for estimating greenhouse gas (GHG) emissions from agriculture (excluding sugar industry) and assessing GHG and sustainable development impacts of agriculture policies, considering that agriculture is one of the country´s most important emitting sectors. Under this ICAT project, the capacity of Fiji to calculate emissions from livestock and rice cultivation using the 2006 IPCC methodologies will be substantially increased. For the next GHG inventory, Fiji should draw upon the lessons learned and capacity built from the ICAT project, enabling access to more detailed and higher quality data for livestock and rice cultivation.

Table 21. Cross-cutting improvement plan.

Cross-Cutting Issues			
Identified fields of improvement			
The National Inventory System of Fiji is not formally institutionalized, lacking legally binding information flows, responsibilities, deadlines, and coordination mechanisms.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Develop TORs for the four Sectoral Technical Working Groups.	2023	CCD
2	Convene Sectoral Technical Working Groups for the First Time under the 1994-2019 edition of the National Inventory of Fiji.	2023	CCD
Short-term Actions		Proposed period of implementation	Institution responsible
3	Finalise the development, approval, and adoption of the Climate Change Act, 2021 to formally establish the governance structure and procedures for the Measurement, Reporting and Verification of Emissions and Emissions Reductions in Fiji under Part 7 of the draft Act, including the establishment of the sector-based collection of data.	2023	Parliament of the Republic of Fiji and CCD
Identified fields of improvement			
The uncertainty assessment of the national GHG inventory of Fiji currently relies on default uncertainty values and expert judgement.			
Long-term Actions		Proposed period of implementation	Institution responsible
1	Collect national specific uncertainty values by category to move towards conducting the uncertainty assessment according to approach 2.	2025-2030	CCD

Table 22. Improvement plan for the energy sector.

Energy Sector – Fuel Combustion			
Identified fields of improvement			
There is no formal energy balance in the country. This affects the quality of the national GHG emission inventory, as the reconciliation of the different data sources has not been made, and so the uncertainty of the estimates is very high.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Enhance the institutional arrangements in place for the elaboration of the energy balance of the country.	2023	Department of Energy
2	Implement a data compilation system for the elaboration of the energy balance.	2023	Department of Energy/Fiji Bureau of Statistics
Energy Sector – Fuel Combustion			
Identified fields of improvement			
Statistics on the combustion of fuelwood are not available.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Assess the possibilities to improve statistics on fuelwood combustion, specially at households, to improve the quality of the national GHG emission inventory.	2023	To be determined
2	Obtain data on fuelwood combustion and improve the estimates in category 1A4 of the inventory.	2023	To be determined
Energy Sector – Mobile Combustion			
Identified fields of improvement			
Data on the number of vehicles classified by type of fuel for the years 2011 to 2019 are available. However, information on technologies and vehicles kilometres travelled by type of vehicle are not available.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Assess the possibilities to improve transport statistics by enhancing the scope of the data and/or implementing new surveys for obtaining information.	2023	Department of Transport/Land Transport Authority
Energy Sector – Fugitive emissions			
Identified fields of improvement			
CO_2, CH_4, and N_2O Emissions from Category 1B. Fugitive emissions from charcoal production were not estimated due to a lack of data. During the validation workshop, national stakeholders confirmed only minor amounts are produced. This needs to be ascertained and transparently documented in future inventories. Some sources report production. See, for instance this link or this link.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Obtain data on charcoal production.	2023	CCD
Energy Sector – Transport			
Identified fields of improvement			
Off road transport statistics are not available. Furthermore, fuel combustion for other sectors (residential, commercial, institutional, agriculture, forestry, and fishing) might include the combustion of off-road. However, this is not currently ascertained.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Confirm if the current fuel combustion statistics consider the use of fuels in off-road vehicles.	2023	To be determined
2	Obtain information on off-road fuel combustion.	2025	To be determined

Table 23. Improvement plan for the IPPU sector.

IPPU Sector – Non-Energy Products from Fuels and Solvent Use			
Identified fields of improvement			
CO_2 emissions could be improved by the enhancement of data on lubricant, grease and solvents consumption.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Confirm that the reported lubricant consumption data is used for lubrication purposes. In addition, the data on grease consumption should be revised to provide a more precise figure.	2023	FRCS
Identified fields of improvement			
NMVOC Emissions could be improved by the collection of further data.			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	The Tier 1 approach for the calculation of NMVOC emissions from domestic solvent use should only be used if no alternative information is available. It is therefore recommended to collect data on the amounts of solvents used in each subsector.	2024	FRCS
IPPU Sector – Product Uses as Substitutes for Ozone Depleting Substances			
Identified fields of improvement			
Estimations could be improved by collecting more reliable data by sub-application.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Collect further information from the FRCS on the import data of refrigeration and air conditioning units to clarify descriptions such as "other" and "parts" to properly allocate them to the sub-application categories in the 2006 IPCC Guidelines.	2023	FRCS/ Department of Environment
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Collect data on the number of fire extinguishers, aerosols, foam blowing units and F-gases contained being imported in Fiji for the entire timeseries to ensure complete and accurate estimations.	2024	Ozone Unit/Departme nt of Environment
2	It is recommended to undertake a survey on refrigeration and air conditioning equipment (number of air conditioning and refrigeration equipment introduced into the market, the refrigerant used and their initial refrigerant charge) to the main users (commercial sector such as supermarkets and hotels) which will allow to estimate F-gas emissions from this category using a tier 2.	2024	Ozone Unit/ Department of Environment
IPPU Sector – Other Product Manufacture and Use			
Identified fields of improvement			
SF_6 emissions from the use of electrical equipment and N_2O emissions from its medical use as anaesthesia are not estimated.			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	To estimate the GHG emissions of category 2G1b, it is recommended to collect data on SF_6 consumption in the electrical sector from stakeholders of the national electricity sector (i.e. regulator, distributors, etc.).	2024	FRCS/ Energy Fiji Limited
2	To estimate N_2O emissions from category 2G3. N_2O from Product Use, it is recommended to collect the data on supply from companies that commercialize N_2O for medical use as anaesthesia or data on consumption from the hospitals.	2024	FRCS
IPPU Sector – Other			
Identified fields of improvement			

More detailed breakdown of production by subsector of the food and drink industry would allow to elaborate better NMVOCs emission estimates.			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Provide more detailed data on food and beverage production by type of product to estimate NMVOCs (for instance, make a distinction between margarine and butter production).	2024	FRCS

Table 24. Improvement plan for the AFOLU sector.

AFOLU Sector - Agriculture			
Identified fields of improvement			
Time inconsistencies are observed regarding livestock populations, both within national values and in comparison, with FAO data. Fiji could use the Census of Agriculture to collect more detailed information on livestock populations; make use of the significant analysis for the key categories; ensure that the default EFs used correspond to the country circumstances and obtain more detailed information allowing to move to a tier 2.			
Immediate Actions		Proposed period of implementation	Institution responsible
1	Incorporate regional meteorological data to better estimate methane emissions from manure management, given that regional-level data on both manure management and weather conditions are available, considering the high sensitivity of these types of emissions to temperature.	2023	Ministry of Agriculture and Fiji Meteorological Service
2	Ensure that the default EFs used correspond to the country circumstances by checking the background information used for the development of the default EFs. Such information is available in the annexes and also in tables 10.10 and 10.11 of the 2006 IPCC Guidelines (e.g. weight, average milk production).	2023	Ministry of Agriculture
Short-term Actions		Proposed period of implementation	Institution responsible
3	Increase regularity in the collection of livestock population data to obtain a more consistent and reliable time series through the conduction of more frequent livestock census.	2023	Ministry of Agriculture
4	Incorporate the collection of data on meat animals that live less than one year into the livestock census processes.	2023	Ministry of Agriculture
5	Align and incorporate results of the ICAT project to build MRV capacity for the agriculture sector, specifically pertaining to GHG emissions from livestock.	2023	Ministry of Agriculture and CCD
Medium-term Actions		Proposed period of implementation	Institution responsible
6	Continue using the Census of Agriculture to collect more detailed information on livestock populations. For 3A1. Enteric fermentation, make use of the significant analysis for the key categories to identify which animal categories are significant and to move to enhance characterization and estimate the gross energy intake with methane conversion factors and EFs (tier 2) for these animal categories. For 3A2. Manure management, make use of the significant analysis for the key categories to get confirmation of the accuracy of these default EFs for both CH_4 and N_2O; for CH_4 emissions, collect the information, stratified by temperature (average annual), and use the manure characteristics (equation 10.23 of the 2006 IPCC Guidelines) and manure management systems allowing to move to a tier 2 and for N_2O emissions, develop country-specific N excretion rates and EFs allowing to move to a tier 2. There is a need to include CCD members and Inventory experts to be part of the Census team.	2024	Ministry of Agriculture
Identified fields of improvement			
Inconsistencies exist between national and FAO data regarding rice cultivation practices in Fiji.			
Medium-term Actions		Proposed period of implementation	Institution responsible

1	Conduct surveys to determine and update the rice cultivation practices in Fiji.	2024-2025	Ministry of Agriculture
2	Align and incorporate results of the ICAT project to build MRV capacity for agriculture sector, specifically pertaining to GHG emissions from rice cultivation.	2024	Ministry of Agriculture and CCD
AFOLU Sector – Forestry and Other Land Uses			
Identified fields of improvement			
While FOLU data is generally of good quality, there is a lack of data on deforested area of natural forest and afforested-reforested land for years other than the reference level (2006-2016).			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Collect data on deforested, afforested and reforested areas.	2023	Ministry of Forestry
Identified fields of improvement			
National data and country-determined categories are not aligned to the IPCC land-use categories to use them for the elaboration of the estimates and data on management changes for estimating carbon stock changes in soils and on disturbances from fires, hurricanes, droughts, and other types of carbon losses (area, and average carbon stocks in the area affected) are not available.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Improve monitoring different land uses and land use change for the six IPCC land categories (forestland, cropland, grassland, wetland, settlements, and other land).	2023	Ministry of Forestry
2	Use national data and assign the country-determined categories to the IPCC land-use categories to use them for the elaboration of the estimates, provide clear definitions for all IPCC land-use categories and collect more detailed information on a routine basis on: • For forest, area, coverage, and height, minimum thresholds should be provided and used in the classification of lands and information should be collected on growth (biomass growth or increment), carbon losses, especially from biomass (wood removals, wood fuels, disturbances) and growing stock information in forestland, • Data on management changes for estimating carbon stock changes in soils (this should consist of estimates of initial and final land use areas as well as the total area of land that is unchanged by category for each year of the inventory: Forest land (unmanaged) and Forest land (managed) including the type of tree and the age class; Grassland (managed) and Grassland (unmanaged); Cropland; Wetlands (managed/unmanaged); Settlements; and Other land), • Data on organic soils according to land use (if occurring in the country), • Data on disturbances from fires, hurricanes, droughts, and other types of carbon losses (area and average carbon stocks in the area affected).	2024	Ministry of Forestry
AFOLU Sector – Aggregated and Non-CO_2 Emissions Sources			
Identified fields of improvement			
Quality and availability of the data on urea applied to soils and synthetic nitrogen fertilisers can be improved. Proportions of animal manure by animal type applied to soils and biomass burning data are not available. For biomass burning, obtain annual data for the different forest types.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Collect annual data on urea applied to soils and on consumption or on imports of synthetic nitrogen fertilisers. Use expert judgement from local agriculture experts on the proportions of animal manure by animal type applied to soils to estimate indirect N_2O emissions from volatilisation from manure management using the tier 1 method provided in the 2006 IPCC Guidelines. For biomass burning, obtain annual data for the different forest types in order to apply separate carbon stock losses per area per each forest type. When the emissions from land-use/management change in soils will be reported, check that the associated direct and indirect N_2O	2023 - 2024	Ministry of Agriculture

	emissions from mineralisation due to land-use management changes in soils are estimated as well.		

Table 25. Improvement plan for the waste sector.

Waste Sector – Solid Waste Generation and Treatment			
Identified fields of improvement			
There is currently a lack of standardized, country-specific, updated information of municipal solid waste composition and generation rates.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Create standardized waste composition categories aligned with IPCC values to be used among all city/town councils waste characterization studies.	2023	Ministry of Housing and Local Government /Department of Environment/Fiji Waste Management Authority
Medium-term Actions		Proposed period of implementation	Institution responsible
2	Align the waste composition categories used in the records of the Naboro Landfill with the IPCC categories for municipal solid waste compositions.	2024	HG Leach/Department of Environment
3	Install weighbridges in all solid waste disposal sites, starting in the biggest-used sites.	2024-2030	Ministry of Housing and Local Government
4	Initiate close monitoring and standard records of open fires and Fiji´s dumpsites in order to apply country-specific values regarding open burning at dumpsites, rather than the IPCC Assumption	2024-2030	HG Leach/Department of Environment
Long-term Actions		Proposed period of implementation	Institution responsible
4	Launch studies on rural waste generation and management practices.	2025-2030	Department of Environment/Ministry for Rural, and Maritime Development and Disaster Management/Fiji Waste Management Authority
5	Launch studies and data collection on industrial waste generation rates, composition and management practices.	2025-2030	Department of Environment/ Ministry for Rural and Maritime Development and Disaster Management/Fiji Waste Management Authority
Identified fields of improvement			
Incineration records of clinical waste at the Divisional Hospitals, as well as the incineration records of quarantined waste in Fiji´s Ports and Biosecurity facilities, require standardized and comprehensive implementation.			
Short-term Actions		Proposed period of implementation	Institution responsible

1	Ensure hospital incineration records are adequately updated every month using standardized templates.	2023	Ministry for Health and Medical Services
Long-term Actions		Proposed period of implementation	Institution responsible
2	Establish standardized and regularly updated quarantine waste incineration records.	2025-2030	Fiji Ports Limited/Biosecurity Authority of Fiji
Identified fields of improvement			
Records of large-scale composting and recycling initiatives are inconsistent.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Begin collecting data on composting facilities using standardized templates.	2023-2025	Fiji Waste Management Authority
Medium-term Actions			
2	Collect data on recycling using standardized templates.	2024-2025	Fiji Waste Management Authority
Waste Sector – Wastewater Treatment and Discharge			
Identified fields of improvement			
There is currently a lack of high-quality information on the number of people connected to each wastewater treatment plant in Fiji, as well as the biological oxygen demand (BOD) of wastewater treated.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Maintain updated annual records of the number of people connected to each wastewater treatment plant.	2023	Water Authority of Fiji
2	Establish a system for frequent, mandatory, and standardized BOD measurements and record-keeping in all wastewater treatment plants by formally requiring the monitoring of BOD under the Draft Water and Sanitation Policy.	2023	Water Authority of Fiji
Identified fields of improvement			
No information is available on the generation and treatment of industrial wastewater in Fiji.			
Long-term Actions		Proposed period of implementation	Institution responsible
1	Begin collecting data on industrial facilities with on-site wastewater treatment plants.	2025-2030	Water Authority of Fiji

CHAPTER 2: FIJIAN GHG EMISSIONS INVENTORY

2.1. National greenhouse gas emissions profile and drivers

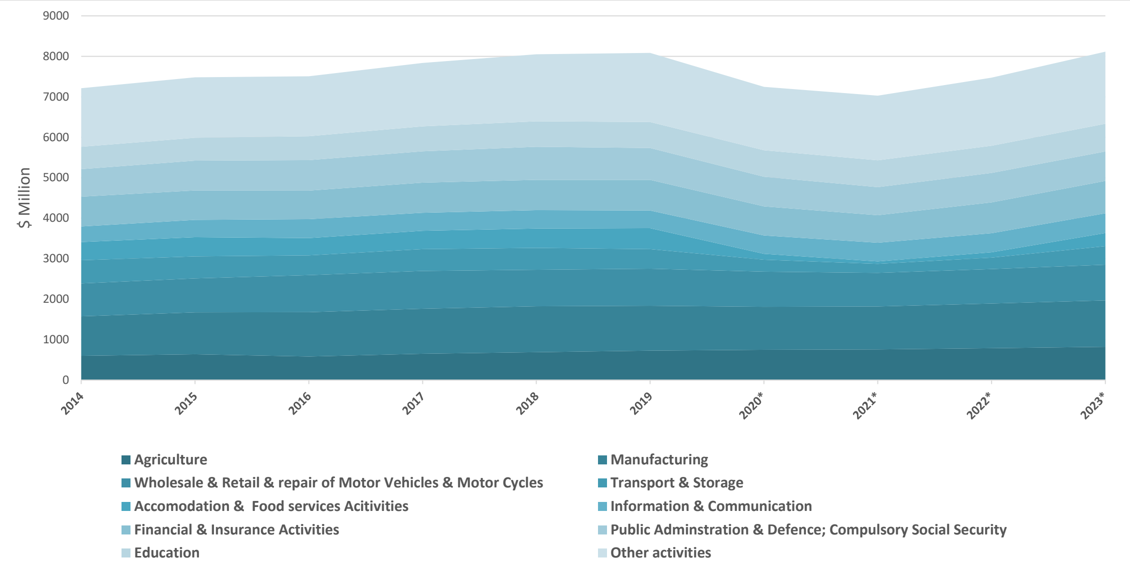
The Republic of Fiji is located in the Southwest Pacific Ocean and consists of roughly 332 islands, with approximately 110 of them being inhabited. The Exclusive Economic Zone (EEZ) has 1.3 million square kilometres in size. Numerous tiny volcanic islands, low-lying atolls, and high reefs make up the group. Viti Levu and Vanua Levu are the two biggest islands, with the bulk of the 884,887 people living there (2017 census). The islands offer a varied range of terrestrial habitats, including vast swaths of native forest. Both larger islands also have distinct wet and dry sides due to prevailing wind patterns. In shallow reef and lagoon regions, mangroves, algae, and seagrass beds make up Fiji's coastal ecosystems. The majority of Fiji's aquatic biodiversity is found in virgin reef types such as barrier, fringing platform, and atoll or patch reefs.

Fiji has a tropical climate with moderate winters and warm summers. Under the prevailing southeast trade winds, the South Pacific Convergence Zone is an important climatic feature that brings in a lot of rain. Because of its geographic location, it is particularly vulnerable to potentially catastrophic weather disasters such as cyclones and floods, which can have serious economic consequences. Because of the significant concentration of economic activity and settlements in coastal areas, forecasted climate change and sea-level rise might have serious effects for the country. Following the destruction caused by Tropical Storm Winston, the country was ranked as the 14th most vulnerable to natural disasters and one of the most sensitive to climate change.

Between 1994 and 2019, the country's population increased by 0.64 percent. Between 2007 and 2019, the urban population increased by 16.3%, while the rural population decreased by 5.5 percent. The majority of Fiji's population lives in big cities, with roughly 44% living in rural towns throughout the country.

Since 2010, the Fijian economy has expanded for nine years in a row, with an average annual growth rate of 4.2 percent. Tourism, building, manufacturing, wholesale and retail commerce, information and communication, transportation, and finance are all contributing to the economy's strong growth.

The following figure shows the composition of Fijian economy using Gross Domestic Product (GDP) data.



Source: own elaboration based on Reserve Bank of Fiji data (https://www.rbf.gov.fj/statistics/economic-and-financial-statistics/). Note – units are provided at constant prices of 2014. Years 2020-2023 are forecasts.

Figure 12. GDP by activity.

The main contributors to Fijian economy in year 2019 are manufacturing activities (14 per cent GDP), wholesale, retail and car repair (11 per cent), public administration (10 per cent), financial & insurance activities (9 per cent) and agriculture (9 per cent). The nature of the Fijian economic structure is service oriented, with fossil intensive activities having a minor representation.

The low carbon profile of Fijian economy is balanced through a significant share of imports. The need to lessen reliance on imported food, particularly rice, beef, fish, and poultry products, has been underlined in development plans. Minerals, equipment, chemicals, and textiles are all important imports. Sugar, seafood, clothes, mineral water, and gold are all exported from Fiji.

The total installed power generation capacity is around 250 MW, 95% of which was run by the Energy Fiji Limited (EFL). From the 1,061,249 MWh of grid electricity, 1,012,433 MWh corresponds to the total EFL generation. Around 53% of grid electricity was produced by hydro, 42% by thermal generators, 0.3% by solar and wind, and the remaining 4.6% from Independent Power Producers (IPPs), using biomass as the main energy source (Energy Fiji Limited Annual Report, 2019[6]).

Since large-scale systematic planting of pine forests began in the 1960s, a timber industry has developed for domestic use and export. Fishing has become increasingly important to

[6] Energy Fiji Limited, 2019. 2019 Annual report. Available at: http://www.parliament.gov.fj/wp-content/uploads/2020/05/Energy-Fiji-Limited-2019-Annual-Report.pdf

the economy; in the early 21st century, fish products accounted for nearly one-tenth of export revenue.

According to *Global Forest Watch*[7], from 2001 to 2020, Fiji lost 44.0 kha of tree cover, equivalent to a 2.8% decrease. This is reflected in the national GHG emission inventory emission profile, deforestation figuring among the main category contributing to the national total emissions.

The larger islands and many smaller ones are served by domestic air services, and there are several international airports. A coastal highway circles Viti Levu, and minor roads to the interior give access to most areas of settlement. For many villagers, however, river punts with outboard motors provide the most efficient form of transport, and from more-remote areas it may still be simplest to transport produce to market by floating it downriver on bamboo rafts. Regular bus services operate within and between the major towns.

Currently, Fiji generates more than 400,000 tons of municipal solid waste annually. Much of this is disposed of at the sanitary landfill at Naboro, located some 24 km from the capital Suva City. It also serves other neighbouring towns. The landfill began operations in October 2005 after the closure of the Lami dump. The landfill has a life of at least 70 years. It covers an area of 7 hectares in the current first stage and will cover 38 hectares in another four stages.

Surface water is used as the main source of supply for all major towns on the larger, high islands of Fiji. Some small, low-lying islands rely exclusively on groundwater and may also harness rainwater. Contamination of the wells in the small islands may happen due to lack of sanitation.

[7] Available at this Link

2.2. Trends in national GHG emissions, population and GDP

The following figure compares the trends of the time series of population, GDP and national total GHG emissions[8]. As illustrated in this figure, the tendencies of two key drivers of Fiji´s development are very similar to the trend of national total GHG emissions, pointing out to the overall dependency of the emissions on the national activity levels.

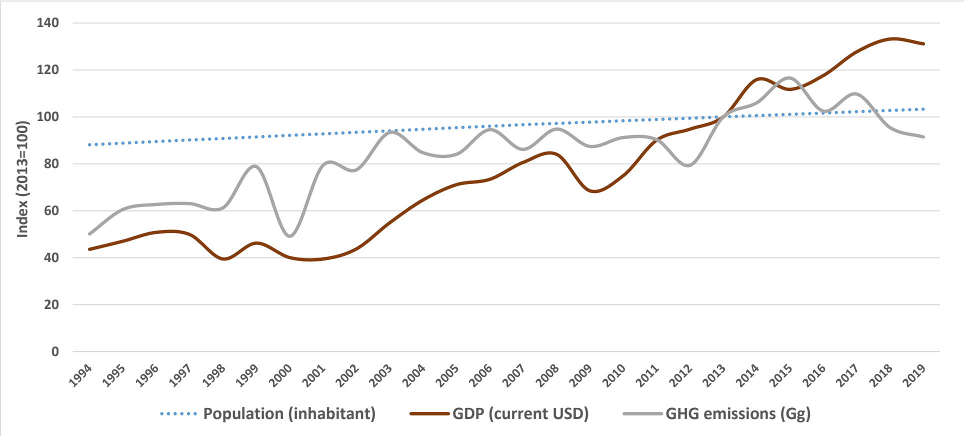


Figure 13. Indexes (2013 =100).

The following figure shows the evolution of GHG emission intensity using GDP and population as levers.

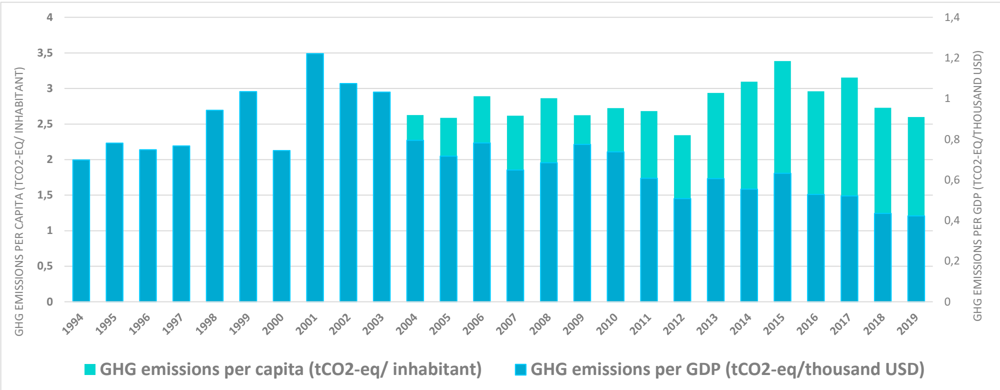


Figure 14. GHG emission intensity.

GHG emissions per capita have substantially risen through the inventoried period, in line with the low pace of demographic growth in the country. The average annual growth rate of population series is just 0.5 per cent. GHG emissions are increasing at a higher annual rate than population, deriving in meaningful increases in per capita indexes. Contrariwise,

[8] This inventory covers the years 2013-2019. However, the years 1994-2012 have been estimated using the splicing techniques of 2006 IPCC Guidelines for illustrative purposes.

the GHG emissions per unit of GDP are declining since 2003, for a value of 0.42 tons of CO_{2-eq} per thousand USD in 2019. This suggest that the country has achieved a slight decoupling of economic growth and GHG emissions, despite the overall rising trends of emissions and economic activity.

2.3. Emission trends by sector

National GHG emissions show an increasing trend in Fiji for all sectors and gases. In 2019 the emissions of the energy sector have the largest contribution to national total emissions (52.74 per cent), followed by Forestry and Other Land Use (21.18 per cent[9]) and Agriculture (13.14 per cent). Industrial Processes (3.24 per cent) and Waste sector (9.70 per cent) have a minor contribution. Fiji´s emission profile is a consequence of the economic structure of the country and its national characteristics, as described in section 2.1 above. Emission trends have changed significantly since the first inventoried year, as shown in following figure.

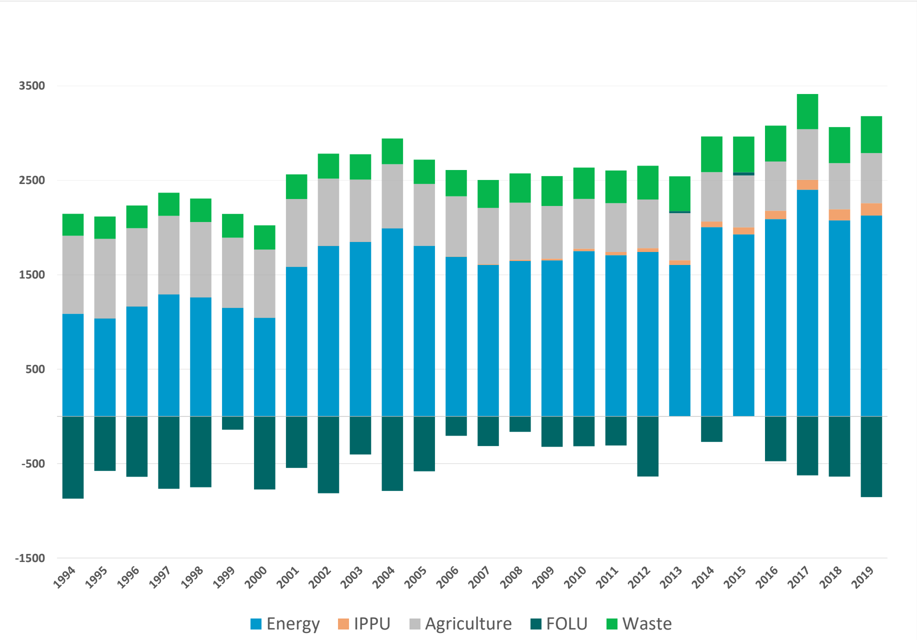


Figure 15. Fiji GHG emissions 1994-2019 (Gg CO_2-eq).

The emissions of the energy, IPPU, waste, and agriculture sectors are driven by the overall economic activity of the country, as reflected in the Gross Domestic Product (GDP). The emissions from the Forestry and Other Land Use change are driven by deforestation trends. However, the trend of emissions is relatively stable throughout the period.

---

[9] These percentages are calculated in absolute levels, meaning that removals from the FOLU sector have been converted into absolute terms before calculating the percentage contribution by sector.

2.4. Emission trends by gas

The most influential gas in national total GHG emission trends is CO_2, as shows in the figure below. However, the evolution and changes in the economic activity of the country have substantially modified the gas contribution of national total emissions.

From 1994 to 2000 CH_4 was the main gas emitted in Fiji, with a contribution ranging within the range 65-48 per cent of national total emissions. CO_2 slightly increased its contribution in these initial years, becoming the predominant gas in 2001 with 50 per cent of national total emissions. In the same vein, N_2O reduced its contribution from a 20 per cent in 1994 to 10 per cent in 2001.

From 2001 to 2019 the main GHG gases broadly maintained their weight in national emission profile, except for the incorporation of HFC into the gas share of the country, with an increased contribution ranging from 1 to 3 per cent to national total emissions in the period 2013-2019.

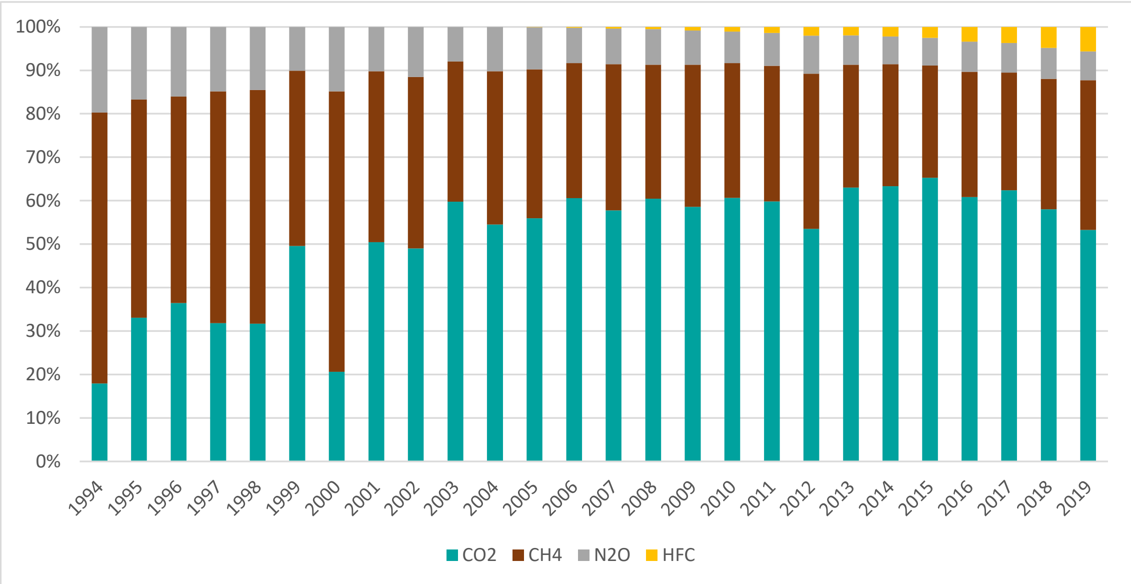


Figure 16. Trends in gas contribution to total GHG emissions.

The emissions by gas are driven by the sectoral contribution to national total emissions. Waste and Agriculture sector are the determinants of CH_4 emissions, while Energy and Forestry and Land Use change drive CO_2 emissions.

2.5. Reporting tables

The UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention (BUR Guidelines) state that the inventory section of the biennial update report should contain Tables 1 and 2 of Decision 17/CP.8. However, those tables use 1996 IPCC Guidelines nomenclatures, and therefore, as Fiji has estimated its inventory following 2006 IPCC Guidelines, the mentioned tables are not applicable. 2006 IPCC Guidelines provide equivalent summary reporting table in chapter 8, volume 1, which are provided in the following pages showing a summary of the emissions of the inventory.

Table 26. Summary table A.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
Total national emissions and removals	**1239.15**	**28.58**	**0.584**	**130.78**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**1.86**	**NA, NE, NO**
1. Energy	**2086.42**	**0.51**	**0.102**						**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**
1A. Fuel combustion (sectoral approach)	2086.42	0.51	0.102						**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**
1A1. Energy industries	333.95	0.01	0.003						NE	NE	NE	NE
1A2. Manufacturing industries and construction	85.63	0.14	0.015						NE	NE	NE	NE
1A3. Transport	1532.32	0.33	0.072						NE	NE	NE	NE
1A4. Other sectors	134.52	0.03	0.012						NE	NE	NE	NE
1A5. Non specified	IE, NO	IE, NO	IE, NO						IE, NO	IE, NO	IE, NO	IE, NO
1B. Fugitive emissions from fuels	NO	NO	NO						NO	NO	NO	NO
1B1. Solid fuels	NO	NO	NO						NO	NO	NO	NO
1B2. Oil and natural gas	NO	NO	NO						NO	NO	NO	NO
1B3. Other emissions from energy production	NO	NO	NO						NO	NO	NO	NO
1C Carbon Dioxide Transport and Storage	NO								NO	NO	NO	NO
1C1. Transport of CO_2	NO								NO	NO	NO	NO
1C2. Injection and Storage	NO								NO	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
2. Industrial processes	**0.01**	**NE, NO**	**NE, NO**	**130.78**	**NA, NO**	**NA, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**1,86**	**NA, NE, NO**
2A. Mineral products	**NO**	**NO**	**NO**						**NO**	**NO**	**NO**	**NO**
2A1 Cement Production	NO	NO	NO						NO	NO	NO	NO
2A2 Lime Production	NO	NO	NO						NO	NO	NO	NO
2A3 Glass Production	NO	NO	NO						NO	NO	NO	NO
2A4 Other Process Uses of Carbonates	NO	NO	NO						NO	NO	NO	NO
2A5 Other (please specify)	NO	NO	NO						NO	NO	NO	NO
2B. Chemical industry	**NO**	**NO**	**NO**						**NO**	**NO**	**NO**	**NO**
2B1. Ammonia production	NO	NO	NO						NO	NO	NO	NO
2B2. Nitric acid production	NO	NO	NO						NO	NO	NO	NO
2B3. Adipic acid production	NO	NO	NO						NO	NO	NO	NO
2B4. Caprolactam, glyoxal and glyoxylic acid production	NO	NO	NO						NO	NO	NO	NO
2B5. Carbide production	NO	NO	NO						NO	NO	NO	NO
2B6. Titanium dioxide production	NO	NO	NO						NO	NO	NO	NO
2B7. Soda ash production	NO	NO	NO						NO	NO	NO	NO
2B8. Petrochemical and carbon black production	NO	NO	NO						NO	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
2B9. Fluorochemical production				NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10. Other (as specified in table 2(I).A-H)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C. Metal industry	**NO**	**NO**	**NO**						**NO**	**NO**	**NO**	**NO**
2C1. Iron and steel production	NO	NO	NO						NO	NO	NO	NO
2C2. Ferroalloys production	NO	NO	NO						NO	NO	NO	NO
2C3. Aluminium production	NO	NO	NO		NO				NO	NO	NO	NO
2C4. Magnesium production	NO			NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5. Lead production	NO								NO	NO	NO	NO
2C6. Zinc production	NO								NO	NO	NO	NO
2C7. Other (as specified in table 2(I).A-H)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D. Non-energy products from fuels and solvent use	**0.01**	**NE**	**NE**						**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**
2D1. Lubricant use	0.01								NE	NE	NE	NE
2D2. Paraffin wax use	NE	NE	NE						NE	NE	NE	NE
2D3. Other									NA	NA	1.86	NA
2E. Electronics industry	**NO**		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2E1. Integrated circuit or semiconductor	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
2E2. TFT flat panel display				NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3. Photovoltaics				NO	NO	NO	NO	NO	NO	NO	NO	NO
2E4. Heat transfer fluid												
2E5. Other (as specified in table 2(II))	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F. Product uses as substitutes for ODS(2)	**NA, NO**	**NA, NO**	**NA, NO**	**130.78**	**NA, NO**		**NA, NO**	**NA, NO**	**NA, NO**	**NA, NO**	**NA, NO**	**NA, NO**
2F1. Refrigeration and air conditioning	NA	NA	NA	130.78	NA		NA	NA	NA	NA	NA	NA
2F2. Foam blowing agents	NA			IE	NA		NA	NA	NA	NA	NA	NA
2F3. Fire protection	NA			IE	NA		NA	NA	NA	NA	NA	NA
2F4. Aerosols				IE	NA		NA	NA	NA	NA	NA	NA
2F5. Solvents				NO	NO		NO	NO	NO	NO	NO	NO
2F6. Other applications	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
2G. Other product manufacture and use	**NO**	**NO**	**NE**	**NO**	**NA, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NA, NO**	**NA, NO**	**NA, NO**	**NA, NO**
2G1. Electrical equipment					NA	NE	NE	NE	NA	NA	NA	NA
2G2. SF6 and PFCs from other product use					NO	NO	NO	NO	NO	NO	NO	NO
2G3. N_2O from product uses			NE						NA	NA	NA	NA
2G4. Other	NO	NO		NO			NO	NO	NO	NO	NO	NO
2H. Other (as specified in tables 2(I).A-H and 2(II))(3)	**NA, NO**	**NA, NO**	**NO**						**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
2H1 Pulp and Paper Industry	NO	NO							NO	NO	NO	NO
2H2 Food and Beverages Industry	NA	NA							NE	NE	NE	NE
2H3 Other (please specify)	NO	NO	NO						NO	NO	NO	NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	**-854.29**	**14.89**	**0.425**						**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**
3A Livestock		**14.01**	**0.001**						**NE**	**NA**	**NE**	**NA**
3A1 Enteric Fermentation		11.65							NE	NA	NE	NA
3A2 Manure Management		2.35	0.001						NE	NA	NE	NA
3B Land	**-854.68**	**NA, NO, NE**	**NA, NO, NE**						**NA**	**NA**	**NA**	**NA**
3B1 Forest Land	-921.11	NA	NA						NA	NA	NA	NA
3B2 Cropland	IE, NE	NA, NE	NA, NE						NA	NA	NA	NA
3B3 Grassland	66,43	NA	NA						NA	NA	NA	NA
3B4 Wetlands	NO	NO	NO						NA	NA	NA	NA
3B5 Settlements	IE, NE	NA, NE	NA, NE						NA	NA	NA	NA
3B6 Other Land	NO	NO	NO						NA	NA	NA	NA
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	**0.39**	**0.89**	**0.424**						**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**
3C1 Biomass Burning	NA	0.66	0.020						NE	NE	NE	NE
3C2 Liming	NE								NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
3C3 Urea Application	0.39								NA	NA	NA	NA
3C4 Direct N_2O Emissions from Managed Soils			0.323						NA	NA	NA	NA
3C5 Indirect N_2O Emissions from Managed Soils			0.082						NA	NA	NA	NA
3C6 Indirect N_2O Emissions from Manure Management			0.000						NA	NA	NA	NA
3C7 Rice Cultivations		0.22	NA						NA	NA	NA	NA
3C8 Other (please specify)	NO	NO	NO						NO	NO	NO	NO
3D Other	**NE,NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NA, NO**	**NA, NO**	**NA, NO**	**NA, NO**
3D1 Harvested Wood Products	NE								NA	NA	NA	NA
3D2 Other (please specify)	NO	NO	NO						NO	NO	NO	NO
4 WASTE	**7.00**	**13.18**	**0.058**						**NE**	**NE**	**NE**	**NE**
4A Solid Waste Disposal		8.62	NE						NE	NE	NE	NE
4B Biological Treatment of Solid Waste		0.09	0.006						NE	NE	NE	NE
4C Incineration and Open Burning of Waste	7.00	0.45	0.007						NE	NE	NE	NE
4D Wastewater Treatment and Discharge		4.02	0.045						NE	NE	NE	NE
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 OTHER	**NO**	**NO**	**NE, NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NOx and NH3			NE						NE	NE	NE	NE
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items (5)	**1781.90**	**0.05**	**0.05**									
International Bunkers	**890.95**	**0.03**	**0.027**						NE	NE	NE	NE
International Aviation (International Bunkers)	621.97	0.00	0.020						NE	NE	NE	NE
International Water-borne Transport (International Bunkers)	268.98	0.025	0.007						NE	NE	NE	NE
Multilateral Operations	NE	NE	NE						NE	NE	NE	NE

Table 27. Summary table B.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
Total national emissions and removals	1239.15	28.58	0.58	**130.780**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**1,86**	**NA, NE, NO**
1. Energy	2086.42	0.51	0.10						**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**
1A. Fuel combustion (sectoral approach)	2086.42	0.51	0.10						NE, NO	NE, NO	NE, NO	NE, NO
1B. Fugitive emissions from fuels	NO	NO	NO						NO	NO	NO	NO
1C Carbon Dioxide Transport and Storage	NO								NO	NO	NO	NO
2. Industrial processes	**0.01**	**NE. NO**	**NE. NO**	**130.78**	**NA, NO**	**NA, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**1,86**	**NA, NE, NO**
2A. Mineral products	NO	NO	NO						NO	NO	NO	NO
2B. Chemical industry	NO	NO	NO						NO	NO	NO	NO
2C. Metal industry	NO	NO	NO						NO	NO	NO	NO
2D. Non-energy products from fuels and solvent use	0.01	NE	NE						NE, NO	NE, NO	NE, NO	NE, NO
2E. Electronics industry	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F. Product uses as substitutes for ODS(2)	NA. NO	NA. NO	NA. NO	130.78	NA, NO		NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G. Other product manufacture and use	NO	NO	NE	NO	NA, NO	NE, NO	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
2H. Other (as specified in tables 2(I).A-H and 2(II))(3)	NA, NO	NA, NO	NO						NE, NO	NE, NO	NE, NO	NE, NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	-854.29	14.89	0.43						**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**
3A Livestock		14.01	0.001						NE	NA	NE	NA
3B Land	-854.68	NA. NO. NE	NA. NO. NE						NA	NA	NA	NA
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	0.39	0.89	0.42						NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
3D Other	NE. NO	NO	NO	NO	NO	NO	NO	NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
4 WASTE	7.00	13.18	0.058						**NE**	**NE**	**NE**	**NE**
4A Solid Waste Disposal		8.62	NE						NE	NE	NE	NE
4B Biological Treatment of Solid Waste		0.09	0.006						NE	NE	NE	NE
4C Incineration and Open Burning of Waste	7.00	0.45	0.007						NE	NE	NE	NE
4D Wastewater Treatment and Discharge		4.02	0.04						NE	NE	NE	NE
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 OTHER	**NO**	**NO**	**NE, NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2	CH_4	N_2O	HFC	PFC	SF6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4	NOx	CO	NMVOCs	SO2
	Gg			CO_2 equivalents (Gg)					Gg			
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NOx and NH3			NE						NE	NE	NE	NE
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items (5)												
International Bunkers	890.95	0.03	0.03						NE	NE	NE	NE
International Aviation (International Bunkers)	621.97	0.00	0.02						NE	NE	NE	NE
International Water-borne Transport (International Bunkers)	268.98	0.03	0.01						NE	NE	NE	NE
Multilateral Operations	NE	NE	NE						NE	NE	NE	NE

2.6. Comparison of 2019 GHG emissions inventory with inventories presented in previous National Communications

Fiji has reported three (3) national GHG emission inventories so far, in the first, second and third national communication of the country to the UNFCCC. The first national communication (FNC) provided the inventory for year 1994; the second national communication (SNC) reported the inventory for year 2004; the third national communication (TNC) included the inventory for years 2006-2011. These inventory editions covered different years and were calculated using heterogeneous methodologies and uneven data.

In its first BUR (FBUR), Fiji estimates the emissions of years 2013-2019, and recalculates the emissions of the time series 1994-2019 ensuring the consistency of the inventory. This approach is considered an essential insight for Fiji, as the availability of trends ease the design and implementation of climate policy and the elaboration of National Determined Contributions.

The following table shows the comparison of the GHG emissions obtained for years 1994 and 2004 by IPCC sector, comparing the first estimates developed against those of the FBUR.

Table 28. Comparison of GHG emissions by inventory edition and sector (FNC & SNC vs FBUR, Gg CO_2-eq).

Inventory sector	1994		2004	
	FNC	**FBUR**	**SNC**	**FBUR**
Energy	776	1 087	1 570	1 992
IPPU	0	0	0	0
Agriculture	484	826	977	679
Forestry and other Land use change (FOLU)	-7 702	-871	-7 988	-789
Waste	76	232	84	273
Total	**-6 365**	**1 275**	**-5 357**	**2 154**

The FNC and the SNC used 1996 IPCC Guidelines. The FBUR uses 2006 IPCC Guidelines, which substantially differ from its previous edition in terms of methodological approaches and scope. Furthermore, the FBUR used the Global Warming Potential (GWP) values of the Fifth IPCC Assessment Report while the FNC and SNC used GWP published in previous Assessment reports. This, together with the low quality of the data used are the main reason explaining the differences between estimates.

The following table shows the comparison of the GHG emissions obtained for years 2006-2011 by IPCC sector, comparing the first estimates developed against those of the FBUR.

Table 29. Comparison of GHG emissions by inventory edition and sector (TNC vs FBUR, Gg CO_2-eq).

Inventory sector	2006		2007		2008		2009		2010		2011	
	TNC	FBUR	TNC	FBUR	TNC	FBUR	TNC	FBUR	TNC	FBUR	TNC	FBUR
Energy	1773	1691	1556	1605	1337	1646	1264	1652	1531	1751	1414	1708
IPPU	0	4	0	9	0	13	0	19	0	26	0	33
Agriculture	560	636	561	595	566	604	552	558	549	528	551	518
Forestry and other Land use change (FOLU)	310	-205	330	-314	570	-164	-250	-322	760	-316	560	-308
Waste	63	278	84	296	80	311	86	316	111	331	130	345
Total	**2 706**	**2 404**	**2 531**	**2 191**	**2 553**	**2 410**	**1 652**	**2 223**	**2 951**	**2 319**	**2 655**	**2 296**

The TNC used the 2006 IPCC Guidelines and the fifth Assessment Report Global Warming Potential, so the emission estimated of the FBUR and the TNC are fully comparable. This is reflected in the similar results obtained by sector for years 2006-2011 for all sectors except FOLU, which suffered a major revision as a result of the revision of the Forest Reference Level reported in the Emission Reduction – Monitoring Report (ER-MR).

The following illustrates the sectoral GHG emission trends obtained in the FBUR together with the emissions calculated in the different NC, to ease the understanding of the resulting differences between inventories.

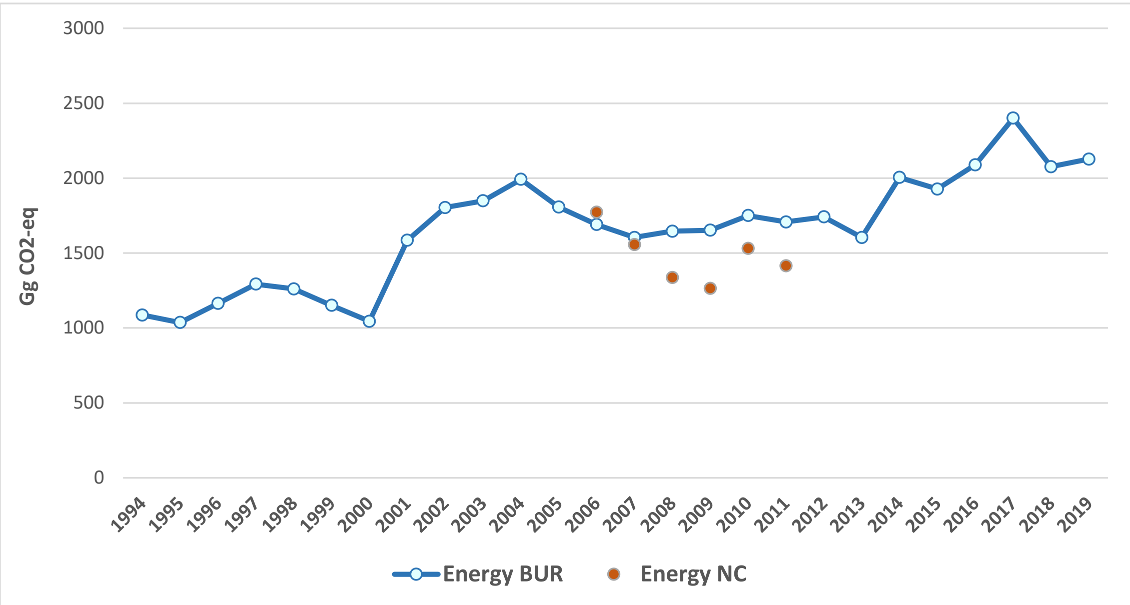


Figure 17. Energy sector emissions in the BUR vs NC (Gg CO_2-eq).

The differences in the energy sector are due to the full revision of the activity data of the energy sector, in line with the ongoing efforts of the country to compile energy balance in a more sustainable way. The methodology applied for years 2013-2019 was also reproduced in years 1994-2012, allowing to obtain consistent trends. There are also minor methodological differences in the emission factors used, as the revision of the activity data encountered misallocations of national fuels into IPCC fuel types.

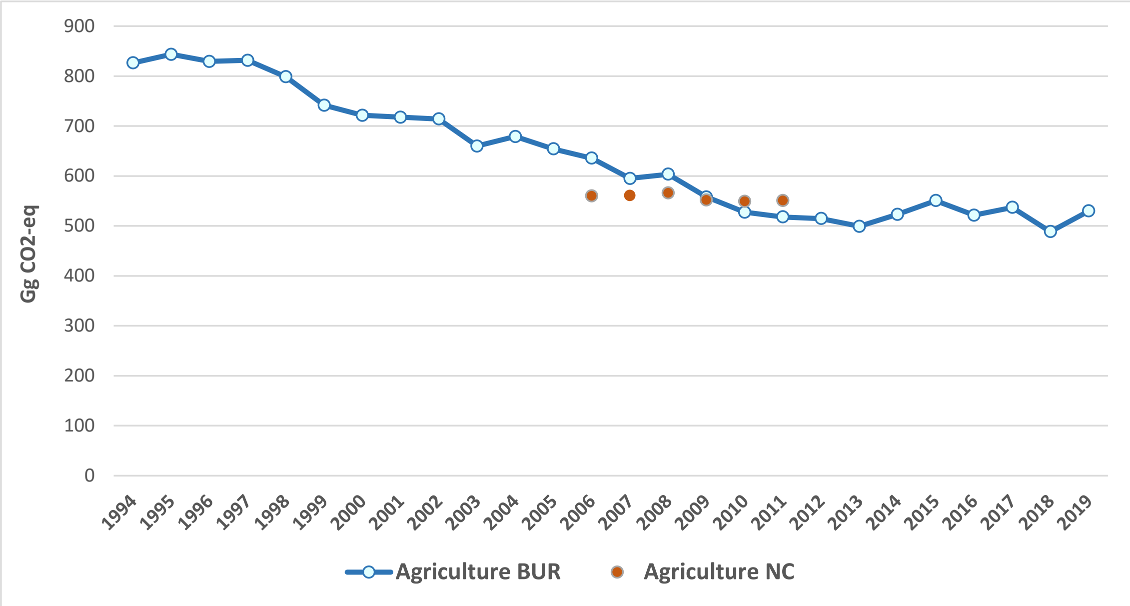


Figure 18. Agriculture sector emissions in the BUR vs NC (Gg CO_2-eq).

Agriculture estimates were built from the activity data used in the TNC with minor updates due to the ongoing data improvement carried out in the country.

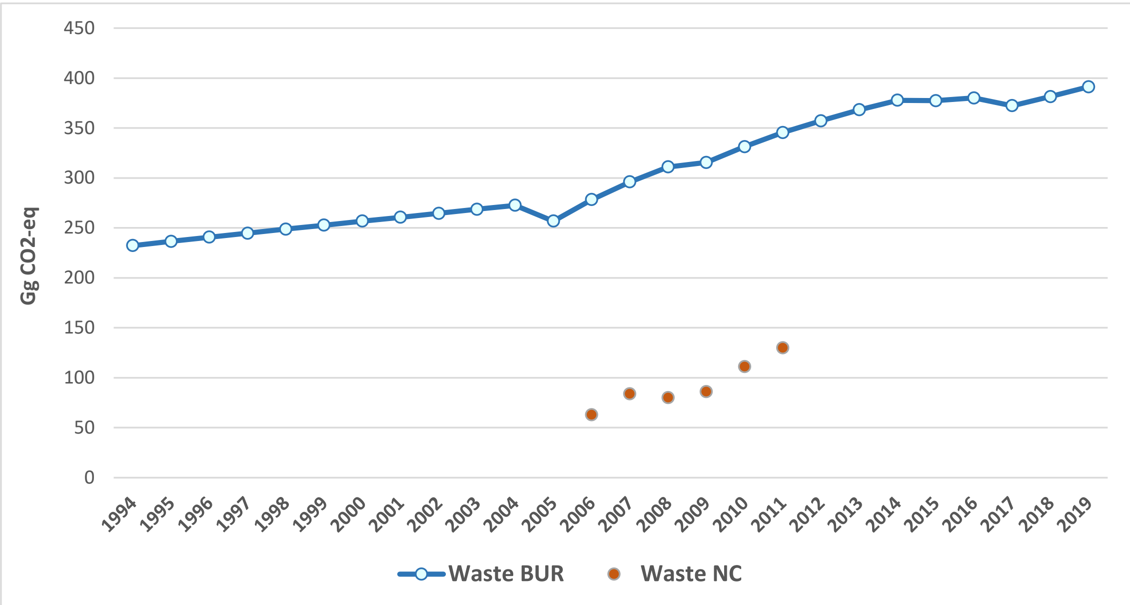


Figure 19. Waste sector emissions in the BUR vs NC (Gg CO_2-eq).

Waste sector emissions suffered from a significant underestimation in the NC submitted to the UNFCCC. In this edition, Fiji has improved its estimates by enhancing the completeness of the estimates, including now the emissions biological treatment of solid waste and incineration and open burning of waste.

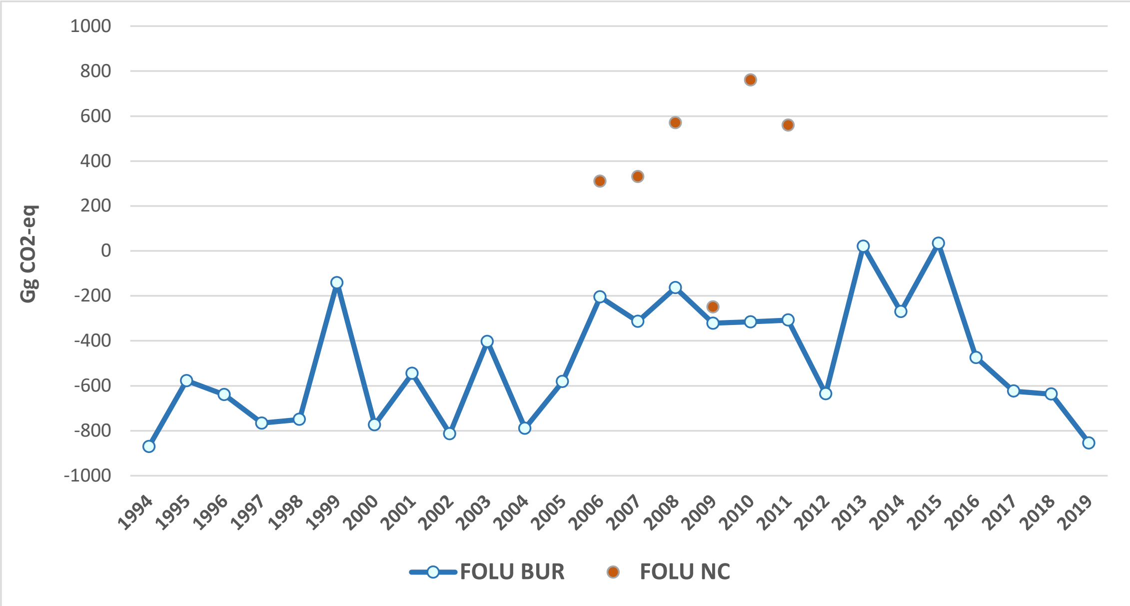


Figure 20. FOLU sector emissions in the BUR vs NC (Gg CO_2-eq).

Fiji made an important effort to compile and improve its land use statistics in the context of REDD+ and the Fiji Forest Reference Level. This has allowed the inventory to obtain more accurate data for years 2006-2016, which in turn were used to build the time series back to 1994. This leads to significant differences in the activity data used for this sector in the FNC, SNC and FBUR.

CHAPTER 3: ENERGY SECTOR

3.1. Overview of the energy sector

The energy sector mainly comprises:

- Exploration and exploitation of primary energy sources,
- Conversion of primary energy sources into more useable energy forms in refineries and power plants,
- Transmission and distribution of fuels,
- Use of fuels in stationary and mobile applications.

Emissions arise from these activities by combustion and as fugitive emissions or escape without combustion.

3.3.1 Description of the energy sector

The energy sector includes all the GHG emissions arising from combustion and fugitive releases of fuels. Based on the IPCC 2006 Guidelines, GHG emissions in the energy sector are split into three main categories: 1A Fuel Combustion Activities, 1B Fugitive emissions from fuels and 1C CO_2 transport and storage. The description of the nature of the emissions included in each category is provided in the following table.

Table 30. Emissions included under the energy sector.

Sector/sub-sector	GHG emissions included
1. Energy sector	All GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are generally not included here but reported under Industrial Processes and Product Use sector.
1A. Fuel combustion activities	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus
1B. Fugitive emissions from fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.
1C. CO_2 transport and storage	Carbon dioxide (CO_2) capture and storage (CCS) involves the capture of CO_2, its transport to a storage location and its long-term isolation from the atmosphere.

Source: Volume 2 IPCC 2006 guidelines

Energy GHG emissions in the Fijian inventory are limited to the emissions originated by the combustion of fuels, and therefore, all emissions of the sector are encompassed under category 1A Fuel Combustion Activities. Fiji fuel combustion activities occur under energy industries, manufacturing industries and construction, transport, and the residential, commercial, and institutional sectors.

The following paragraphs provide a brief description of energy sector emissions by sub-category, pointing out the main characteristics of the country for each emitting activity.

Energy Industries

Energy Industries comprises emissions from fuels combusted by the fuel extraction or energy-producing industries. It includes the emissions from:

- Main Activity Electricity and Heat Production
- Petroleum Refining
- Manufacture of Solid Fuels and Other Energy Industries

In Fiji, energy industry emissions include the emissions which occur in the combustion of fuels for electricity generation. Other emissions that should be accounted for in this category (such as petroleum refining) do not occur in the country.

Manufacturing Industry and construction

Manufacturing Industry and construction emissions relate to fuels combusted in industries, including fuel combustion for the generation of electricity and heat for own use in these industries. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of all Economic Activities (ISIC).

Sugarcane processing accounts for a sizable percentage of the industrial sector. Fiji's garment manufacturing and mineral water bottling sectors are also thriving. Boat building, mainly fishing boats and leisure ships, cement manufacture, brewing, and paint manufacturing are among the other manufacturing industries.

Transport

Transport emissions include the emissions originated from the combustion and evaporation of fuel for all transport activity, regardless of the sector, specified by transport mode.

Public transportation is the main mode of transport in Fiji’s main islands. Rail transport is mainly used for the transport of sugar cane and is owned by the Fiji Sugar Corporation (FSC), so it is not used for passenger transport or public use.

Fiji is also served by the ports of Labasa, Lautoka, Levuka, Savusavu and Suva; and two airports that handle international traffic, the main airport being Nadi International Airport and a secondary airport called Nausori International Airport, which handles a smaller number of international flights. There are 13 smaller domestic airports spread throughout the country’s outer islands, catering mainly small propeller aircraft. All these airports are operated by Airports Fiji Limited (AFL).

Other fuel combustion emissions

Fuel combustion emissions also occurs in the residential, commercial, and institutional sectors. Furthermore, fuel combustion emissions from agriculture, forestry, fishing, fish and farms are also accounted for in national GHG emission inventories.

Fugitive Emissions

The 2006 IPCC Guidelines describes fugitive emissions as the intentional or unintentional release of greenhouse gases occurring during extraction, processing, and delivery of fossil fuels to the point of final use. These emissions have been divided into two sub-categories:

- Fugitive emissions from mining, processing, storage, and transportation of coal
- Fugitive emissions from oil and natural gas systems

Fugitive emissions tend to be diffuse and are difficult to monitor directly. Typically, only a small percent of the emissions in the energy sector arises from fugitive emissions from extraction, transformation, and transportation of primary energy carriers.

Indigenous fossil fuel production in Fiji is limited to minor amount of charcoal production, for which data was not available[10].

Carbon Dioxide Transport and Storage

To avoid substantial amounts of CO_2 emissions and achieve stabilization of atmospheric GHG concentrations while the use of fossil fuels continues, carbon dioxide capture and storage (CCS) is an option which is being applied. The 2006 IPCC Guidelines describes CCS as a chain consisting of three major steps:

- The capture and compression of CO_2 (Usually at a large industrial installation[11])
- The transport of the compressed CO_2 to a storage location
- The long-term isolation of the compressed CO_2 from the atmosphere

Geological storage can take place in natural underground reservoirs such as oil and gas fields, coal seams and saline water-bearing formations utilizing natural geological barriers to isolate the CO_2 from the atmosphere. It can take place either at sites where the sole purpose is CO_2 storage, or in tandem with enhanced oil recovery, enhanced gas recovery or enhanced coalbed methane recovery operations. This category currently does not occur in the country.

[10] During the validation workshop, national stakeholders confirmed there are no large production levels of charcoal.

[11] Examples of large point sources of CO_2 where capture is possible include power generation, iron and steel manufacturing, natural gas processing, cement manufacture, ammonia production, hydrogen production and ethanol manufacturing plants.

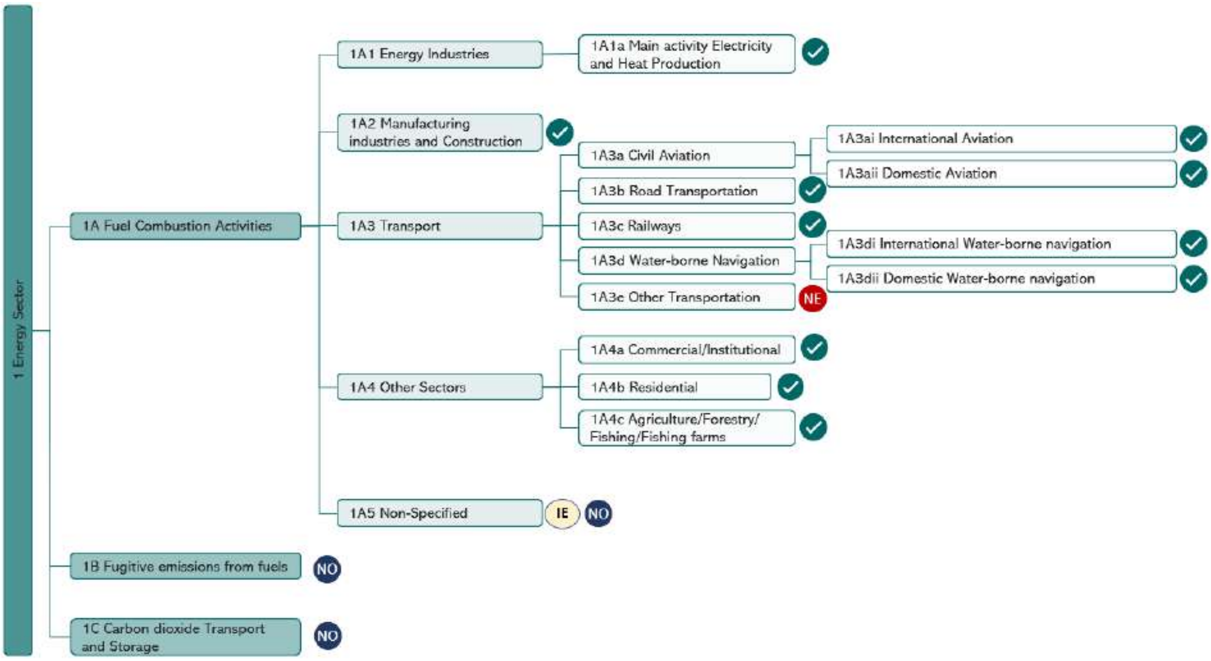
3.3.2 Energy categories covered in the inventory

According to the 2006 IPCC Guidelines, the following categories are covered in the Energy Sector of Fiji:

- **Category 1A: Fuel combustion activities:** This category covers the CO_2, CH_4 and N_2O emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus in Fiji's thirteen (13) main thermal power stations and all its substations, road transportation, water-borne navigation through its five (5) main ports, and air transport through its two (2) international airports and its thirteen (13) domestic airports.
    - **Category 1A1: Energy Industries:** This category comprises emissions from fuels combusted by the fuel extraction or energy-producing industries in Fiji's thirteen (13) main thermal power stations and all its substations.
    - **Category 1A2: Manufacturing Industries and Construction:** This category comprises emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries. Fiji's main industrial activity is mining and quarrying, but there are more industrial activities, such as food processing and other non-identified industrial activities that must be taken into consideration.
    - **Category 1A3: Transport:** Emissions from the combustion and evaporation of fuel for all transport activity in Fiji, which includes road transportation, water-borne navigation through its five (5) main ports, and air transport through its two (2) international airports and its thirteen (13) domestic airports.
        - **Category 1A3a: Civil aviation:** This category covers emissions from international and domestic civil aviation, including take-offs and landings from Fiji's two (2) international airports and its thirteen (13) domestic airports.
            - **Category 1A3ai: International Aviation (International Bunkers:** International aviation comprises flights that depart in one country and arrive in a different country of Fiji's two (2) international airports. Include take-offs and landings for these flight stages. This category is estimated and reported as a memo item and it is excluded from the total emissions.
            - **Category 1A3aii: Domestic Aviation**: Domestic Aviation comprises emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.) through Fiji's thirteen (13) domestic airports, including take-offs and landings for these flight stages.
        - **Category 1A3b: Road Transportation:** Comprises all combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.
        - **Category 1A3c: Railways:** This category includes emissions from railway transport for freight traffic routes of Fiji Sugar Corporation (FSC).

  - **Category 1A3d: Water-borne Navigation:** Emissions from fuels used in Fiji's five (5) main ports to propel water-borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels.
    - **Category 1A3di: International Water-Borne Navigation (International Bunkers):** This category covers emissions from fuels used in vessels of all flags that are engaged in international water-borne navigation through Fiji's five (5) main ports. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters and includes emissions from journeys that depart in one country and arrive in a different country. This category is estimated and reported as a memo item and it is excluded from the total emissions.
    - **Category 1A3dii: Domestic Water-Borne Navigation:** Domestic navigation includes emissions from fuels used by vessels of all flags that depart and arrive in the same country through Fiji's five (5) main ports.
- **Category 1A4: Other sectors:** This category includes emissions from combustion activities for each of the sectors included in the following subcategories, including combustion for the generation of electricity and heat for own use in these sectors.
  - **Category 1A4a: Commercial/Institutional:** This category includes emissions from fuel combustion in commercial and institutional buildings.
  - **Category 1A4b: Residential:** This category includes all emissions (CO_2, CH_4 and N_2O) from fuel combustion in households.
  - **Category 1A4c: Agriculture/Forestry/Fishing/Fish Farms:** This category includes emissions from fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms.

The following figure illustrates the completeness of the energy sector, identifying the emission sources not estimated (NE), not occurring (NO) and those which are allocated somewhere else in the inventory (IE).



NE – Not estimated; NO – Not occurring; IE – Included elsewhere.

Figure 21. Categories of the energy sector.

The following provides a further information on the reported NE and IE reported:

- Category 1A3e shall include combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities not otherwise reported under other inventory categories. Some of those activities might occur in the country, but their activity levels and associated emissions have not been estimated for this inventory edition.
- Category 1A5 shall include the emissions from all remaining emissions from fuel combustion that are not specified elsewhere. This includes emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations. Fuel combustion for military activities has not been differentiated from fuel combustion statistics, and therefore a notation key IE has been used.
- Category 1B shall include fugitive emissions occurring during extraction, processing, and delivery of fossil fuels to the point of final use. There is no evidence on the occurrence of this emission sources in the country (NO).

3.3.3 Summary of energy sector emission results

Energy sector GHG emissions for the year 2019 are 2127.65 Gg CO_2-eq, representing 53 percent of national total GHG emissions[12] for this year. Energy is the main contributor to national total GHG emissions, followed by AFOLU, Waste, and IPPU.

The energy sector emissions show an increasing trend in line with the overall growth of the activity levels in the country, as shown in the figure below.

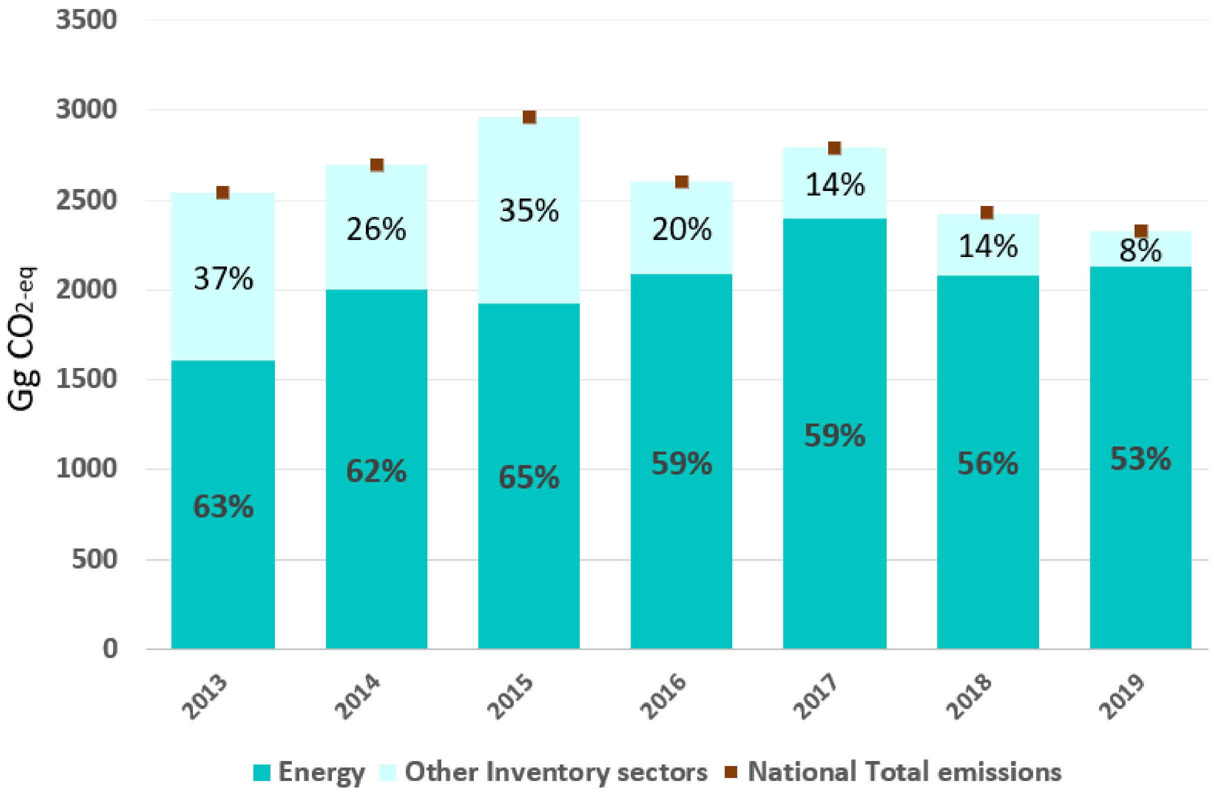


Figure 22. Energy contribution to national total emissions (Gg CO_2-eq).

The contribution of the different IPCC categories to energy sector emissions has remained stable for the entire period 2013-2019.

Transport (1A3) and **Energy Industries (1A1)** are the major emission sources within the Energy Sector, accounting for 73.35 percent and 15.75 percent of the sectoral emissions in 2019 and constituting two of the national key categories. **Manufacturing** industries (1A2) and **residential, commercial/institutional and agriculture/forestry/fishing (1A4)** have a lesser contribution to energy emissions, with 4.39 percent and 6.51 percent for the year 2019, respectively.

[12] Considering the contribution by sector in absolute terms.

Figure 23. Energy sector emissions by IPCC category (Gg CO_2-eq).

From the base year (2013), GHG emissions of the energy sector have grown 32.63 percent. In the same period, the main driver of energy emissions (economic activity represented by GDP) grew a 53.89 percent.

In terms of gases, CO_2 is the main gas emitted in the energy sector, with a contribution of over 98 percent of sectoral emissions for all the inventoried periods.

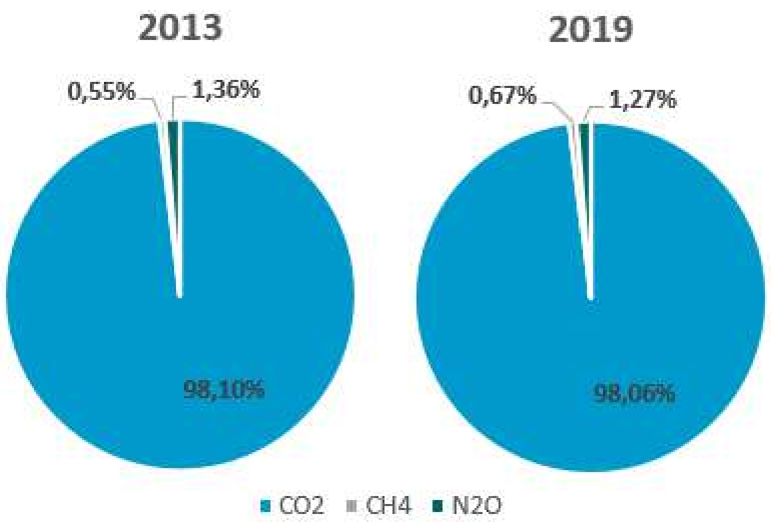


Figure 24. Split of emissions by gas.

The table below shows the GHG emissions by gas and IPCC category for the period 2013-2019.

Table 31. Summary of GHG emissions from the energy sector.

Category	Gas	GHG emissions in Gg CO_{2eq}						
		2013	2014	2015	2016	2017	2018	2019
1A1. Energy industries	CO_2	248.82	355.53	373.41	317.33	368.03	316.51	333.95
	CH_4	0.28	0.40	0.42	0.35	0.41	0.35	0.37
	N_2O	0.52	0.75	0.79	0.66	0.77	0.66	0.69
	Total	249.62	356.68	374.62	318.34	369.21	317.52	335.01
1A2. Manufacturing industries and construction	CO_2	77.89	76.82	73.14	80.18	86.50	88.49	85.63
	CH_4	2.67	3.03	3.04	2.31	2.71	3.33	3.89
	N_2O	3.42	3.86	3.88	2.96	3.46	3.668	3.94
	Total	83.98	83.72	80.07	85.44	92.67	95.49	93.46
1A3. Transport	CO_2	1145.00	1443.93	1357.82	1533.23	1770.84	1505.16	1532.32
	CH_4	4.92	5.82	5.31	8.27	9.73	8.68	9.18
	N_2O	14.82	18.84	17.72	19.42	22.48	18.95	19.17
	Total	1164.74	1468.59	1380.85	1560.92	1803.05	1532.79	1560.67
1A4. Other sectors	CO_2	101.92	92.47	89.10	121.35	132.03	127.24	134.52
	CH_4	0.90	0.84	0.79	0.84	0.83	0.82	0.83
	N_2O	3.02	2.03	2.13	2.27	2.59	2.59	3.17
	Total	105.83	95.33	92.02	124.47	135.45	130.65	138.52
TOTAL Energy Sector	CO_2	1573.63	1968.75	1893.47	2052.09	2357.41	2037.41	2086.42
	CH_4	8.76	10.09	9.56	11.77	13.67	13.17	14.27
	N_2O	21.78	25.48	24.51	25.30	29.30	25.87	26.96
	Total	1604.17	2004.32	1927.55	2089.16	2400.38	2076.45	2127.65

3.2. Data and methodology used

Emission estimates in the energy sector have been prepared on the basis of country-specific activity data and default emission factors and other parameters from 2006 IPCC Guidelines.

Fiji does not count with an official energy balance for the consolidation of national energy statistics. Currently, energy data is available at different sources, and the country does carry out the reconciliation processes needed to obtain robust national energy statistics. To solve this drawback, the inventory team has compiled fuel combustion statistics for the years 2013-2019 using different data sources available at the national level, notably Fiji Revenue and Customs Service (FRCS), Energy Fiji Limited (EFL), Vatukoula Gold Mines Limited and Fiji sugar corporation limited (FSC), among others.

The data available from the First and Second National Communication was used to develop a time series of fuel combustion back to 1994, the first inventory year reported by Fiji in its First National Communication.

Splicing techniques by fuel and category were used to ensure the consistency of the time series, obtaining the fuel combustion profile shown in the figure below.

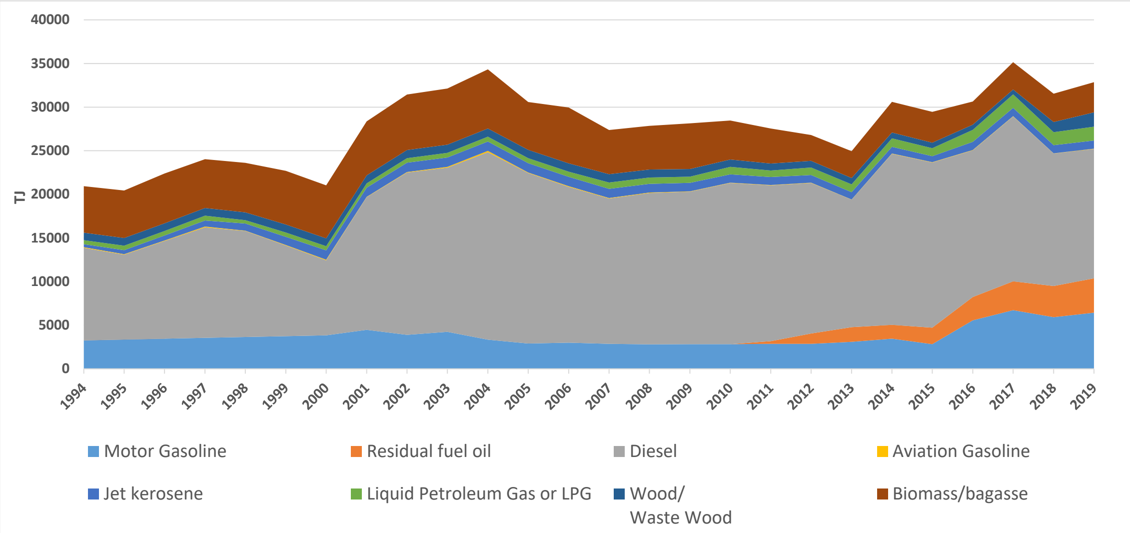


Figure 25. Fuel combustion by fuel type 1994-2019 (TJ).

The following are the main assumptions and splicing techniques used for building the fuel combustion activity data used for estimating the emissions of category 1A:

- Fuelwood used in households is not available in national statistics. However, a national report[13] on fuel used in the residential sector identified the total fuelwood consumption for years 2017 and 2007. This allowed the calculation of a per capita consumption of fuelwood (this ratio was interpolated between 2007-2017; the value of 2007 was used before 2007; the value for 2017 was used beyond 2017), which permitted to calculate the fuelwood consumed for the entire time series.
- Bagasse consumption is allocated to category 1A2, as bagasse is used in cogeneration of heat and power in the four sugar mills of Fiji Sugar Cooperation (FSC) and in Tropik Wood Industries Limited (TWIL). Data on total GWh produced was used to extrapolate back the time series until 1994.
- An outlier for year 2015 was identified in the available data on diesel consumption time series. This was corrected by interpolating the amount consumed in years 2014 and 2016.
- The splicing technique surrogate data was used to extrapolate back from 2013 to 1994 the time series of motor gasoline, diesel, and jet kerosene.
- The total amount of LPG imported was assumed to be consumed in the residential, transport and industrial end use sectors, using the data provided by Blue Gas and Fiji Gas.

Fuel consumption activity data was compared against different sources to ascertain its associated uncertainty.

[13] Available in file "Annex 8_4_FireandFuelwood_v3" provided by national stakeholders.

Table 32. Comparison of national total fuel used from different sources (TJ).

Data source	2013	2014	2015	2016	2017	2018	2019
Raw national statistics (top down)	20 228	25 408	17 181	25 979	29 866	25 602	26 153
UN Statistics	16 526	17 429	21 107	19 155	18 949	18 686	-
National Communications	24 054	25 084	-	-	-	-	-
Inventory fuel consumption (bottom up)	**25 392**	**31 162**	**30 070**	**31 556**	**36 197**	**32 540**	**33 915**

Fuel statistics considered in the First BUR include fuel combustion from biomass sources, as an improvement from the First and Second National Communications. Likewise, raw statistics compiled from different sources lacked biomass consumption, partially explaining the differences between raw statistics and inventory fuel combustion in the table above.

The following table presents the main data sources used for the preparation of emission estimates from the Energy Sector by category.

Table 33. Data sources for the energy sector.

Category	Type of data	Data source
1A1 Energy Industries	Residual Fuel oil combustion for electricity generation	EFL
	Diesel combustion for electricity generation	EFL
	Default emission factors for stationary combustion in the energy industries	Default values in Table 2.2 of chapter 2, Volume 2 from 2006 IPCC Guidelines
1A2 Manufacturing Industries and Construction	Diesel combustion	Vatukoula Gold Mines Limited
	Residual Fuel Oil combustion	Vatukoula Gold Mines Limited
	LPG combustion	FRCS and Blue gas/Fiji Gas
	Biomass combustion	FSC and TWIL
	Default emission factors for stationary combustion in the manufacturing industries and construction	Default values in table 2.3 of chapter 2, Volume 2 from 2006 IPCC Guidelines
1A3ai International Aviation (International Bunkers)	Aviation gasoline combustion from flights that depart in one country and arrive in a different country	FRCS
	Jet kerosene combustion from flights that depart in one country and arrive in a different country	FRCS
	Number of Landing/Take-Off Cycles (LTOs) by Aircraft type	FRCS
	Tier 2 default emission factors for aviation	Default values in the table 3.6.9 of chapter 3, Volume 2 from 2006 IPCC Guidelines
1A3aii Domestic Aviation	Aviation gasoline combustion from civil domestic passenger and freight traffic that departs and arrives in the same country	FRCS
	Jet kerosene combustion from flights that depart in one country and arrive in a different country	FRCS
	Number of Landing/Take-Off Cycles (LTOs) by Aircraft type	FRCS
	Tier 2 default emission factors for aviation	Default values in the table 3.6.9 of chapter 3, Volume 2 from the 2006 IPCC Guidelines
1A3b Road Transportation	Motor gasoline combustion for road transportation	FRCS
	Diesel combustion on road transportation	FRCS
	Vehicle Liquid Petroleum Gas combustion on road transportation for years 2006-2015	FRCS and Blue gas/Fiji Gas

Category	Type of data	Data source
	Default emission factors for road transportation	Default values in the table 3.2.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines
1A3c Railways	Diesel combustion on railway transport for freight traffic routes 2012-2019	FSC
	Default emission factors for the most common fuels used for rail transport	Default values in the table 3.4.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines
1A3di International Water-borne Navigation	Residual Fuel Oil combustion used in vessels of all flags that are engaged in international water-borne navigation for 2012-2019	FRCS
	Diesel combustion used in vessels of all flags that are engaged in international water-borne navigation for 2012-2019	FRCS
	Default emission factors for water-borne navigation	Default values in the tables 3.5.2 and 3.5.3 of chapter 3, Volume 2 from the 2006 IPCC Guidelines
1A3dii Domestic Water-borne Navigation	Motor Gasoline combustion used by vessels of all flags that depart and arrive in the same country for years 2012-2019	FRCS
	Diesel combustion used by vessels of all flags that depart and arrive in the same country for years 2012-2019	FRCS
	Default emission factors for water-borne navigation	Default values in the tables 3.5.2 and 3.5.3 of chapter 3, Volume 2 from the 2006 IPCC Guidelines
1A4a Residential/Commercial/Institutional	Kerosene combustion	FRCS
	Liquid Petroleum Gas combustion	LPG data
	Fuelwood consumption	Estimated based on a national survey for years 2007 & 2017.
	Default emission factors for stationary combustion in the commercial and institutional buildings	Default values in table 2.4 of chapter 2, Volume 2 from the 2006 IPCC Guidelines
1A4c Agriculture/Forestry/Fishing/Fish Farms	Diesel combustion	FRCS
	Default emission factors for stationary combustion in the residential and agriculture/forestry/fishing/fishing farms categories	Default values in table 2.5 from chapter 3, Volume 2 from the 2006 IPCC Guidelines

Emissions from the Energy sector were mostly estimated using a Tier 1 methodology from 2006 IPCC Guidelines, with the exceptions of aviation where a Tier 2 has been used. A summary description of the methodologies used to estimate emissions from the Energy sector by source categories is provided in tables 33 and 34, while a more detailed description is available in sections 3.3 and 3.7 of this chapter.

Table 34. Methodological tiers adopted for the energy sector.

Category	Tier	Activity Data	Emission Factors and Other Parameters
1A1 Energy Industries	Tier 1	Country-specific data	2006 IPCC default values
1A2 Manufacturing Industries and Construction	Tier 1	Country-specific data	2006 IPCC default values
1A3ai International Aviation (International Bunkers)	Tier 2	Country-specific data	2006 IPCC default values
1A3aii Domestic Aviation	Tier 2	Country-specific data	2006 IPCC default values
1A3b Road Transportation	Tier 1	Country-specific data	2006 IPCC default values
1A3c Railways	Tier 1	Country-specific data	2006 IPCC default values
1A3di Water-borne Navigation	Tier 1	Country-specific data	2006 IPCC default values
1A3dii International Water-borne Navigation (International Bunkers)	Tier 1	Country-specific data	2006 IPCC default values
1A4a Commercial/Institutional	Tier 1	Country-specific data	2006 IPCC default values
1A4b Residential	Tier 1	Country-specific data	2006 IPCC default values
1A4cii Off-road Vehicles and Other Machinery	Tier 1	Country-specific data	2006 IPCC default values
1A4ciii Fishing (mobile combustion)	Tier 1	Country-specific data	2006 IPCC default values

Table 35. Main methodologies and Assumptions Adopted for the Energy Sector by IPCC subcategory (2013-2019).

Category	Methodology	Assumptions
1A1 Energy industries	Equation 2.1 of chapter 2, Volume 2 from 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from energy industries. The Tier 1 method was adopted, applying the default emission factors for stationary combustion provided in Table 2.2 of Volume 2 and using country-specific data on the fuel combustion for the energy industries to produce electricity.	No specific assumptions have been made for this category.
1A2 Manufacturing Industries and Construction	Equation 2.1 of chapter 2, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from manufacturing industries and construction. The Tier 1 method was adopted, applying the default emission factors for stationary combustion in the manufacturing industries and construction in Table 2.3 of chapter 2, Volume 2 and using country-specific data on the fuel combustion in the manufacturing industries and construction.	LPG consumption was allocated to this emission source using data provided by Blue gas/Fiji Gas for years 2006-2015.

Category	Methodology	Assumptions
1A3ai International Aviation (International Bunkers)	Equations 3.6.2, 3.6.3, 3.6.4 and 3.6.5 of chapter 3, Volume 2 from the 2006 IPCC Guidelines were used to estimate CO_2, CH_4 and N_2O emissions from the fuel combustion during air transport based on the number of LTOs and cruise emissions, respectively. Default emission factors were used for LTO in Table 3.6.9 of Volume 2. Country-specific data on that depart in one country and arrive in a different country were used.	No specific assumptions have been made for this category.
1A3aii Domestic Aviation	Equations 3.6.2, 3.6.3, 3.6.4 and 3.6.5 of chapter 3, Volume 2 from the 2006 IPCC Guidelines were used to estimate CO_2, CH_4 and N_2O emissions from the fuel combustion during air transport based on the number of LTOs and cruise emissions, respectively. Default emission factors were used for LTO in Table 3.6.9 of Volume 2. Country-specific data on flights that depart and arrive in Fiji were used.	No specific assumptions have been made for this category.
1A3b Road Transportation	Equation 3.2.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from the road transportation, respectively. The Tier 1 method was adopted, utilizing the default emission factors for road transportation in Table 3.2.1 of Volume 2 and using country-specific data on the fuel combustion for road transportation.	LPG consumption was allocated to this emission source using data provided by Blue gas/Fiji Gas for years 2006-2015.
1A3c Railways	Equation 3.4.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from locomotives, respectively. The Tier 1 method was adopted, utilizing the default emission factors for the fuels used for rail transport in Table 3.4.1 of Volume 2 and using country-specific data on the fuel combustion for rail transport.	No specific assumptions have been made for this category.
1A3di International Water-borne Navigation	Equation 3.5.1 of Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from water-borne navigation. The Tier 1 method was adopted, utilizing the default emission factors for Water-borne navigation in Tables 3.5.2 and 3.5.3 of Volume 2 and using country-specific data on the fuel combustion used in vessels of all flags that are engaged in international water-borne navigation.	No specific assumptions have been made for this category.
1A3dii domestic Water-borne Navigation (International Bunkers)	Equation 3.5.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions from water-borne navigation, respectively. The Tier 1 method was adopted, utilizing the default emission factors for Water-borne navigation in Tables 3.5.2 and 3.5.3 of Volume 2 and using country-specific data on the fuel combustion used by vessels of all flags that depart and arrive in the same country.	No specific assumptions have been made for this category.
1A4a Residential/Commercial/Institutional	Equation 2.1 of chapter 2, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions. The Tier 1 method was adopted, applying the default emission factors for stationary combustion and using country-specific data on fuel combustion.	Fuelwood consumption has been estimated by using data available for years 2007 and 2017 in a national report. LPG consumption was allocated to this emission source using data provided by Blue gas/Fiji Gas for years 2006-2015.
1A4c Agriculture/Forestry/Fishing/Fish Farms	Equation 2.1 of chapter 3, Volume 2 from the 2006 IPCC Guidelines was used to estimate CO_2, CH_4 and N_2O emissions. The Tier 1 method was adopted, applying the default emission factors for stationary combustion and using country-specific data on fuel combustion.	No specific assumptions have been made for this category.

3.3. Fuel combustion activities (1.A)

The most detailed data available in the country has been used to estimate through a sectoral approach the emissions of category 1A Fuel Combustion activities.

In the sectoral approach, the emissions are estimated using a bottom-up procedure, from the most disaggregated data available by activity.

Except the emissions from civil aviation (category 1A3a), all the emissions of the sectoral approach of the energy sector have been estimated using a tier 1 approach for all categories of the energy sector, using fuel-specific emission factors provided by 2006 IPCC guidelines using the expression shown below:

$$Emissions_{GHG,Fuel} = Fuel\ Consumption_{Fuel} \cdot Emission\ Factor_{GHG,Fuel}$$

Where:

$Emissions_{GHG,Fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

$Fuel\ Consumption_{Fuel}$ = amount of fuel combusted (TJ)
$Emission\ Factor_{GHG,Fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.

The data used was available in different units. The following table shows the low calorific value and the carbon content of the fuels, which have been used where appropriate.

Table 36. Low calorific value and carbon content of fuels in the energy sector.

Fuel	Net Calorific Value (TJ/Gg)	Carbon content (% wet mass)
Motor gasoline	44.3	18.9
Residual fuel oil	40.4	21.1
Diesel	43.0	20.2
Aviation gasoline	44.3	19.1
Jet kerosene	44.1	19.5
LPG	47.3	17.2
Fuelwood	15.6	30.5
Bagasse	7.67*	22.5*

Source: Chapter 1, Volume 2, 2006 IPCC Guidelines. *Provided by FSC

In the following sub-sections, information on the activity data, emission factors and emissions obtained for each category included in the sectoral approach of the energy sector is provided in more detail. A comparison between the sectoral approach and reference approach is provided subsequently to illustrate the quality of the data used by the inventory.

3.3.1. Energy Industries (1A1)

As for many other small islands developing states (SIDs), Fiji's geographical characteristics make affordable and accessible energy supply a challenge. Fiji is thus highly dependent on imported fossil fuel for its energy needs. Nonetheless, Fiji has a large renewable energy infrastructure, accounting for more than 57% of the country's total energy production in 2019 and being primarily hydroelectric power. EFL aims to be 90 percent renewable-powered by 2025 and 99 percent by 2030.

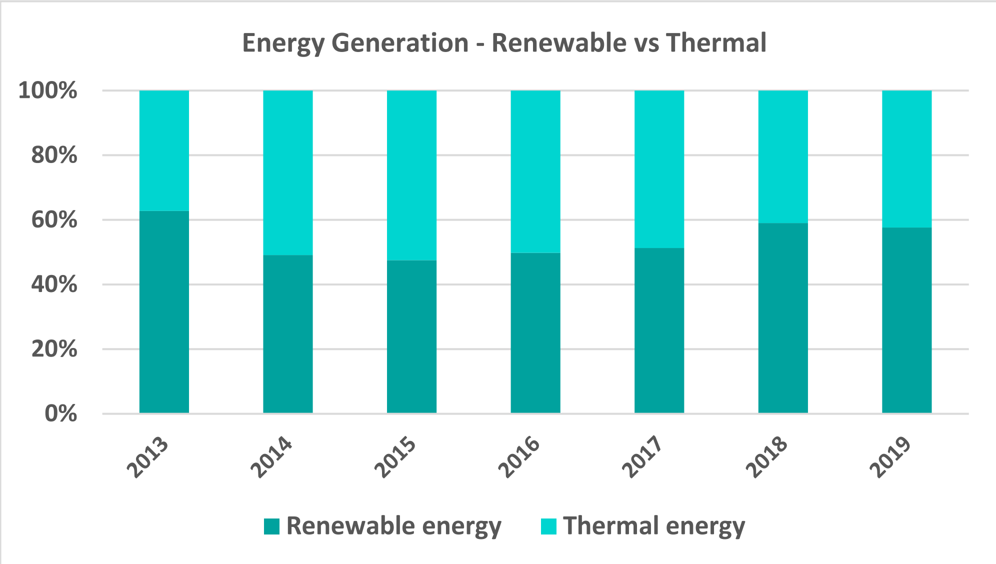


Figure 26. Energy generation mix – renewables vs thermal.

EFL controls most of the electricity grid in Fiji. The total installed power generation capacity is around 250 MW, 95% of which was run by the EFL, delivering in 2019 1,061,249 MWh with a share of the 20% held by FNPF (Fiji National Provident Fund) and a 5% by the domestic account holders.

From the 1,061,249 MWh of grid electricity, 1,012,433 MWh corresponds to the total EFL generation. Around 53% of grid electricity was produced by hydro, 42% by thermal generators, 0.3% by solar and wind, and the remaining 4.6% from Independent Power Producers (IPPs), using biomass as the main energy source (Energy Fiji Limited Annual Report, 2019). The following table shows the energy generation trends for the years 2013-2019, based on the Energy Fiji Limited Annual Report for 2019.

Table 37. Energy generation trends for years 2013-2019 (MWh).

Energy Generation	2013	2014	2015	2016	2017	2018	2019
Total Generated by Hydroelectric power	527 397	400 968	405 968	405 949	491 189	566 709	559 392
Total Generated by Thermal generators	324 755	454 039	480 422	424 507	490 958	423 741	449 662
Total Generated by Wind & Solar power	5 348	4 269	5 674	3 632	2 083	2 558	3 419
Independent Power Producers (Biomass)	14 719	32 513	22 235	10 058	23 483	39 939	48 816
Total Generation	872 219	891 789	914 395	934 208	1 007 713	1 032 947	1 061 249

Source: Energy Fiji Limited Annual Report, 2019. Available at: http://www.parliament.gov.fj/wp-content/uploads/2020/05/Energy-Fiji-Limited-2019-Annual-Report.pdf

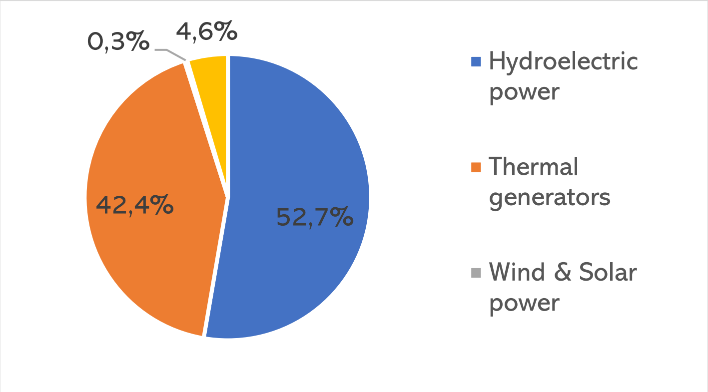


Figure 27. Power generation mix for the year 2019 in Fiji.

There is a total of twenty-one (21) power stations in Fiji, seven (7) of which hydroelectric stations, one is a wind farm and the remaining 13 are thermal power stations. In addition, there are a large number of substations scattered throughout Fiji, which are responsible for setting the appropriate voltage levels for the transmission and distribution of electricity. These stations are listed as follows:

Hydro Generation:

- Wailoa Power Station
- Nadarivatu Hydro-power Station
- Wainikasou Hydro-power Station
- Nagado Hydro-power Station
- Somosomo Hydro-power Station
- Wainiqeu Hydro-power Station
- Monasavu Dam

Wind generation

- Butoni Wind Farm

Thermal generation

- Kinoya Station
- Vuda Power Station
- Labasa Station
- Ovalau Station
- Rakiraki Station
- Nadi Station
- Sigatoka Station
- Savusavu Station
- Rokobili Station
- Deuba Station
- Korovou Station
- Qeleloa Station
- Taveuni Station

In addition to these stations, which generate and sell electricity as their primary activity, there are several autoproducers of energy, which are defined by the 2006 IPCC Guidelines as an enterprise that, in support of its primary activity, generates electricity and/or heat for its own use or for sale, but not as its main business. These autoproducers, or Independent Power Producers as EFL names them, are Tropik Wood Industries Limited, Fiji Sugar Corporation and Nabou Green Energy. The emissions from autoproducers are accounted for in IPCC category 1A2 as specified by 2006 IPCC Guidelines.

The following provides the activity data and emission factors used for estimating the emissions of category 1A1, accounting the emissions from fuel combustion in thermal power plants.

Activity data

Table 38. Activity data used in energy industries.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Fuel oil	1679	1588	1887	2670	2965	2744	3142
Diesel	1605	3139	3068	1494	1870	1405	1224

Emission factors

Table 39. Emission factors used in energy industries.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Crude Oil	77400	3	0.6
Diesel	74100	3	0.6

Emissions

Table 40. Emission estimated for energy industries (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	248.82	355.53	373.41	317.33	368.03	316.51	333.95
CH_4	0.28	0.40	0.42	0.35	0.41	0.35	0.37
N_2O	0.52	0.75	0.79	0.66	0.77	0.66	0.69
Total	249.62	356.68	374.62	318.34	369.21	317.52	335.01

Explanation of the trend

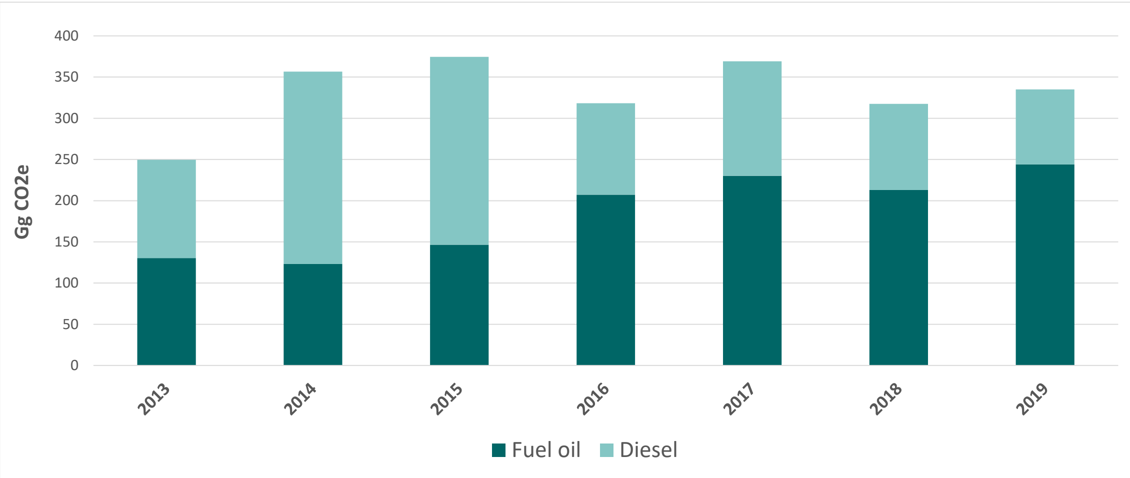


Figure 28. GHG emission trend (Gg CO_2-eq).

Due to the expansion of thermal generation in 2014 (from 324,755 MWh in 2013 to 454,039 MWh in 2014), GHG emissions in category 1A1 increased by 42.8 percent. After this rapid growth, energy industry emissions remained stable from 2014 to 2019. It is worth noting that diesel is being phased out of the energy industry in favour of fuel oil. Fuel oil usage climbed by 87 percent over the inventory period, making it the most common fuel for electricity generation in 2019.

Uncertainty

Table 41. Uncertainty in energy industries.

Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
	Gg of CO_2-eq		%	%	%
CO_2	248.82	333.95	2	7	7
CH_4	0.28	0.37	2	100	100
N_2O	0.52	0.69	2	100	100

Activity data uncertainty has been extracted from table 2.15 (chapter 2, volume 2, 2006 IPCC Guidelines). The value for "Surveys" under less developed statistical systems has been used, considering that the data is provided by the EFL.

Emission factors uncertainties have been selected from chapter 2, volume 2, 2006 IPCC Guidelines as follows:

- CO_2: 7% based on the information provided in page 2.38
- CH_4: middle point of the range provided in table 2.12
- N_2O: expert judgement from the values provided in page 2.38

As specified in 2006 IPCC Guidelines, emission factors for CH_4 and N_2O are highly uncertain. High uncertainties in emission factors may be ascribed to lack of relevant measurements and subsequent generalisations, uncertainties in measurements, or an insufficient understanding of the emission generating process.

3.3.2. Manufacturing industries and construction (1A2)

The following provides the activity data and emission factors used for estimating the emissions of category 1A2, and the results obtained by gas.

Activity data

Table 42. Activity data used in Manufacturing industries and construction.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Fuel oil	0	0	0	0	335	822	788
Diesel	863	839	801	801	497	31	9
LPG	221	233	219	330	376	358	380
Fuelwood	0	0	0	0	0	616	1,077
Bagasse	3088	3513	3537	2660	3128	3254	3464

Emission factors

Table 43. Emission factors used in Manufacturing industries and construction.

Fuel type	Greenhouse Gases		
	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)
Fuel oil	77400	3	0.6
Diesel	74100	3	0.6
LPG	63100	1	0.1
Fuelwood	112000*	30	4
Bagasse	100000*	30	4

Source: Table 2.3. Chapter 2 Stationary combustion, Volume 2, 2006 IPCC Guidelines. *CO_2 emissions from biomass sources are not accounted for in national totals.

Emissions

Table 44. Emission estimated for manufacturing industries and construction (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	77.89	76.82	73.14	80.18	86.50	88.49	85.63
CH_4	2.67	3.03	3.04	2.31	2.71	3.33	3.89
N_2O	3.42	3.86	3.88	2.96	3.46	3.67	3.94
Total	83.98	83.72	80.07	85.44	92.67	95.49	93.46

Explanation of the trend

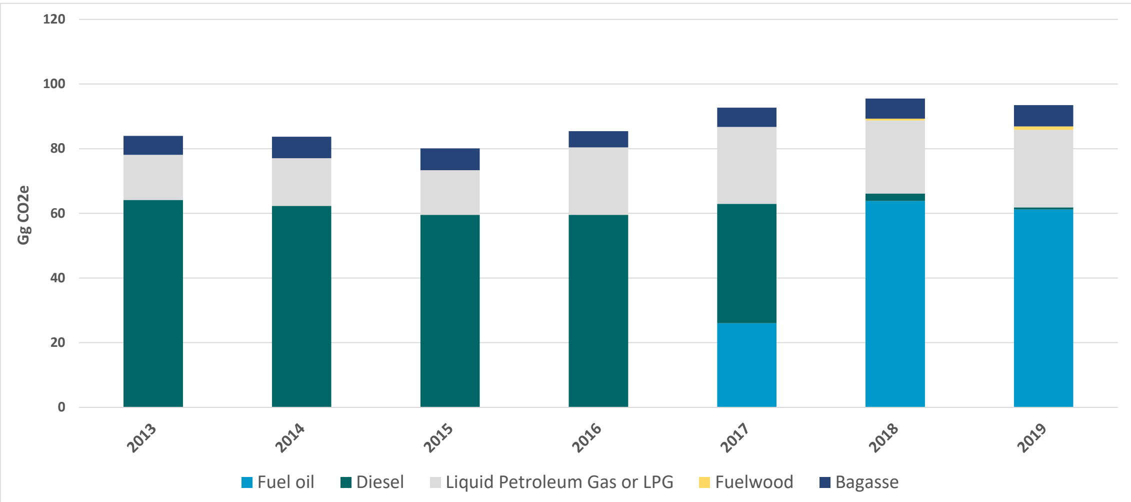


Figure 29. GHG emission trend (Gg CO_2-eq).

The GHG emissions of category 1A2 showed a slight increasing trend during the period 2013-2019. Fuel oil consumption raised significantly in years 2017-2019, replacing diesel consumption for those years.

Uncertainty

Table 45. Uncertainty in the manufacturing industries and construction sector.

IPCC category	Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
		Gg of CO_2-eq		%	%	%
1A2 – Manufacturing industries and construction - Biomass	CH_4	2.59	3.81	30	100	104
1A2 – Manufacturing industries and construction - Biomass	N_2O	3.27	3.80	30	100	104
1A2 – Manufacturing industries – Liquid	CO_2	77.89	85.63	15	7	17
1A2 – Manufacturing industries – Liquid	CH_4	0.08	0.08	15	100	101
1A2 – Manufacturing industries – Liquid	N_2O	0.14	0.14	15	100	101

Activity data uncertainty has been assumed to be 15 percent for liquid fuels (upper range provided for other industrial combustion in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines) and 30 per cent for biomass (lower range provided for biomass in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines). The uncertainty of the activity data is relatively high. As explained in section 3.5 on the comparison between the sectoral and the reference approach, the quality of energy statistics needs to be improved for future inventory submissions.

Emission factors uncertainties have been selected from chapter 2, volume 2, 2006 IPCC Guidelines as follows:

- CO_2: 7% based on the information provided in page 2.38
- CH_4: middle point of the range provided in table 2.12
- N_2O: expert judgement from the values provided in page 2.38

As specified in 2006 IPCC Guidelines, emission factors for CH_4 and N_2O are highly uncertain. High uncertainties in emission factors may be ascribed to lack of relevant measurements and subsequent generalisations, uncertainties in measurements, or an insufficient understanding of the emission generating process.

3.3.3. Transport (1A3)

The transport in Fiji is an essential activity very bounded to the development of the country: in 2019 transport activities contributed a 32.86% to national total GDP.

Transport emissions are driven by the contribution of road transport, which accounts for over 90 percent of transport emissions.

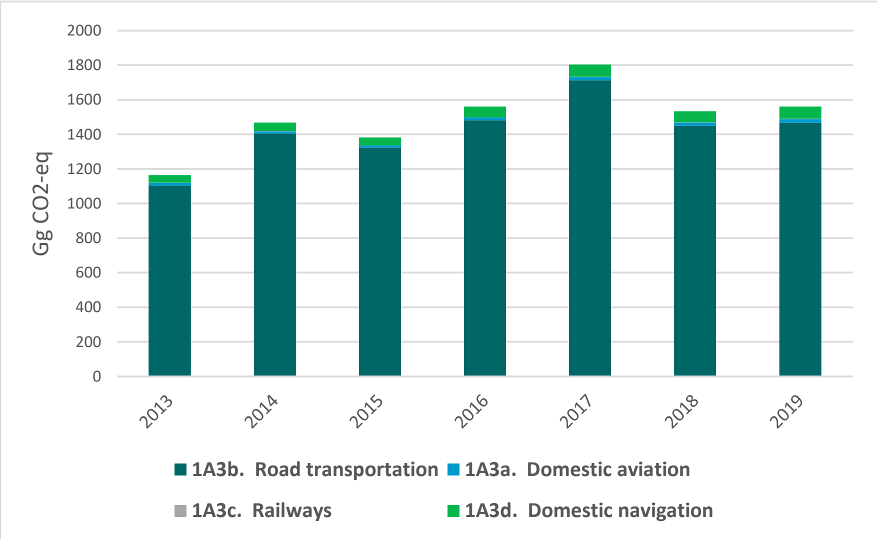


Figure 30. GHG emission trend (Gg CO_2-eq) emitted by activity under the transport sector.

3.3.3.1. (1A3aii) Domestic Aviation

Fiji has 2 international airports and 13 domestic airports. There are two domestic airlines: Fiji Link (7 airplanes in the fleet: 1 ATR 42-600, 2 ATR 72-600 and 4 DHC-4-400 Twin Otter) and Northern Air (6 airplanes in the fleet: 2 BN2 Islander and 4 EMB 110).

The emissions of this category have been estimated following the tier 2 approach provided by 2006 IPCC Guidelines. The equations 3.6.2 to 3.6.5 provided in chapter 3, volume 2, 2006 IPCC guidelines were used as follows:

$$Total\ Emissions = LTO\ emissions + Cruise\ emissions$$

Where:

$$LTO\ emissions = Number\ of\ LTO \cdot Emission\ Factor\ LTO$$

$$LTO\ Fuel\ Consumption = Number\ of\ LTO \cdot Fuel\ consumption\ per\ LTO$$

$$Cruise\ emissions = (Total\ Fuel\ Consumption - LTO\ Fuel\ consumption) \cdot Emission\ Factor\ cruise$$

The following provides the activity data and emission factors used for estimating the emissions of category 1A3aii, and the results obtained by gas.

Activity data

Table 46. Total fuel consumption (TJ).

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Aviation Gasoline	23.19	29.61	32.41	37.49	43.05	32.76	30.01
Jet Kerosene	181.72	160.97	136.92	207.51	219.28	231.26	279.26

Table 47. Activity data used – Nº Landing/Take-off Cycles (LTOs).

Aircraft type	Number of LTOs						
	2013	2014	2015	2016	2017	2018	2019
ATR42-500	9312	8276	-	-	-	-	-
ATR42 600	-	624	5438	5208	5206	4988	4904
ATR72 600	-	280	3016	3598	3486	3976	4792
DHT300	4390	4864	-	6160	6344	2250	42
DHT400	-	-	5310	-	315	7788	9538
Total	13702	14044	13764	14966	15351	19002	19276

Emission factors

Table 48. Emission factors used.

Aircraft type	LTO Emission factor (kg/LTO)			LTO Fuel Consumption kg/LTO
	CO_2	CH_4	N_2O	
ATR42-500	640.00	0.03	0.02	200.00
ATR42 600	640.00	0.03	0.02	200.00
ATR72 600	640.00	0.03	0.02	200.00
DHT300	230.00	0.06	0.01	70.00
DHT400	230.00	0.06	0.01	70.00

Source: Chapter 3, volume 2, 2006 IPCC Guidelines.

Emissions

Table 49. Emission estimated (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	14.76	13.74	12.22	17.63	18.87	19.03	22.27
CH_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N_2O	0.13	0.12	0.11	0.15	0.16	0.17	0.19
Total	14.91	13.88	12.34	17.80	19.06	19.22	22.49

Uncertainty

Table 50. Uncertainty in the domestic aviation estimations.

Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
	Gg of CO_2-eq		%	%	%
CO_2	14.76	22.27	15	7	17
CH_4	0.02	0.02	15	100	101
N_2O	0.13	0.19	15	100	151

Activity data and emission factors uncertainty is based on the information provided in section 3.6.1.7 of 2006 IPCC Guidelines (chapter 3, volume 2, 2006 IPCC Guidelines).

Activity data uncertainty is allocated using expert judgement, considering that the data comes from surveys developed a national level.

Category specific QC activity

For domestic aviation, the data required for performing the Tier 1 and Tier 2 approaches was available. The Tier 1 approach was calculated for QC purposes, and the results were compared against those obtained using the Tier 2 approach. The differences between approaches remain below 2 percent. The results of the comparison are displayed in the figure below.

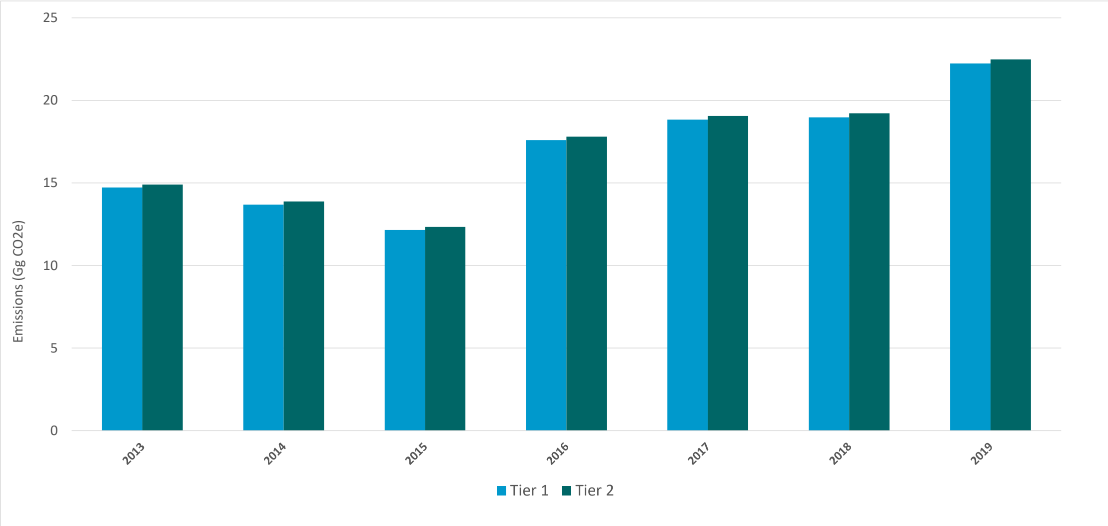


Figure 31. GHG emissions (Gg CO_2-eq) obtained using the Tier 1 and Tier 2 approaches.

3.3.3.2. (1A3b) Road Transport

The following provides the activity data and emission factors used for estimating the emissions of category 1A3b, and the results obtained by gas.

Activity data

Table 51. Total fuel consumption (TJ).

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Motor gasoline	2687	3018	2509	5027	6056	5379	5796
Diesel	11626	15201	14591	13981	15956	13151	12915
LPG	589	704	729	1100	1255	1193	1267

Emission factors

Table 52. Emission factors used.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Motor gasoline	69300	33	3.2
Diesel	74100	3.9	0.6
LPG	63100	62	0.2

Source: Chapter 3, volume 2, 2006 IPCC Guidelines.

Emissions

Table 53. Emission estimated (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	1084.88	1379.93	1300.99	1453.71	1681.17	1422.54	1438.60
CH_4	4.78	5.67	5.18	8.08	9.52	8.48	8.96
N_2O	14.33	18.31	17.25	18.77	21.69	18.22	18.33
Total	1103.98	1403.91	1323.42	1480.56	1712.38	1449.23	1465.90

Uncertainty

Table 54. Uncertainty.

Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
	Gg of CO_2-eq		%	%	%
CO_2	CO_2	1084.88	1438.60	15	7
CH_4	CH_4	4.78	8.96	15	100
N_2O	N_2O	14.33	18.33	15	100

Activity data uncertainty is suggested to be +/-5 in chapter 3 of 2006 IPCC Guidelines. However, considering that the quality of the data is similar to the activity data used in categories 1A2 and 1A3a, and aiming at ensuring the consistency of the inventory, the same uncertainty values have been used for the activity data of sub-categories1A2, 1A3a and 1A3b.

Likewise, in the Tier 1 approach the nature of the emission factors used is homogeneous for all category 1A. As a result of this, the emission factor uncertainty of the all the emission factors used in the category is the same, as discussed under previous sub-categories.

4.3.1.1. (1A3c) Railways

Fiji counts with almost 600 km of rails. Half of them is dedicated to the transport of products related to the sugar cane industry (the Cane Train) that has an impact in the GDP of 1,2% of GDP (2018).

The following provides the activity data and emission factors used for estimating the emissions of category 1A3c, and the results obtained by gas.

Activity data

Table 55. Activity data used in railways.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Diesel	4.53	5.53	4.94	4.67	13.05	13.21	15.41

Emission factors

Table 56. Emission factors used in railways.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Diesel	74100	4.15	28.6

Source: Table 3.4.1. Chapter 3 Mobile combustion, Volume 2, 2006 IPCC Guidelines.

Emissions

Table 57. Emission estimated for railways (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	0.34	0.41	0.37	0.35	0.97	0.98	1.14
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	0.03	0.04	0.04	0.04	0.10	0.10	0.12
Total	0.37	0.45	0.40	0.38	1.07	1.08	1.26

Explanation of the trend

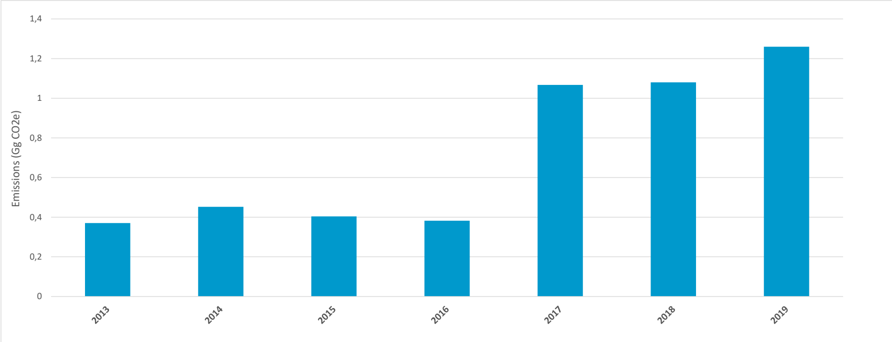


Figure 32. GHG emission trend (Gg CO_2-eq).

The GHG emissions of category 1A3c showed a sharp increase in year 2017. There are ongoing efforts in the country to upgrade the locomotives and the rail network; however, the reason for this increase could not be ascertained for the current inventory edition.

Uncertainty

Table 58. Uncertainty in railways.

Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
	Gg of CO_2-eq		%	%	%
CO_2	0.34	1.14	15	7	21
CH_4	0.00	0.00	15	100	102
N_2O	0.03	0.12	15	100	102

Activity data uncertainty is suggested to be +/-5 in chapter 3 of 2006 IPCC Guidelines. However, considering that the quality of the data is similar to the activity data used in categories 1A2, 1A3a, and 1A3b, and aiming at ensuring the internal consistency of the inventory, the same uncertainty values have been used for the activity data of sub-categories1A2, 1A3a, 1A3b and 1A3c.

Likewise, in the Tier 1 approach the nature of the emission factors used is homogeneous for all category 1A. As a result of this, the emission factor uncertainty of the all the emission factors used in the category is the same, as discussed under previous sub-categories.

4.3.1.2. (1A3d) Domestic Navigation

As an archipelago, the domestic navigation results essential in the country. There are five seaports of which two of them are container terminals, summing more than 200km of well stablished waterways.

The following provides the activity data and emission factors used for estimating the emissions of category 1A3d, and the results obtained by gas.

Activity data

Table 59. Activity data used in domestic navigation.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Gasoline	420.62	443.70	328.24	543.50	676.59	548.87	643.51
Diesel	214.27	257.77	290.00	322.23	309.54	331.63	346.93

Emission factors

Table 60. Emission factors used in domestic navigation.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Gasoline	69300	7	2
Diesel	74100	7	2

Source: Tables 3.5.2. and 3.5.3. Chapter 3 Mobile combustion, Volume 2, 2006 IPCC Guidelines.

Emissions

Table 61. Emission estimated for domestic navigation (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	45.03	49.85	44.24	61.54	69.82	62.61	70.30
CH_4	0.12	0.14	0.12	0.17	0.19	0.17	0.19
N_2O	0.34	0.37	0.33	0.46	0.52	0.47	0.52
Total	45.49	50.36	44.68	62.17	70.54	63.25	71.02

Explanation of the trend

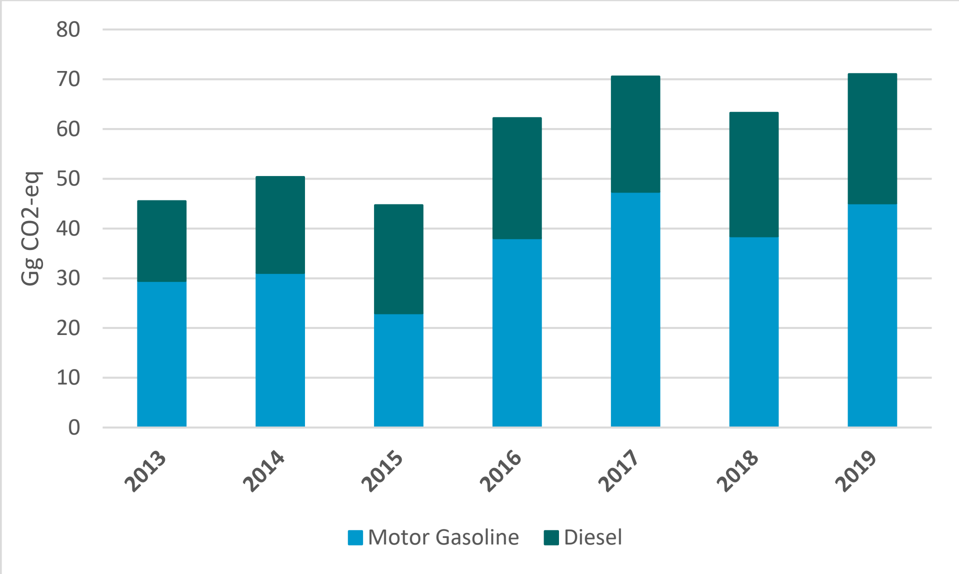


Figure 33. GHG emission trend (Gg CO_2-eq).

The GHG emissions of category 1A3c showed a steady increase during the inventoried period, in line with the overall economic growth.

Uncertainty

Table 62. Uncertainty in domestic navigation.

Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
	Gg of CO_2-eq		%	%	%
CO_2	0.34	1.14	15	7	21
CH_4	0.00	0.00	15	100	102
N_2O	0.03	0.12	15	100	102

Activity data uncertainty is suggested to be +/-5 in chapter 3 of 2006 IPCC Guidelines. However, considering that the quality of the data is similar to the activity data used in categories 1A2, 1A3a, and 1A3b, and aiming at ensuring the internal consistency of the inventory, the same uncertainty values have been used for the activity data of sub-categories1A2, 1A3a, 1A3b and 1A3c.

Likewise, in the Tier 1 approach the nature of the emission factors used is homogeneous for all category 1A. As a result of this, the emission factor uncertainty of the all the emission factors used in the category is the same, as discussed under previous sub-categories.

4.3.2. Other sectors (1A4)

Category 1A4 Other sectors encompass combustion emissions from a variety of end-use sectors, including the residential, commercial, and institutional sectors, as well as the emissions from fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms. In the inventory of Fiji, the emissions of these end use sectors have been allocated under two subcategories: 1A4b residential and 1A4c agriculture/forestry/fishing/fish farms.

4.3.2.1. Residential (1A4b)

The following tables provides the activity data and emission factors used for estimating the emissions of category 1A4b, and the results obtained by gas.

Activity data

Table 63. Activity data used in residential.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Kerosene	665.05	598.25	553.83	726.16	718.12	694.16	666.37
LPG	525.49	597.95	571.55	862.59	984.18	935.61	993.57
Fuelwood	717.48	676.05	634.13	591.71	548.79	551.75	554.70

The activity data collected has been used to estimate the emissions of category 1A4b Residential. However, it includes the consumption carried out by the commercial and institutional sector.

Emission factors

Table 64. Emission factors used in residential.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Kerosene	71900	10	0,6
LPG	63100	5	0,1
Fuelwood	112000*	30	4

Source: Table 2.5. Chapter 2 Stationary combustion, Volume 2, 2006 IPCC Guidelines. *CO_2 emissions from biomass sources are not accounted for in national totals.

Emissions

Table 65. Emission estimated for residential (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	80.98	80.75	75.89	106.64	113.73	108.95	110.61
CH_4	0.86	0.82	0.77	0.82	0.80	0.79	0.79
N_2O	0.88	0.83	0.78	0.77	0.72	0.72	0.72
Total	82.72	82.39	77.43	108.23	115.26	110.46	112.12

Explanation of the trend

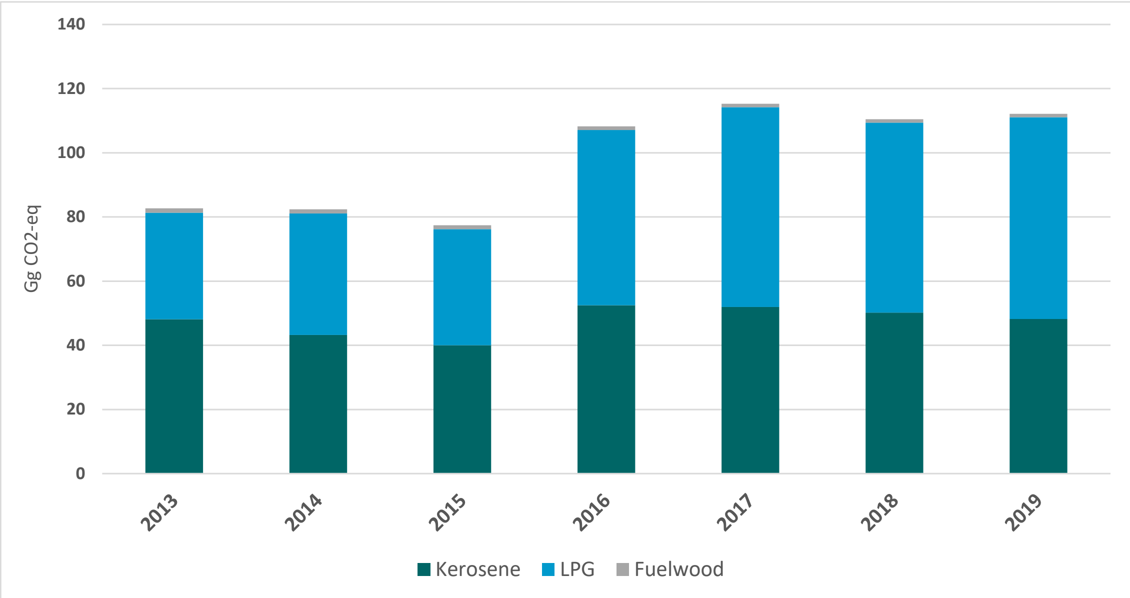


Figure 34. GHG emission trend (Gg CO_2-eq).

The GHG emissions of category 1A4b showed a slight increasing trend during the period 2013-2019. LPG consumption raised significantly in years 2017-2019, replacing kerosene consumption for those years. Fuelwood consumption emissions are a minor source of GHG, as CO_2 is accounted as a memo item.

Uncertainty

Table 66. Uncertainty in residential.

IPCC category	Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
		Gg of CO_2-eq		%	%	%
1A4 – Other sectors – Liquid	CO_2	101.92	134.52	15	7	17
1A4 – Other sectors – Liquid	CH_4	0.29	0.36	15	100	101
1A4 – Other sectors – Liquid	N_2O	2.26	2.58	15	100	101
1A4 – Other sectors – Biomass	CH_4	0.60	0.47	30	100	104
1A4 – Other sectors – Biomass	N_2O	0.76	0.59	30	100	104

Uncertainty of subcategory 1A4b is assessed together 1A4c following the disaggregation proposed by 2006 IPCC for developing the uncertainty assessment and KCA.

Activity data uncertainty has been assumed to be 15 percent for liquid fuels (upper range provided for Commercial, institutional, residential combustion in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines) and 30 per cent for biomass (lower range provided for biomass in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines).

Emission factors uncertainties have been selected from chapter 2, volume 2, 2006 IPCC Guidelines as follows:

- CO_2: 7% based on the information provided in page 2.38
- CH_4: middle point of the range provided in table 2.12
- N_2O: expert judgement from the values provided in page 2.38

As specified in 2006 IPCC Guidelines, emission factors for CH_4 and N_2O are highly uncertain. High uncertainties in emission factors may be ascribed to lack of relevant measurements and subsequent generalisations, uncertainties in measurements, or an insufficient understanding of the emission generating process.

4.3.2.2. Agriculture/Forestry/Fishing/Fish Farms (1A4c)

The following tables provides the activity data and emission factors used for estimating the emissions of category 1A4c, and the results obtained by gas.

Activity data

Table 67. Activity data used in agriculture/forestry/fishing/fish farms.

Fuel	Activity data in TJ NCV						
	2013	2014	2015	2016	2017	2018	2019
Diesel	283	158	178	199	247	247	323

Emission factors

Table 68. Emission factors used in agriculture/forestry/fishing/fish farms.

Fuel type	Greenhouse Gases		
	CO_2 (Kg/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Diesel	74100	4.15	28.6

Source: Table 2.3. Chapter 2 Stationary combustion, Volume 2, 2006 IPCC Guidelines.

Emissions

Table 69. Emission estimated for agriculture/forestry/fishing/fish farms (Gg CO_2-eq).

Gas	GHG emissions in Gg CO_2eq						
	2013	2014	2015	2016	2017	2018	2019
CO_2	20.94	11.72	13.22	14.71	18.30	18.30	23.91
CH_4	0.03	0.02	0.02	0.02	0.03	0.03	0.04
N_2O	2.14	1.20	1.35	1.50	1.87	1.87	2.45
Total	23.11	12.94	14.59	16.24	20.20	20.20	26.40

Explanation of the trend

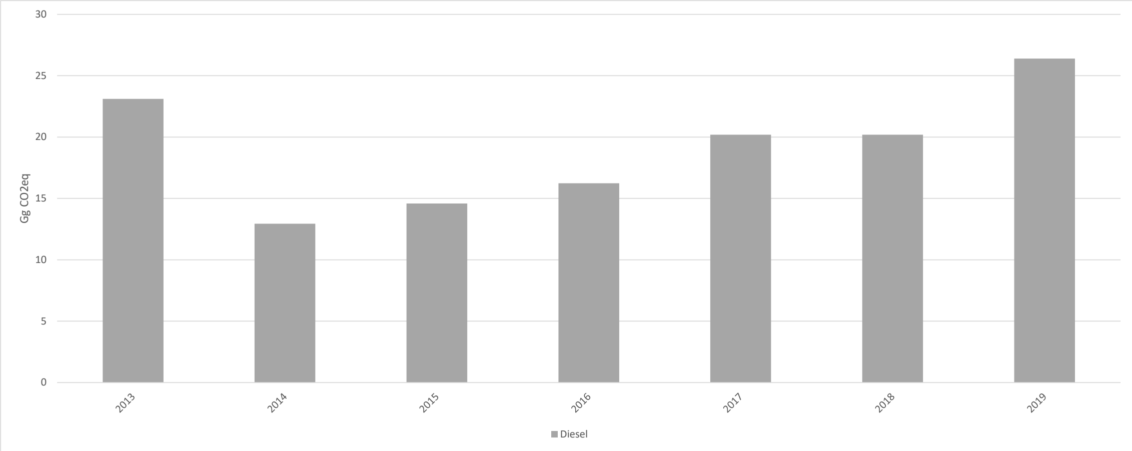


Figure 35. GHG emission trend (Gg CO_2-eq).

The GHG emissions of category 1A4c decreased significantly in year 2014, following a strong increasing trend during the period 2014-2019 which is in line with the expansion of GDP in the country.

Uncertainty

Table 70. Uncertainty for agriculture/forestry/fishing/fish farms.

IPCC category	Gas	Base year emissions (2013)	2019 emissions	Activity data uncertainty	Emission factor Uncertainty	Combined uncertainty
		Gg of CO_2-eq		%	%	%
1A4 – Other sectors – Liquid	CO_2	101.92	134.52	15	7	17
1A4 – Other sectors – Liquid	CH_4	0.29	0.36	15	100	101
1A4 – Other sectors – Liquid	N_2O	2.26	2.58	15	100	101
1A4 – Other sectors – Biomass	CH_4	0.60	0.47	30	100	104
1A4 – Other sectors – Biomass	N_2O	0.76	0.59	30	100	104

Uncertainty of subcategory 1A4c is assessed together 1A4b following the disaggregation proposed by 2006 IPCC for developing the uncertainty assessment and KCA.

Activity data uncertainty has been assumed to be 15 percent for liquid fuels (upper range provided for Commercial, institutional, residential combustion in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines) and 30 per cent for biomass (lower range provided for biomass in surveys in table 2.15 in chapter 2, volume 2, 2006 IPCC Guidelines).

Emission factors uncertainties have been selected from chapter 2, volume 2, 2006 IPCC Guidelines as follows:

- CO_2: 7% based on the information provided in page 2.38
- CH_4: middle point of the range provided in table 2.12
- N_2O: expert judgement from the values provided in page 2.38

As specified in 2006 IPCC Guidelines, emission factors for CH_4 and N_2O are highly uncertain. High uncertainties in emission factors may be ascribed to lack of relevant measurements and subsequent generalisations, uncertainties in measurements, or an insufficient understanding of the emission generating process.

3.5. Comparison between the reference and the sectoral approach

IPPC guidelines recommend applying a Sectoral approach and a Reference approach to estimate country's CO_2 emissions from fuel combustion and to compare the results of these two independent estimates. The Sectoral approach uses values bounded to each category that together add up the national total of the Energy sector while the Reference approach uses the total values of the national energy statistics.

The Reference approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. Therefore, the Reference approach is designed to calculate the emissions of CO_2 from fuel combustion, starting from high level energy supply data.

The assumption is that carbon is conserved so that, for example, carbon in crude oil is equal to the total carbon content of all the derived products.

The Reference approach does not distinguish between different source categories within the energy sector and only estimates total CO_2 emissions from Source category 1A, Fuel Combustion.

The reference approach is generally estimated using the energy balance of the country, considering the apparent consumption of fuels and the excluded carbon for calculating overall CO_2 emissions. Nevertheless, Fiji does not count with an official energy balance for reconciling national energy statistics. To solve this drawback, the inventory team compiled fuel consumption statistics for years 2013-2019 using different data sources available at national level.

With the objective of estimating a reference approach, the inventory team attempted to compile energy supply and energy transformation statistics, to complement the data on energy consumption which has been used to calculate the sectoral approach (see section 3.2 above for further information on the data used for calculating the sectoral approach).

For estimating CO_2 emissions using the reference approach, the following 5 steps methodology needs to be followed:

- Step 1: Estimate Apparent Fuel Consumption in Original Units
- Step 2: Convert to a Common Energy Unit
- Step 3: Multiply by Carbon Content to Compute the Total Carbon
- Step 4: Compute the Excluded Carbon

❖ Step 5: Correct for Carbon Unoxidized and Convert to CO_2 Emissions

These steps are expressed in the following equation:

$$CO_2 = \sum_{all\,fuels} \left[\left(\left(AC_{fuel} * CFactor_{fuel} * CC_{fuel} \right) * 10^{-3} - ECarbon_{fuel} \right) * COF_{fuel} * 44/12 \right]$$

Where:

AC= Apparent Consumption = production + imports – exports – international bunkers – stock change
CFactor = conversion factor for the fuel to energy units (TJ) on a net calorific value basis
CC = carbon content (tonne C/TJ (= kg C/GJ))
ECarbon = carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C)

The carbon content used for the national activity data are the default values proposed in table 1.3, Volume 2 of the 2006 IPCC Guidelines.

The absence of an official energy balance hampers the calculation of the reference approach, as data on stock changes and statistical differences is not available. Although this information is not available, the reference approach has been calculated aiming at illustrating the need to reconcile energy statistics in an official energy balance. The results of the comparison between the reference and the sectoral approach are presented in the table below.

Table 71. Differences between the sectoral and the reference approach (%).

2016	2017	2018	2019
26.5%	25.7%	16.7%	18.1%

The differences between approaches are much larger than those recommended by the IPCC (+/-5%). These differences are explained by the discrepancy between gross consumption (energy supply data) and calculated consumption (final energy consumption data), in particular due to the fact that supply statistics do not include information on stock changes.

3.6. International Bunkers

Fuel consumption for both international maritime bunkers and international aviation is collected separately from national fuel consumption by the FRCS survey. Similarly to the approach followed for national aviation emissions, the calculations for international aviation have been estimated using the Tier 2 approach using information on LTO cycles. The emissions obtained are provided hereby.

Table 72. Emissions from international aviation.

Gas	GHG emissions in Gg CO_{2eq}						
	2013	2014	2015	2016	2017	2018	2019
CO_2	451.90	527.00	458.02	529.74	424.61	520.09	621.97
CH_4	0.02	0.01	0.02	0.02	0.02	0.02	0.02
N_2O	3.80	4.45	3.86	4.46	3.57	4.37	5.23

Table 73. Emissions from international navigation.

Gas	GHG emissions in Gg CO_{2eq}						
	2013	2014	2015	2016	2017	2018	2019
CO_2	367.20	338.04	180.70	345.50	289.72	269.99	268.98
CH_4	0.97	0.89	0.48	0.91	0.76	0.71	0.71
N_2O	2.61	2.40	1.29	2.46	2.05	1.92	1.91

3.7. Planned improvements

During the inventory compilation, certain areas were identified for future improvements to ensure building greater confidence in the inventory estimate by reducing uncertainties to the extent possible. Fiji is already underway in increasing data quality and availability. Efforts should be prioritized to formalise the elaboration of an official energy balance in the country.

The following table contains the list of identified improvements for the energy sector of the inventory.

Table 74. Improvement plan for the energy sector.

Energy Sector – Fuel Combustion		
Identified fields of improvement		
There is no formal energy balance in the country. This affects the quality of the national GHG emission inventory, as the reconciliation of the different data sources has not been made, and so the uncertainty of the estimates is very high.		
Immediate Action	Proposed period of implementation	Institution responsible

1	Enhance the institutional arrangements in place for the elaboration of the energy balance of the country.	2023	Department of Energy
2	Implement a data compilation system for the elaboration of the energy balance.	2023	Department of Energy/Fiji Bureau of Statistics
Energy Sector – Fuel Combustion			
Identified fields of improvement			
Statistics on the combustion of fuelwood are not available.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Assess the possibilities to improve statistics on fuelwood combustion, specially at households, to improve the quality of the national GHG emission inventory.	2023	To be determined
2	Obtain data on fuelwood combustion and improve the estimates in category 1A4 of the inventory.	2023	To be determined
Energy Sector – Mobile Combustion			
Identified fields of improvement			
Data on the number of vehicles classified by type of fuel for the years 2011 to 2019 are available. However, information on technologies and vehicles kilometres travelled by type of vehicle are not available.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Assess the possibilities to improve transport statistics by enhancing the scope of the data and/or implementing new surveys for obtaining information.	2023	Ministry of Transport/Land Transport Authority
Energy Sector – Fugitive emissions			
Identified fields of improvement			
CO_2, CH_4, and N_2O Emissions from Category 1B. Fugitive emissions from charcoal production were not estimated due to a lack of data. During the validation workshop, national stakeholders confirmed only minor amounts are produced. This needs to be ascertained and transparently documented in future inventories. Some sources report production. See, for instance this link or this link.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Obtain data on charcoal production.	2023	CCD
Energy Sector – Transport			
Identified fields of improvement			
Off road transport statistics are not available. Furthermore, fuel combustion for other sectors (residential, commercial, institutional, agriculture, forestry, and fishing) might include the combustion of off-road. However, this is not currently ascertained.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Confirm if the current fuel combustion statistics consider the use of fuels in off-road vehicles.	2023	To be determined
2	Obtain information on off-road fuel combustion.	2025	To be determined

CHAPTER 4: IPPU SECTOR

4.1. Overview of the IPPU sector

The IPPU sector covers greenhouse gas (GHG) emissions occurring from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon.

4.1.1. Description of the IPPU sector

The IPPU sector of Fiji is very limited, with barely any industrial processes currently occurring on the islands, and mainly relates to the use of non-energy products and products as substitutes for Ozone Depleting Substances.

Mineral Industry

These are the process-related CO_2 emissions resulting from the use of carbonate raw materials in the production and use of multiple mineral industry products. The primary process resulting in the release of CO_2 is the calcination of carbonate compounds. This occurs in a variety of industries but is typically the result of small quantities of carbonate being present as an impurity in an acidification process to upgrade a non-carbonate material. Principally, the process by which calcination-related emissions are released are similar among all the categories in the mineral industry. Although CH_4 and N_2O emissions can be emitted from some mineral industries, the emissions are assumed to be negligible. Emissions in the mineral industry could occur in the following sub-categories:

- **Cement Production:** Comprises emissions from the production of clinker to finely ground hydraulic cement.
- **Lime Production:** Emissions from the lime production by heating limestone to decompose the carbonates.
- **Glass Production**: Emissions from the production of glass for commercial purposes which can be divided into four main groups, namely, containers, flat glass, fibre glass, and specialty glass.
- **Other Process Uses of Carbonates:** Emission from other consumption of carbonates such as in metallurgy, agriculture, construction, and environmental pollution control.

Within the national context of Fiji, emissions from the mineral industry do not occur in the country before 2019, with all the materials being imported. However, after 2019, limited lime production activities have commenced. Furthermore, liming is used in Fiji in sugar production to reduce soil acidity and improve plant growth. This leads to CO_2 emissions which are accounted for in category 3C2 Liming.

Chemical Industry

The chemical industry relates to emissions that result from the production of various inorganic and organic chemicals, which have been divided in the following categories in the 2006 IPPC Guidelines:

- Ammonia production
- Nitric acid production
- Adipic acid production
- Caprolactam, glyoxal, and glyoxylic production
- Carbide production
- Titanium dioxide production
- Soda ash production
- Petrochemical and carbon black production
- Fluorochemical production

Fiji reports no chemical production occurring in the country, with all the chemicals being imported.

Metal Industry

The metal industry relates to emissions occurring during the production of metals, which have been divided in the following categories in the 2006 IPPC Guidelines:

- Iron and steel, and metallurgical coke production
- Ferroalloy production
- Aluminium production
- Magnesium production
- Lead production
- Zinc production

Fiji reports no metal production occurring in the country, with all the metals being imported.

Non-Energy Products from Fuels and Solvent Use

Non-Energy Products from Fuels and Solvent Use refers to emissions from the first use of fossil fuels as a product for primary purposes other than (i) combustion for energy purposes and (ii) use as feedstock or reducing agent, which are accounted for in the chemical industry and in the metal industry categories. The products covered in this category comprise lubricants, paraffin waxes, bitumen/asphalt, and solvents. Emissions from further uses or disposal of the products after first use are estimated and reported in the waste sector when incinerated, or in the energy sector when energy recovery takes place. Emissions in non-energy products from fuels and solvent use occur in the following sub-categories:

- **Lubricant Use:** Comprises emissions from the consumption of lubricants in industrial and transportation applications.
- **Paraffin Wax Use:** Emissions from the consumption of paraffin waxes in applications such as candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, and surfactants.

- **Solvent Use:** Comprises the non-methane volatile organic compound (NMVOC) emissions from the use of solvents manufactures using fossil fuels as feedstock.

Fiji uses lubricants and grease for industrial and transportation applications, such as in engines of transport vehicles, e.g., as buses, coaches, lorries, tractors, etc. Furthermore, Fiji consumes solvents in paint for domestic applications such as wall paints or house paints, cosmetics and toiletries, household products, construction/DIY, car care products and pesticides. Fiji also contains dry cleaning facilities and use pharmaceutical products.

Electronics Industry

Electronics industries utilise fluorinated compounds (FCs) in two important steps of electronics manufacturing, namely, (i) plasma etching silicon containing materials, and (ii) cleaning chemical vapour deposition (CVD) tool chamber-walls where silicon has deposited. The electronics industry is subdivided into four sub-categories:

- Integrated Circuit of Semiconductor
- TFT Flat Panel Display
- Photovoltaics
- Heat Transfer Fluid

Emissions vary according to the gases used in manufacturing different types of electronic devices, the process, the brand of process tool used, and the implementation of emission reduction technology. Generally, the emissions from the electronics industry are estimated on the basis of the activity data from electronics and the average emission factors.

Fiji reports no electronic industry activities occurring in the country, with all these components being imported from other countries.

Product Uses as Substitutes for Ozone Depleting Substances

As CFCs, halons, carbon tetrachloride, methyl chloroform, and, ultimately, HCFCs are finally being phased out under the Montreal Protocol, hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), are serving as alternatives to ozone depleting substances (ODS). Current and expected application areas of HFCs and PFCs include:

- Refrigeration and air conditioning
- Foam blowing agents
- Fire suppression and explosion protection
- Aerosols
- Solvent cleaning
- Other applications

HFCs and PFCs are not controlled by the Montreal Protocol because they do not contribute to depletion of the stratospheric ozone layer. HFCs are chemicals which only contain hydrogen, carbon, and fluorine. Prior to the Montreal Protocol and the phase-out of various ODS, the only HFCs produced were HFC-152a and HFC-23. HFC-134a entered production in 1991 and a variety of other HFCs have since been introduced and are now being used as ODS substitutes.

HFCs and PFCs have high global warming potentials (GWPs) and, in the case of PFCs, long atmospheric residence times and have very different potencies as GHG. There is a difference between the actual emissions and the potential emissions which is caused by the fact that there is a time lag between consumption of ODS substitutes and emission which may be considerable in application areas such as closed cell foams, refrigeration, and fire extinguishing equipment. A time lag results from the fact that a chemical placed in a new product may only slowly leak out over time, often not being released until end-of-life. A household refrigerator, for example, emits little or no refrigerant through leakage during its lifetime and most of its charge is not released until its disposal, many years after production.

In Fiji HFCs and PFCs are used as substitutes for phasing out CFCs, halons, carbon tetrachloride, methyl chloroform, and, ultimately, HCFCs under the Montreal Protocol, which the country ratified in 1989. Fiji ratified the Kigali Amendment to the Montreal Protocol in June 2020, to further reduce HFC emissions. Within the Fijian Government, the Ozone Depleting Substances Unit under the Ministry of Environment is responsible for phasing out ODS.

Other Product Manufacture and Use

This includes the emissions from the manufacture and use of electrical equipment and several other products include sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), and nitrous oxide (N_2O). These GHG are often deliberately incorporated into the product to exploit one or more of the physical properties of the chemical, such as the high dielectric strength of SF_6, the stability of PFCs, and the anaesthetic effect of N_2O. These applications have a wide range of emission profiles, ranging from immediate and unavoidable release of all the chemical to largely avoidable delayed release from leak-tight products after 40 years of use. Emissions in the manufacture and use of products occur in the following sub-categories:

- **Electrical Equipment:** Sulphur hexafluoride (SF_6) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity.
- **SF_6 and PFCs from Other Product Uses:** Emissions from the production of SF_6 and PFCs emission used in military applications, in university, research, and industrial particle accelerators, in sound-proof windows, and in cosmetics and medical applications.
- **N_2O from Product Uses:** Evaporative emissions of N_2O arising from product use such as medical applications, propellant in aerosol products, oxidising agent, production of sodium azide, fuel oxidant in auto racing, and oxidising agent in blowtorches.

Fiji uses SF_6 for electrical equipment in the electricity sector, such as regulators, distributors, etc. In addition, Fiji, uses N_2O for medical use as anaesthesia throughout its primary health services spanning a network of 98 nursing stations, 84 health centres and 19 subdivisional hospitals, which require anaesthesia for their activities.

Other

This category considers other industries which have not been accounted for elsewhere in the IPPU sector.

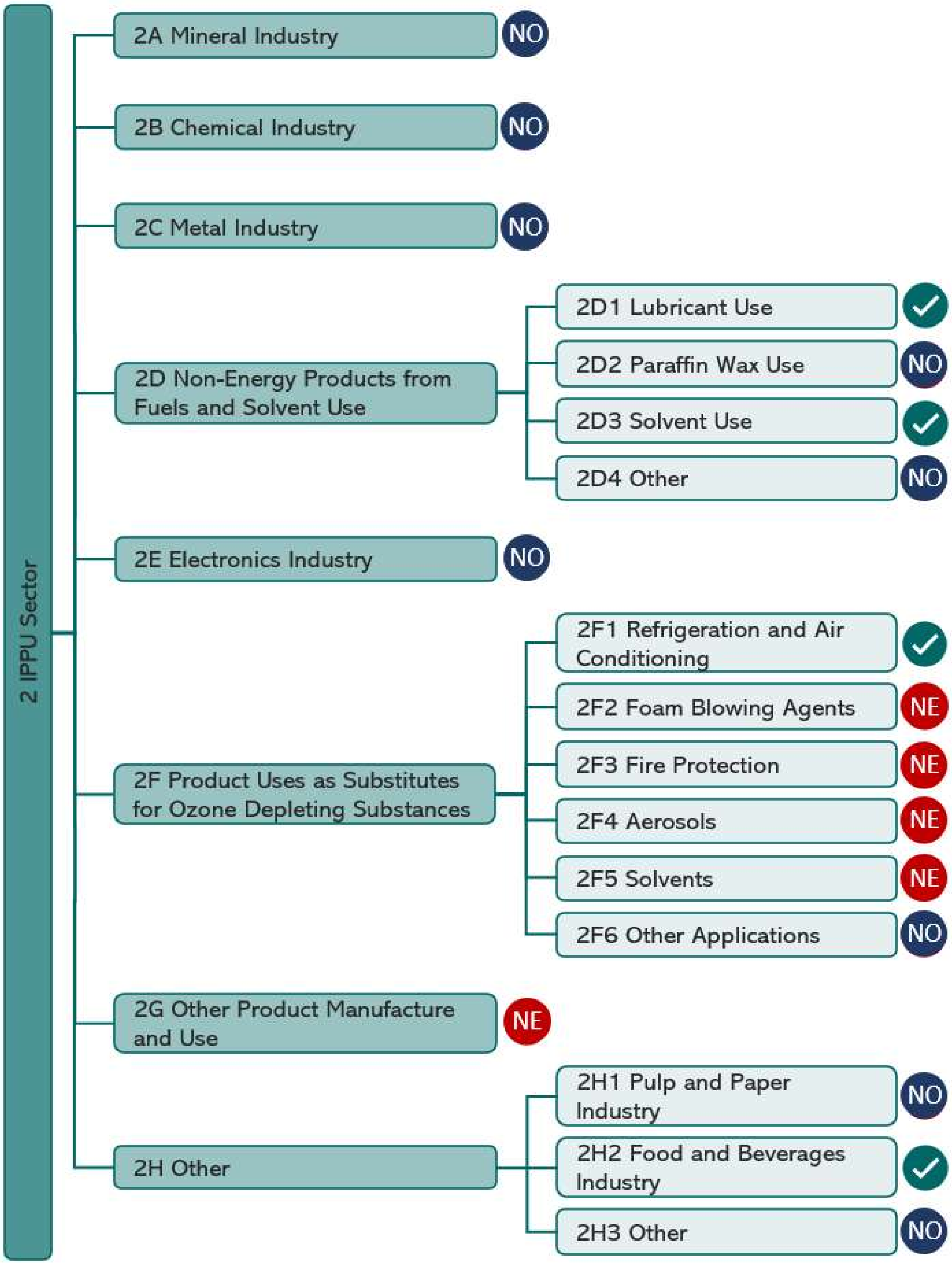
One of which is the food and beverage industry, with the following activities occurring in Fiji:

- Bread production
- Sugar production
- Production of cereals, cooking, and sweets
- Beer production
- Wine production
- Whiskey production
- Rum production
- Other spirits production
- Toasted coffee production
- Animal feed production
- Production of butter and margarine
- Meat production
- Fish production
- Eggs production

4.1.2. IPPU categories covered in the inventory

According to the 2006 IPCC Guidelines, the following categories (see Figure 36) are covered in the IPPU Sector of Fiji:

- **Category 2D: Non-Energy Products from Fuels and Solvent Use:** This category includes emissions from the first use of fossil fuels as a product for primary purposes other than combustion for energy purposes and use as feedstock or reducing agent, which are accounted for in the chemical industry and in the metal industry categories.
  - **Category 2D1: Lubricant Use:** This subcategory comprises emissions from the consumption of lubricants in industrial and transportation applications.
  - **Category 2D3: Solvent Use:** This subcategory comprises the non-methane volatile organic compound (NMVOC) emissions from the use of solvents manufactures using fossil fuels as feedstock.
    - **Category 2D3a: Domestic solvent use including fungicides:** This subcategory comprises of non-methane volatile organic compounds (NMVOCs) and certain other pollutant emissions from the domestic use of solvent-containing products.
    - **Category 2D3d: Coating applications:** This subcategory includes the use of paints within the industrial and domestic sectors.
- **Category 2F: Product Uses as Substitutes for Ozone Depleting Substances:** This category includes emissions from the hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), substitutes as alternatives to ozone depleting substances (ODS).
  - **Category 2F1: Refrigeration and air conditioning:** Includes the emissions from refrigeration and air-conditioning (RAC) systems classified in up to six sub-application domains.
- **Category 2H: Other:** This sector considers other industries which have not been accounted for elsewhere in the IPPU sector.
  - **Category 2H2: Food and Beverages Industry:** This subcategory comprises the food and beverage industry in Fiji.



NE – Not estimated; NO – Not occurring; IE – Included elsewhere

Figure 36. Categories of the IPPU sector.

Previous editions of Fiji's national GHG inventory, namely, the GHG emissions inventory of 1994 reported in Fiji's First National Communication (NC1) of 2005 according to 1996 IPCC Guidelines and the GHG emissions inventory of 2004 reported in Fiji's Second National Communication (NC2) of 2013 according to 1996 IPCC Guidelines, estimated IPPU emissions but without concrete sources of information for each of the categories. The last national GHG inventory of Fiji, namely, the GHG emissions inventory of 2006-2011 reported in Fiji's Third National Communication (NC3) according to 2006 IPCC Guidelines, did not estimate IPPU emissions as they were considered negligible. Therefore, this is the first time IPPU estimations are estimated using the 2006 IPPC Guidelines including concrete sources of information for the categories present in Fiji.

4.1.3. Summary of IPPU sector emission results

In 2019, the IPPU sector represented approximately 3.24% of national total GHG emissions of Fiji. It is the smallest sector in Fiji in terms of total GHG emission but does play an important role as it is the only source of HFCs and PFCs emissions, which have high global warming potentials (GWPs). Consequently, the IPPU sector only accounts for 0.00039% of total CO_2 emissions in 2019. The sector does not contribute to the total CH_4 or N_2O emissions of Fiji. The following figure shows the trend of the GHG emissions of the IPPU sector compared to the national total of Fiji.

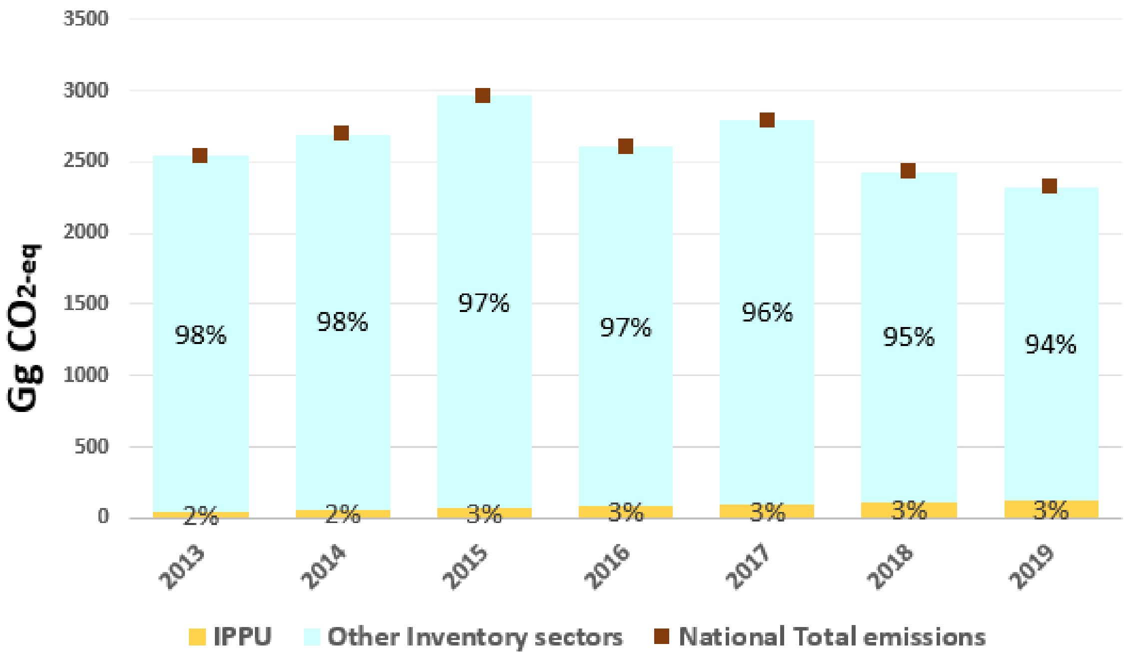


Figure 37. IPPU contribution to national total emissions (Gg CO_2-eq).

The following table and figure summarise the GHG emissions and trends of the IPPU sector by source category and by gas. The total GHG emissions from the IPPU sector were 0.13079 $MtCO_2eq$ in 2019 and 0.04988 $MtCO_2eq$ in 2013, representing an increase of 162.21% on total sectoral emissions recorded from 2013 to 2019. HFC was the most important GHG in the IPPU sector in 2019, during which HFC emissions totalled 0.13078 $MtCO_2eq$ (99.99% of total emissions in the sector), followed by CO_2 emissions with 0.00001 $MtCO_2eq$ (0.01% of total emissions in that year. Category 2F "Product Uses as substitutes for Ozone Depleting Substances" was the most important source of emissions within the IPPU sector, accounting for 99.99% of the total sectoral emissions in 2019 and constituting one of the national key categories.

Within the period 2013-2019, emissions non-energy products from fuels and solvent use (Category 2D) remained relatively constant. On the other hand, an important increasing trend can be observed for product uses as substitutes for ozone depleting substances (Category 2F), corresponding to a total increase of 162.29% between 2013 and 2019. This can be attributed to the growing population and economic development of Fiji which increases the demand for refrigeration and air-conditioning, in for example newly build offices or houses.

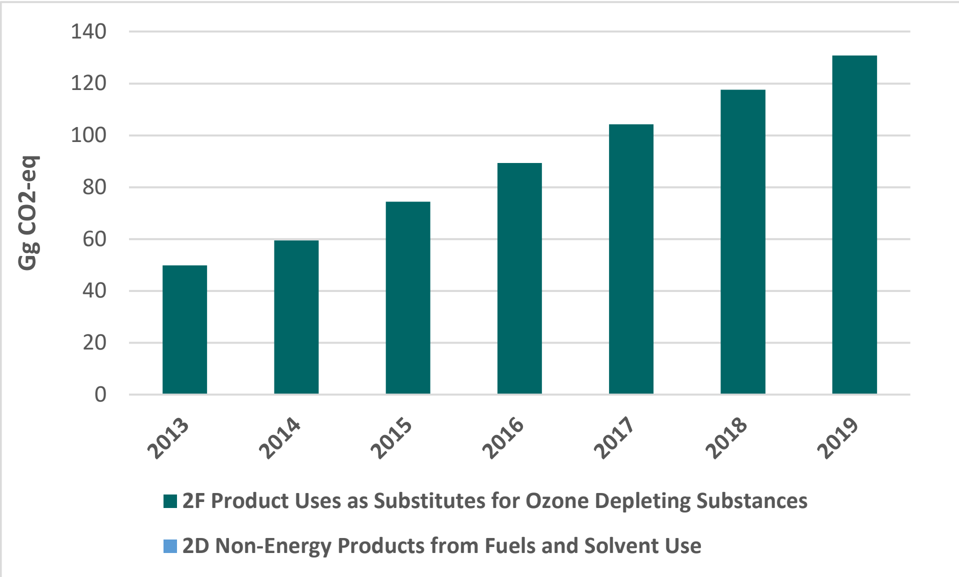


Figure 38. Total GHG emissions from the IPPU sector by category (Gg CO_2-eq).

The following table provides a summary of the GHG emissions in Gg CO_2-equivalents in the period 2013-2019 within each of the categories, and the total emissions of the IPPU sector.

Table 75. Summary of GHG emissions from the IPPU sector.

Category	Gas	GHG emissions in Gg CO_2eq						
		2013	2014	2015	2016	2017	2018	2019
2D Non-Energy Products from Fuels and Solvent Use	CO_2	0.02	0.02	0.02	0.01	0.02	0.02	0.01
	CH_4	-	-	-	-	-	-	-
	N_2O	-	-	-	-	-	-	-
	Total	0.02	0.02	0.02	0.01	0.02	0.02	0.01
2F Product Uses as Substitutes for Ozone Depleting Substances	CO_2	-	-	-	-	-	-	-
	CH_4	-	-	-	-	-	-	-
	N_2O	-	-	-	-	-	-	-
	HFC	49.86	59.48	74.42	89.33	104.29	117.62	130.78
	Total	49.86	59.48	74.42	89.33	104.29	117.62	130.78
TOTAL IPPU	CO_2	0.02	0.02	0.02	0.01	0.02	0.02	0.01

Category	Gas	GHG emissions in Gg CO_2eq						
		2013	2014	2015	2016	2017	2018	2019
Sector	CH_4	-	-	-	-	-	-	-
	N_2O	-	-	-	-	-	-	-
	HFC	49.86	59.48	74.42	89.33	104.29	117.62	130.78
	Total	49.88	59.50	74.44	89.34	104.31	117.64	130.79

4.2. Data and methodology used

The emissions estimates for the IPPU sector were prepared on the basis of country-specific activity data and default emission factors and other parameters from the 2006 IPCC Guidelines and the EMEP/CORINAIR Emission Inventory Guidebook 2019. Data collected from the Data Collection Form for the IPPU Sector, as well as other international databases and default values from the 2006 IPPC Guidelines and the EMEP/CORINAIR Emission Inventory Guidebook 2019 were consulted to compile all the necessary information for the preparation of the GHG inventory estimates for the IPPU sector in a way that best represents the sector's contribution to the total inventory and fits coherently with the national context and its temporal evolution. Through the Data Quality Assessment Report for the IPPU Sector, this data was evaluated in terms of availability, completeness, accuracy, and timeline coherency, while comparing domestic data sources against international information. From the results of such assessment report, the final data was selected to prepare the emission estimates from the IPPU Sector. To the extent possible, national statistics were prioritized in the data selection process, indicating areas of improvement for the future to increase its coverage and quality.

The following table presents the main data sources used for the preparation of emission estimates from the IPPU sector.

Table 76. Data sources for the IPPU sector.

Category	Type of data	Data source	Data providers
Cross-cutting issues in the IPPU sector	Total population of Fiji	World Development Indicators on total population Fiji	World Bank
2D Non-Energy Products from Fuels and Solvent Use – 2D1 Lubricant Use	Total lubricant consumption data	Data Collection Form for the IPPU Sector	Fiji Revenue & Customs Services
	Specific carbon content of lubricant type	Default value as per Section 5.2.2.2 of Volume 3, Chapter 2 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
	ODU factor of lubricant type	Default value as per Section 5.2.2.2 of Volume 3, Chapter 2 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
2D Non-Energy Products from Fuels and Solvent Use – 2D3a Domestic solvent use including fungicides	Data on domestic solvent use per capita	Default values as per Section 3.1.2 of Chapter 2.D.3.a from the EMEP/CORINAIR Emission Inventory Guidebook 2019	EMEP/CORINAIR Emission Inventory Guidebook 2019

Category	Type of data	Data source	Data providers
2D Non-Energy Products from Fuels and Solvent Use – 2D3d Coating Applications	Consumption of solvents and other products	Data Collection Form for the IPPU Sector	Climate Change Division, Office of the Prime Minister
	Data on pollutant per kg of applied paint	Default values as per Section 3.2.2 of Chapter 2.D.3.d from the EMEP/CORINAIR Emission Inventory Guidebook 2019	EMEP/CORINAIR Emission Inventory Guidebook 2019
2F Product Uses as Substitutes for Ozone Depleting Substances – 2F1 Refrigeration and Air Conditioning	Data on amount of HFCs, and blends imported in Fiji	Usage of HCFs in Fiji 2016-2020	Fiji Revenue & Customs Services
	HFC content of blends	Values as per Table 7.8 of Volume 3, Chapter 7 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
2H Other – 2H2 Food and Beverages Industry	Agro-food industry production data	Data Collection Form for the IPPU Sector	Fiji Bureau of Statistics
	Data on amount of pollutants by product produced	Default values as per Section 3.2.2 of Chapter 2.H.2 from the EMEP/CORINAIR Emission Inventory Guidebook 2019	EMEP/CORINAIR Emission Inventory Guidebook 2019

Emissions originating from the IPPU sector were estimated using a Tier 1 Methodology from the 2006 IPCC Guidelines and EMEP/CORINAIR Emission Inventory Guidebook 2019. A summary description of the methodologies used to estimate emissions from the IPPU sector by source categories is provided in the following tables, while a more detailed description is available in Sections 4.3 through 4.6 of this chapter.

Table 77. Methodological tiers adopted for the IPPU sector.

Category	Tier	Activity Data	Emission Factors and Other Parameters
2D Non-Energy Products from Fuels and Solvent Use	Tier 1	Country-specific data	2006 IPCC and EMEP/CORINAIR Emission Inventory Guidebook 2019 default values
2F Product Uses as Substitutes for Ozone Depleting Substances	Tier 1	Country-specific data	2006 IPCC default values
2H Other	Tier 1	Country-specific data	EMEP/CORINAIR Emission Inventory Guidebook 2019 default values

Table 78. Main Methodologies and Assumptions Adopted for the IPPU Sector.

Category	Methodology	Assumptions
2D Non-Energy Products from Fuels and Solvent Use – 2D1 Lubricant Use	Equation 5.2 of Volume 3, Chapter 5 of the 2006 IPCC Guidelines was used to apply a tier 1 approach for the estimation of CO_2 emissions from	Country-specific activity data was provided for the period 2010-2019 on fuel consumption data. It was assumed that the consumption of

Category	Methodology	Assumptions
	lubricant use, utilizing the default emission factors for the carbon content and ODU factors. Country-specific activity data was used for the consumption of lubricants.	lubes and grease was for the purpose of lubricants in engines for their lubricating properties, which should therefore be considered and reported in the IPPU sector.
2D Non-Energy Products from Fuels and Solvent Use – 2D3a Domestic solvent use including fungicides	Algorithm 3.1.1 of Chapter 2.D.3.a from the EMEP/CORINAIR Emission Inventory Guidebook 2019 was used to apply a tier 1 approach for the estimation of NMVOC emissions from domestic solvent use including fungicides, utilizing the default emission factors for the domestic solvent use per capita. International data was used for the statistics of the total population of Fiji.	The application of this approach assumes an average range of products used in the domestic sector that are representative for the domestic solvent use sector as a whole. As such, it assumes that the entire national total population uses the same quantity of domestic solvents to which a default emission factor is applied.
2D Non-Energy Products from Fuels and Solvent Use – 2D3d Coating Applications	Algorithm 3.2.1 of Chapter 2.D.3.d from the EMEP/CORINAIR Emission Inventory Guidebook 2019 was used to apply a tier 1 approach for the estimation of NMVOC emissions from coating applications, utilizing the default emission factors for the amount of pollutant per kg of applied paint. Country-specific activity data was used for the consumption of solvents and other products for domestic use.	No assumptions have been applied for this category.
2F Product Uses as Substitutes for Ozone Depleting Substances – 2F1 Refrigeration and Air Conditioning	The tier 1 approach A of Volume 3, Chapter 7 of the 2006 IPCC Guidelines was applied for the estimation of HFC emissions from refrigeration and air conditioning, utilizing the HFC content of blend from as per Table 7.8 of Volume 3, Chapter 7 from the 2006 IPCC Guidelines. Country-specific activity data was used for the amount of HFC, and blends imported in Fiji.	No assumptions have been applied for this category.
2H Other – 2H2 Food and Beverages Industry	Algorithm 3.2.1 of Chapter 2.H.2 from the EMEP/CORINAIR Emission Inventory Guidebook 2019 was used to apply a tier 1 approach for the estimation of NMVOC emissions from the food and beverages industry, utilizing the default emission factors for the amount of pollutants by product produced. Country-specific activity data was used for the agro-food industry production.	Country-level specific data was provided of the ‘production of butter and margarine’ in tonnes. Considering that the tier 1 default approach of the of Chapter 2.H.2 from the EMEP/CORINAIR Emission Inventory Guidebook 2019 is based on national production figures including, among others, ‘total production of fats <u>excluding butter</u>’, it is assumed that the country-level data on ‘production of butter and margarine’ is to be ‘total production of fats as margarine excluding butter.

4.3. Non-energy Products from Fuels and Solvent Use (2.D)

Non-Energy Products from Fuels and Solvent Use refers to emissions from the first use of fossil fuels as a product for primary purposes other than combustion for energy purposes and use as feedstock or reducing agent. It includes the subcategories Lubricant Use (2D1) and Solvent Use (2D3).

4.3.1. Lubricant Use (2D1)

The use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions to be reported in the IPPU sector.

The CO_2 emissions concerning non-energy use of lubricants are calculated according to the tier 1 methodology of the 2006 IPCC Guidelines using total lubricant consumption data, as described in the following formula.

$$CO_2 Emissions = LC \times CC_{Lubricant} \times ODU_{Lubricant} \times 44/12$$

Where:

CO_2 Emissions = CO_2 emissions from lubricants, tonne CO_2
LC = total lubricant consumption, TJ
$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= C/GJ)
$ODU_{Lubricant}$ = ODU factor, fraction
44/12 = mass ratio of CO_2/C

This tier 1 methodology multiplies the total lubricant consumption with the emission factor, which is composed of a carbon content factor multiplied by the ODU factor and the mass ratio of CO_2/C. Since CH_4 and N_2O emissions are very small in comparison to CO_2, these can be neglected for the greenhouse gas calculation within this subcategory.

The following table presents the data of consumption of lubricants in Fiji between 2013 and 2019 which are used for lubricating activities and not for combustion activities.

Table 79. Activity data used to estimate GHG emissions from lubricant use (TJ).

Data	2013	2014	2015	2016	2017	2018	2019
Lubes – Shell Rimula 15W40	0.400	0.669	0.753	0.502	0.452	0.703	0.502
Lubes – Shell Caprinus 20W40	0.707	0.707	0.640	0.167	0.836	0.772	0.470
Grease	1.108	1.377	1.393	0.669	1.288	1.475	0.972

The default carbon contents factor is 20.0 kg C/CJ, which is identical to C/TJ. Furthermore, Fiji has total consumption data with specific details on the specific quantities of lubricants used as motor oils/industrial oils and as greases and can therefore apply different default ODU factors according to the 2006 IPCC Guidelines as presented in the following table.

Table 80. Default oxidation factor for lubricant oils and grease for lubricant use.

Data	2013	2014	2015	2016	2017	2018	2019
ODU factor for lubricating oil	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ODU factor for grease	0.05	0.05	0.05	0.05	0.05	0.05	0.05

The following resulted in total CO_2eq emissions from lubricant use in Fiji as presented in the following figure.

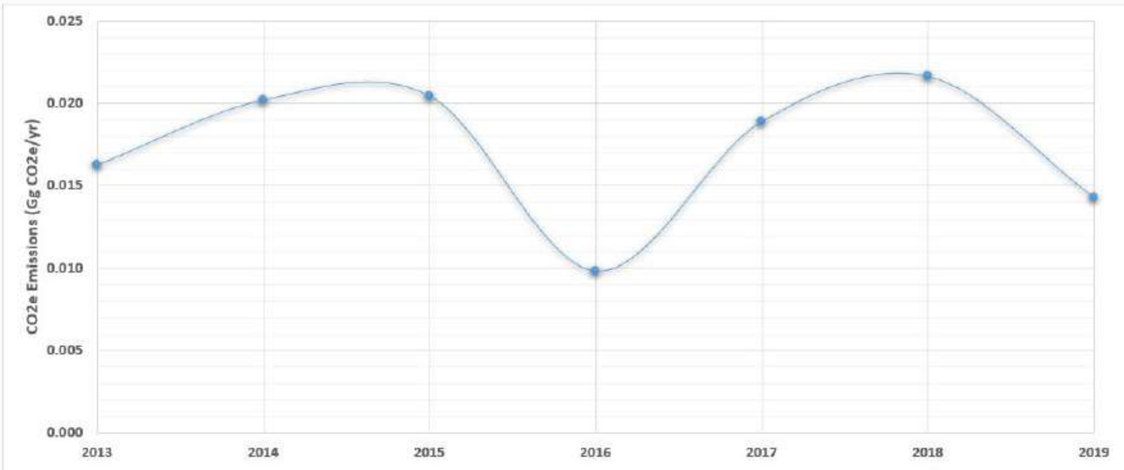


Figure 39. Total emissions from lubricant use in Fiji (Gg CO_2eq).

Emissions from this category accounted for 0.014 Gg CO_2eq in 2019 and 0.016 Gg CO_2eq in 2013 and have been fluctuating in this period with a peak of 0.022 Gg CO_2eq in 2018 and a low of 0.010 Gg CO_2eq in 2016, linked to a considerable reduction in the consumption of lubricants in that year. The following table presents an overview of the GHG emissions from lubricant use in Fiji for the period 2013-2019.

Table 81. Summary of GHG emissions from lubricant use in Fiji (Gg CO_2eq).

	2013	2014	2015	2016	2017	2018	2019
Total Gg CO_2e q	0.016	0.020	0.020	0.010	0.019	0.022	0.014

4.3.2. Solvent Use (2D3)

The methodologies for estimating the NMVOC emissions from solvent use (2.D.3) are reported in the EMEP/CORINAR Emission Inventory Guidebook. It is treated as a separate category because the nature of this source requires a slightly different approach to emissions estimation than that used for calculating other emission categories in the 2006 IPCC Guidelines. However, the same overall approach is followed, where NMVOC emissions are calculated by applying default emission factors to the total solvent activity data. It includes the subcategories Domestic Solvent Use Including Fungicides (2D3a) and Coating Applications (2D3a).

4.3.2.1. Domestic Solvent Use Including Fungicides (2D3a)

This subcategory addresses NMVOC emissions from the domestic use of solvent-containing products, often used in industry and commerce. NMVOCs are used in a large number of products sold for use by the public. These can be divided into a number of categories, with the main categories that can be distinguished in the domestic use of solvents being cosmetics and toiletries, household products, construction and DIY, car care products, and pesticides.

The NMVOC emissions for domestic solvent use are estimated using the tier 1 default approach from the EMEP/CORINAR Emission Inventory Guidebook 2019 presented in chapter "2.D.3.a Domestic solvent use including fungicides" as presented in the following formula.

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

Where:

$E_{pollutant}$ = *emission of the specified pollutant*
$AR_{production}$ = *activity rate of the coating application, national population*
$EF_{pollutant}$ = *emission factor for the pollutant, kg/capita*

This equation is applied at the national level, using annual national total figures for the population of Fiji, and assuming an average or typical range of products used in the domestic sector which are representative for the domestic solvent use sector as a whole. Emissions are therefore estimated based on the population size of a country as it is a common activity parameter which is readily available for all countries.

The following table presents the total population data of Fiji used to calculate emissions from the domestic solvent use sector between 2013 and 2019.

Table 82. Total population data used to estimate NMVOC emissions from domestic solvent use.

Data	2013	2014	2015	2016	2017	2018	2019
Total population (persons)	865 608	866 453	868 627	872 399	877 459	883 483	889 953

The tier 1 approach applies the default emission factor for NMVOC emissions from domestic solvent use, which is based on different country groups as per the EMEP/CORINAR Emission Inventory Guidebook 2019.

Table 83. Default emission factor for domestic solvent use.

Data	2013	2014	2015	2016	2017	2018	2019
kg NMVOC/capita	1.2	1.2	1.2	1.2	1.2	1.2	1.2

The application of the tier 1 approach resulted in total NMVOC emissions from domestic solvent use in Fiji as presented in the following figure.

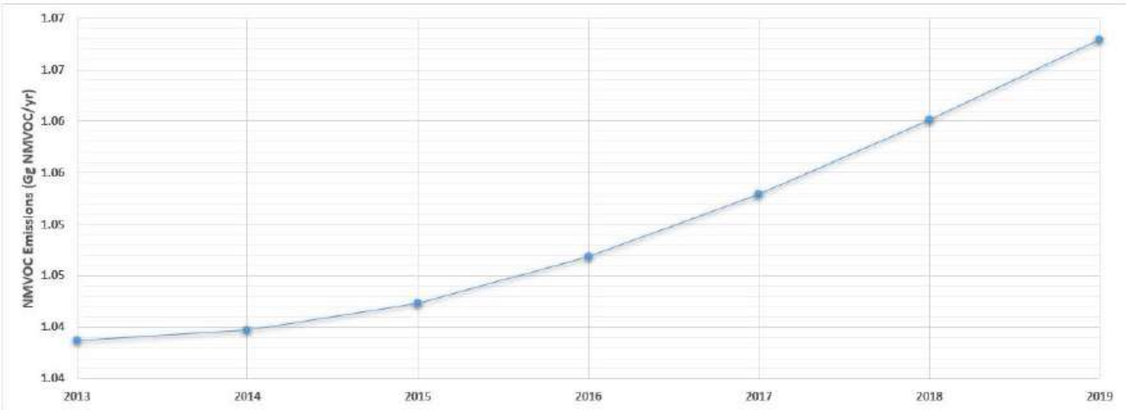


Figure 40. Total NMVOC emissions from domestic solvent use in Fiji.

Emissions from this category accounted for 1.07 Gg NMVOC in 2019 and 1.04 Gg NMVOC in 2013 and have been steadily been increasing each year. This is related to the population growth of Fiji, on which the estimations are based, and which has been increasing on a yearly basis. The following table presents an overview of the NMVOC emissions from domestic solvent use in Fiji for the period 2013-2019.

Table 84. Summary of NMVOC emissions from domestic solvent use in Fiji.

	2013	2014	2015	2016	2017	2018	2019
Total Gg NMVOC	1.039	1.040	1.042	1.047	1.053	1.060	1.068

4.3.2.2. Coating Applications (2D3d)

This subcategory addresses NMVOC emissions from the use of paints within the industrial and domestic sectors, split in decorative coating applications, industrial coating applications, and other coating applications. NMVOC emissions result from the use of organic solvents in these paints.

The NMVOC emissions for domestic solvent use are estimated using the tier 1 default approach from the EMEP/CORINAR Emission Inventory Guidebook 2019 presented in chapter "2.D.3.d Coating Applications" as presented in the following formula.

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

Where:

$E_{pollutant}$ = *emission of the specified pollutant*
$AR_{production}$ = *activity rate of the coating application, consumption of paint in tonnes*
$EF_{pollutant}$ = *emission factor for the pollutant, g/kg paint applied*

This methodology applies annual national total figures for the consumption of paint and assumes an averaged or typical technology and abatement implementation in Fiji.

The following table presents the data on the consumption of paint for domestic use in Fiji which was used to estimate the emissions from coating applications between 2013 and 2019.

Table 85. Total consumption of paint for domestic use in tonnes used to estimate NMVOC emissions from coating applications.

Data	2013	2014	2015	2016	2017	2018	2019
Paint for domestic use	4 423	4 104	4 707	5 498	5 990	9 184	5 287

The EMEP/CORINAR Emission Inventory Guidebook 2019 provides default emission factors according to the source category it relates to, namely, decorative coating application, industrial coating application, or other coating application. The activity data of coating applications in Fiji relates to decorative coating application, and the corresponding default emission factor was applied.

Table 86. Default emission factor for decorative coating application.

Data	2013	2014	2015	2016	2017	2018	2019
g/kg paint applied	150	150	150	150	150	150	150

The application of the tier 1 approach resulted in total NMVOC emissions coating applications in Fiji as presented in the following figure.

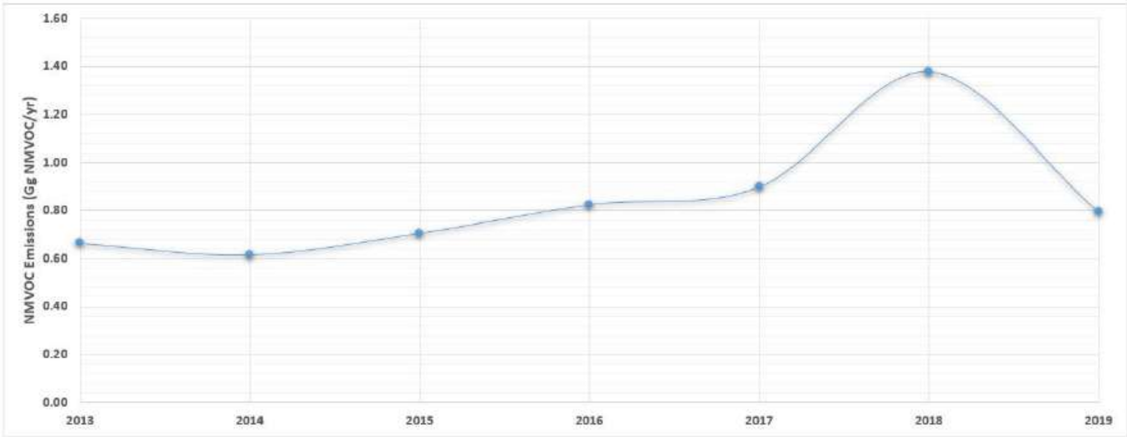


Figure 41. Total NMVOC emissions from coating applications in Fiji.

Emissions from this category accounted for 0.79 Gg NMVOC in 2019 and 0.66 Gg NMVOC in 2013, which highlights a growth of 19.7% in the given period. Overall, there is gradual increase in the consumption of paint for domestic use, with 2018 being an outlier when almost twice as much paint for domestic use was consumed. The following table presents an overview of the NMVOC emissions from coating applications in Fiji for the period 2013-2019.

Table 87. Summary of NMVOC emissions from coating applications in Fiji.

	2013	2014	2015	2016	2017	2018	2019
Total Gg NMVOC	0.66	0.62	0.71	0.82	0.90	1.38	0.79

4.4. Product Uses as Substitutes for ODS (2.F)

Hydrofluorocarbons (HFCs) and perfluorocarbons (PFC) serve as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. Until the inception of the Kigali Amendment to the Montreal Protocol, HFCs and PFCs were not controlled by the Montreal Protocol because they did not contribute to depletion of the stratospheric ozone layer. However, HFCs and PFCs have high global warming potentials and are potent greenhouse gases. HFCs are used in a variety of equipment including refrigeration and air conditioning equipment, foam, fire extinguishers, and aerosols.

In Fiji, HFCs and PFCs are used as substitutes for phasing out CFCs, halons, carbon tetrachloride, methyl chloroform, and, ultimately, HCFCs under the Montreal Protocol, which the country ratified in 1989. Fiji ratified the Kigali Amendment to the Montreal Protocol in June 2020, to further reduce HFC emissions. The country uses HFCs for air conditioning and refrigeration, which are considered in subcategory Refrigeration and Air Conditioning (2F1).

4.4.1. Refrigeration and Air Conditioning (2F1)

This subcategory addresses emissions from refrigeration and air conditioning systems which can be classified in up to six sub-application domains or categories, namely, (i) domestic refrigeration, (ii) commercial refrigeration including different types of equipment, from vending machines to centralised refrigeration systems in supermarkets, (iii) industrial processes including chillers, cold storage, and industrial heat pumps used in the food, petrochemical and other industries, (iv) transport refrigeration including equipment and systems used in refrigerated trucks, containers, reefers, and wagons, (v) stationary air conditioning including air-to-air systems, heat pumps, and chillers for building and residential applications, (vi) mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains.

Both Tier 1 and Tier 2 methods result in estimates of actual emissions rather than potential emissions. This reflects the fact that they take into account the time lag between consumption of ODS substitutes and emission because the chemical placed in a new product may only slowly leak out over time, often not being released until end-of-life.

The HFC emissions from this category are estimated according to the 2006 IPCC Guidelines tier 1a/b approach, and using the following assumptions which are based on the tier 1 defaults:

- The year of introduction is 2005
- The growth rate in new equipment sales is 0%
- Emission factor from installed base is 15%
- % of gas destroyed at end of life is 15%

The following table presents the data of the amount of blends imported in Fiji in the years 2016 to 2019 which was used to calculate emissions from refrigeration and air conditioning in Fiji.

Table 88. Activity data used to estimate HFC emissions from refrigeration and air conditioning in metric tonnes.

Data	2016	2017	2018	2019
HFC-134A	11.40	49.50	19.54	16.34
R-32	0.41	0.04	0.12	0.18
R-404A	28.80	7.00	33.30	26.30
R-407C	3.20	3.56	1.61	2.55
R-507C	0.11	3.45	5.52	9.28
R-410A	20.44	14.74	33.13	30.51

The blends in the activity data are subsequently converted to the relevant HFC content according to the composition percentages as per the 2006 IPCC Guidelines. The composition of R-507C is not provided in the 2006 IPCC Guidelines and has been converted using other internationally recognised sources. The following table presents the composition of the blends used in Fiji.

Table 89. Composition of blends used in refrigeration and air conditioning in Fiji.

Data	HFC-32	HFC-125	HFC-143a	HFC-134a
HFC-134A	-	-	-	100%
R-32	100%	-	-	-
R-404A	-	44%	52%	4%
R-407C	23%	25%	-	52%
R-507C	-	50%	50%	-
R-410A	50%	50%	-	-

These compositions are applied to the activity data of Fiji, which results in the total amount of HFC in operation as presented in the following table.

Table 90. HFC in operation from refrigeration and air conditioning in metric tonnes.

Data	2016	2017	2018	2019
HFC-32	11.37	8.23	17.06	16.02
HFC-125	23.75	13.07	34.38	32.10
HFC-143a	15.03	5.37	20.08	18.32
HFC-134a	14.22	51.63	21.71	18.72

The application of the tier 1 approach resulted in total CO_2e emissions from the use of HFCs in refrigeration and air conditioning in Fiji as presented in the following figure.

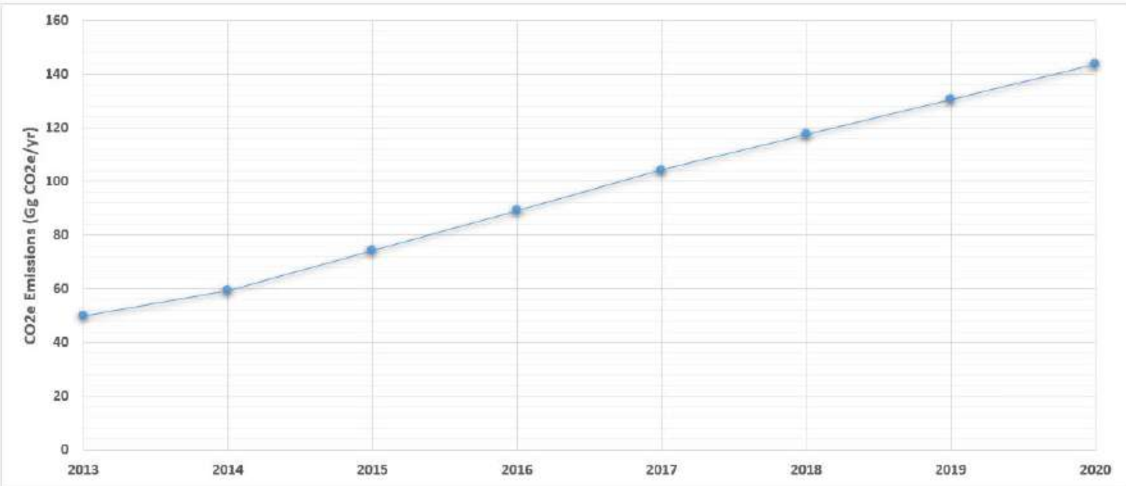


Figure 42. Total emissions from refrigeration and air conditioning in Fiji (Gg CO_2eq).

Emissions from this category account for 130.78 Gg CO_2eq in 2019 and 49.86 Gg CO_2eq in 2013, showing a considerable increase of 162.29%. This rapid increase in HFC emissions from refrigeration and air conditioning in Fiji can be linked to the economic growth of the country, resulting in higher demand for refrigeration and air conditioning for buildings. The following table presents an overview of the GHG emissions from HFC use in refrigeration and air conditioning in Fiji for the period 2013-2019.

Table 91. Summary of GHG emissions from HFC use in refrigeration and air conditioning in Fiji (Gg CO_2eq).

	2013	2014	2015	2016	2017	2018	2019
Total Gg CO_2eq	49.86	59.48	74.42	89.33	104.29	117.62	130.78

4.5. Other (2.H)

This category considers other industries which have not been accounted for elsewhere in the IPPU sector. As there is no specific section on these categories provided in the 2006 IPCC Guidelines, the parameters have been based on the EMEP/CORINAR Emission Inventory Guidebook. Fiji has production activities in the agro-food industry, which are considered in subcategory Food and Beverages Industry (2H2).

4.5.1. Food and Beverages Industry (2H2)

This subcategory addresses NMVOC emissions from food and beverages manufacturing. Emissions from food manufacturing include all processes in the food production chain, which occur after the slaughtering of animals and the harvesting of crops. NMVOCs emissions occur primarily from the following sources: the cooking of meat fish and poultry, releasing mainly fats and oils and their degradation products; the processing of sugar beet and cane and the subsequent refining of sugar; the processing of fats and oils to produce margarine and solid cooking fat; the baking of bread, cakes biscuits and breakfast cereals; the processing of meat and vegetable by-products to produce animal feeds; and the roasting of coffee beans

Emissions from drink manufacturing include the production of alcoholic beverages, especially wine, beer, and spirits.

The NMVOC emissions are estimated using the tier 1 default approach from the EMEP/CORINAR Emission Inventory Guidebook 2019 presented in chapter “2.H.2 Food and Beverages Industry” as presented in the following formula.

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

Where:

$E_{pollutant}$ = emission of the specified pollutant
$AR_{production}$ = activity rate of the annual national total food and drink production, tonnes
$EF_{pollutant}$ = emission factor for the process, kg/tonne product produced

This method multiplies annual national total food and drink production data with default emission factors. The following table presents the agro-food industry production data used to calculate emissions from the food and beverages industry in Fiji between 2013 and 2019.

Table 92. Activity data used to estimate NMVOC emissions from the food and beverages industry.

Data	Unit	2013	2014	2015	2016	2017	2018	2019
Sugar production	Tonnes	232	264	283	222	233	161	176
Beer production	Mega litres	24	24	25	27	28	29	20
Animal feed production	Tonnes	59 361	55 084	54 731	50 531	48 593	48 773	48 524
Production of butter and margarine	Tonnes	1 890	1 211	1 406	1 473	1 333	1 431	1 308
Fish production	Tonnes	6 719	7 113	5 541	3 944	69 280	7 841	9 711
Eggs production	Tonnes	12 841	13 583	14 623	14 135	14 712	11 871	10 769

The Tier 1 approach needs emission factors for all relevant pollutants. These emission factors integrate all subprocesses within the industry from the feed of raw material to the final shipment of the products off site. There is no data available on the different techniques that occur in the food and drink manufacturing in Fiji. The default emission factor as per the EMEP/CORINAR Emission Inventory Guidebook 2019 has therefore been applied for the estimation of NMVOC emissions from the food and beverages industry.

Table 93. Default emission factor for the food and beverages industry.

Data	2013	2014	2015	2016	2017	2018	2019
Kg NMVOC/Mg (tonne) product produced	2	2	2	2	2	2	2

The application of the tier 1 approach resulted in total NMVOC emissions from the food and beverages industry in Fiji as presented in the following figure.

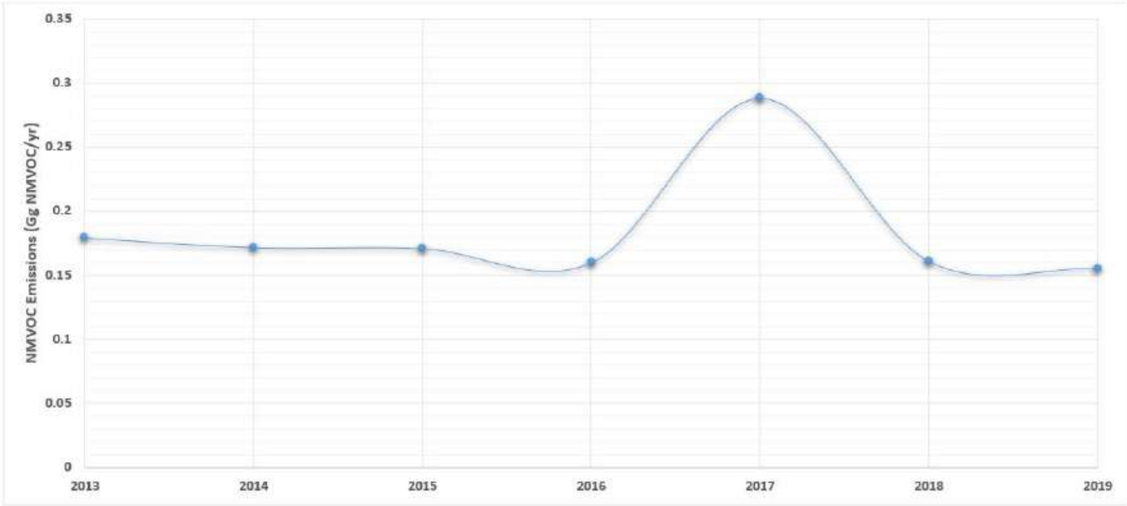


Figure 43. Total NMVOC emissions from the food and beverages industry.

Emissions from this category account for 0.16 Gg NMVOC in 2019 and 0.18 Gg NMVOC in 2013, showing a slight decrease of 11.11%. A considerable spike can be observed in 2017, when emissions reached 0.29 Gg NMVOC. Throughout the other years in the period 2013-2019 NMVOC emissions remained relatively constant. The spike in NMVOC emissions in 2017 can be accounted for by the increase of fish production in that year, which increased to 69,290 tonnes. The following table presents an overview of the NMVOC emissions from the food and beverages industry in Fiji for the period 2013-2019.

Table 94. Summary of NMVOC emissions from food and beverages industry in Fiji.

	2013	2014	2015	2016	2017	2018	2019
Total Gg NMVOC	0.18	0.17	0.17	0.16	0.29	0.16	0.16

4.6. Planned improvements

During the inventory compilation, certain areas were identified for future improvements to ensure building greater confidence in the inventory estimate by reducing uncertainties to the extent possible.

The following table contains the list of identified planned improvement activities and the necessary next steps that must be taken.

Table 95. Improvement plan for the IPPU sector.

IPPU Sector – Mineral Industry		
Identify fields of improvement		
Estimation of process-related CO_2 emissions from lime production by heating limestone to decompose the carbonates. During the validation workshop, national stakeholders confirmed that after 2019 limited production activities have commenced.		
Immediate Action	Proposed period of implementation	Institution responsible

1	Obtain data on lime production.	2023	FRCS
IPPU Sector – Non-Energy Products from Fuels and Solvent Use			
Identified fields of improvement			
CO_2 emissions could be improved by the enhancement of data on lubricant, grease and solvents consumption.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Confirm that the reported lubricant consumption data is used for lubrication purposes. In addition, the data on grease consumption should be revised to provide a more precise figure.	2023	FRCS
Identified fields of improvement			
NMVOC emissions estimations could be improved by the collection of data on solvents used by sector.			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	The Tier 1 approach for the calculation of NMVOC emissions from domestic solvent use should only be used if no alternative information is available. It is therefore recommended to collect data on the amounts of solvents used in each subsector.	2024	FRCS
IPPU Sector – Product Uses as Substitutes for Ozone Depleting Substances			
Identified fields of improvement			
Estimations could be improved by collecting more reliable data by sub-application.			
Immediate Action		Proposed period of implementation	Institution responsible
1	Collect further information from the FRCS on the import data of refrigeration and air conditioning units to clarify descriptions such as “other” and “parts” to properly allocate them to the sub-application categories in the 2006 IPCC Guidelines.	2023	FRCS/Department of Environment
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Collect data on the number of fire extinguishers, aerosols, foam blowing units and F-gases contained being imported in Fiji for the entire timeseries to ensure complete and accurate estimations.	2024	Ozone Unit/Department of Environment
2	It is recommended to undertake a survey on refrigeration and air conditioning equipment (number of air conditioning and refrigeration equipment introduced into the market, the refrigerant used and their initial refrigerant charge) to the main users (commercial sector such as supermarkets and hotels) which will allow to estimate F-gas emissions from this category using a tier 2.	2024	Ozone Unit/Department of Environment
IPPU Sector – Other Product Manufacture and Use			
Identified fields of improvement			
SF_6 emissions from the use of electrical equipment and N_2O emissions from its medical use as anaesthesia are not estimated.			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	To estimate the GHG emissions of category 2G1b, it is recommended to collect data on SF_6 consumption in the electrical sector from stakeholders of the national electricity sector (i.e., regulator, distributors, etc.).	2024	FRCS/Energy Fiji Limited
2	To estimate N_2O emissions from category 2G3. N_2O from Product Use, it is recommended to collect the data on supply from companies that commercialize N_2O for medical use as anaesthesia or data on consumption from the hospitals.	2024	FRCS
IPPU Sector – Other			
Identified fields of improvement			
More detailed breakdown of production by subsector of the food and drink industry would allow to elaborate better NMVOCs emission estimates.			
Medium-term Actions		Proposed period of implementation	Institution responsible

1	Provide more detailed data on food and beverage production by type of product to estimate NMVOCs (for instance, make a distinction between margarine and butter production).	2024	FRCS

CHAPTER 5: AFOLU SECTOR

5.1. Overview of the AFOLU Sector

The 2006 IPCC Guidelines. Volume 4 addresses the GHG emissions/removals for the AFOLU sector: Agriculture, Forestry and Other Land Uses. GHG emissions/removals are divided in the different subsectors, emissions/removals sources/sinks, categories, and subcategories.

The three subsectors under the AFOLU sector and their codes are as follows: Livestock (3A), Land (3B) and Aggregated and Non-CO_2 Emissions Sources (3C). GHG emissions/removals within this sector were estimated following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and relevant methodological publications, most importantly the Forest Reference Level.

The following figure displays the categories available under the IPCC framework for the AFOLU sector and highlights the ones estimated, not estimated, and not occurring in Fiji.

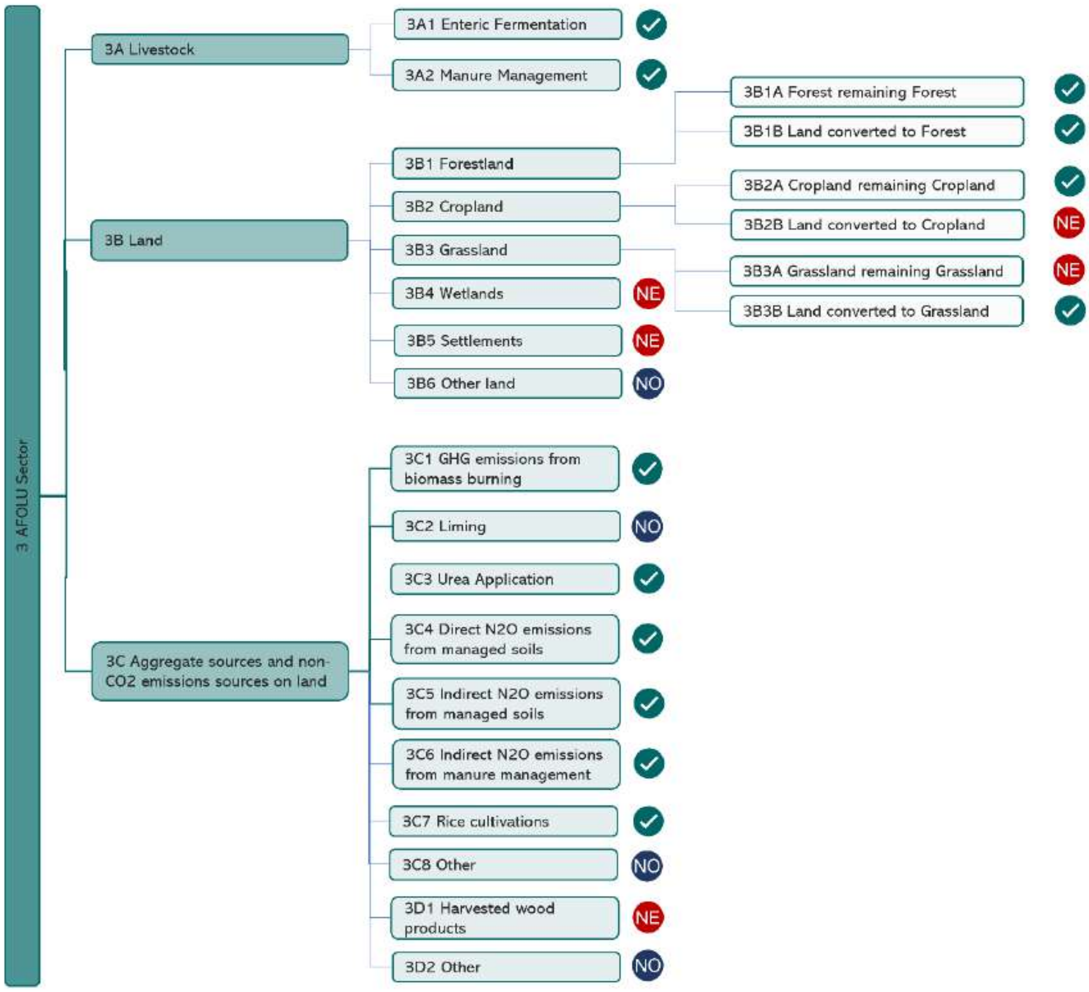


Figure 44. Estimated Categories for Fiji under the AFOLU sector.

5.1.1 Description of the AFOLU sector

Agriculture

Agriculture is a productive sector representing a substantial part of the national economy of Fiji as it contributes FJ$200 million in expert earnings annually (TNC). The sector can be broken down in several sectors: crops, sugarcane, livestock, fisheries and forestry. The main crops for subsistence are taro, cassava and sweet potato while ginger, taro, kava, cassava, and wild harvest turmeric are the main crops for exports. Cassava remains the top agriculture commodity in Fiji, due to its domestic consumption. Due to major declines in productivity, shortages of labour and increase in production costs, the sugarcane industry has suffered large declines, even though it used to be the country's backbone. It remains an important sector, contributing to 5% of the national GDP and employing 200,000 people.

In 2015, the agricultural GDP reached $542 million for a production of 295,537 million tons (both crop and livestock). This represents 8.1% of the national GDP. The growth of the sector has been driven by increases in the production of yagona, pineapple and coconut. The trade balance remains unequal in Fiji: while $198 million worth of products were exported, more than $514 million were imported. The exports represent 18% of the National Domestic Export Value. The growth of agricultural exports has mainly been driven by the expansion of market scoping particularly to the US market.

The Ministry of Agriculture is guided in its daily operations by several legislations and regulations. These include:

- Agricultural Land & Tenant Act
- Banana Export and Marketing Act
- Coconut Industry Development Authority Act 1998
- Dairis Act
- Fruits Export and Marketing Act
- Land Conservation and Improvement Act

The Ministry has established the Crop Extension Services in 2015 through which 14 programs supported the implementation of activities enhancing food and income security, export promotion and poverty alleviation in Fiji. These Programs form part of wider national development plans, which include the National Green Growth Framework and the 5-Year and 20-Year National Development Plan.

Furthermore, **the Fiji 2020 Agriculture Sector Policy Agenda** clearly states that the development objective of the sector is to build a sustainable community. The strategies focus on using conservation and environmentally sound agriculture technologies and practices. Through the best use of land and water resources, this will prepare the sector for the future impacts of climate change. Current agricultural projects encourage sustainable land management, agroforestry landscape approach, organic farming, and backyard gardening. The regulation of fertiliser usage, land degradation neutrality and livestock management will strengthen the incentives to shift to more resilient production systems. Development on climate-resilient local crops is also underway to cater for food security for the growing population.

The consequences of climate change continue to threaten the sector which is of primordial importance for subsistence, domestic consumption, economic activity, and poverty alleviation. The TNC provides estimations of the disaster effects per sector. For agriculture, the total disaster effects reach 836.3 FJ$ million, split in 241.8 FJ$ million from physical damage and 594.5 FJ$ million from economic losses. The expected increase in the frequency and intensity of extreme events, most importantly tropical cyclones, floods, droughts, and landslides, will exacerbate these effects. Taken together, the costs of recovery and reconstruction reach 161.4 FJ$ million, which is by far the highest for all the production sectors. The introduction of conventional farming to meet commercial production needs has reduced the resilience of the sector, traditional crops and production systems being less susceptible to climate variability.

Forestry

Concerning the Forestry and Other Land Uses (FOLU), in Fiji the sector is largely dominated by Forestry: the national forests cover an area of about 1.16 million hectares, representing 60% of the total land area. Native forests, including the mangroves, cover 53% of the land while plantation forests cover the remaining 7%. Around 50,000 ha are stocked with mangroves.

The native forests are predominantly split between mangroves, dry forests (which are endangered), lowland, upland and cloud forests. The data quality available for the first Forest Reference Level & GHG Inventory calculations only allowed differentiation of forest below and above the 600 meters altitude. Therefore, these two categories are referred to lowland and upland rainforests in this report, with mangrove forests disregarded. With this sector technology fast evolving, improved forest differentiation between the various forest types in Fiji is planned as soon as possible for future BUR calculations. The Forest Reference Level, based on an accuracy assessment, has established that stable lowland forest cover 670,300 ha while stable upland forest cover 229,098 ha. Given ongoing dynamics of deforestation and afforestation/reforestation, the annual spatial extents are highly variable.

With regards to plantations, they are split into hardwood plantations and softwood plantations. Hardwood plantations are managed by Fiji Hardwood Corporation Limited (FHCL), whose lease area was estimated as 58,997 ha by the FAO Global Forest Resources Assessment of 2015. Softwood plantations are managed by Fiji Pine Limited (FPL) whose lease was estimated to be 72,663 ha in 2010. The main species produced by FHCL is mahogany, while the FPL produces pines.

The forest sector is an integral part of the economy: logging from natural (indigenous) forests and forest plantations contribute on average 1.2% of the GDP and 4.1% of export earnings. Over 90% of the exported timber products come from exotic plantation (pine and mahogany) species. In 2016, FJD 31.8 million worth of wood chips or particles and FJD 25.7 million worth of mahogany were exported.

Forests also constitute an important source of subsistence for rural populations, as a source of goods such as fuel wood, food products, medicine, and construction material. Commercial harvesting in natural forests has been largely replaced by timber extraction from plantations in order to preserve natural forests and the ecosystem services associated, such as improving the quality of water resources, improving agricultural land, contributing to biodiversity protection and climate change mitigation, and reducing vulnerability to natural disasters, particularly floods.

In terms of the policy and regulatory framework, activities in the forestry sector depend directly on land ownership conditions and their regulation in the relevant laws and regulations. More than 80% of land in Fiji is native land, which would be governed by the Native Land Trust Board, according to the iTaukei Land Trust Act. The **National Forest Inventory** provides the framework for the sustainable management of Fiji's forest resources (NAR January 2010). It can be considered as the formalisation of the Fiji National Forest Policy 2007 and the National Forest Program.

In addition, Fiji has adapted the national **REDD+ programme**, through which the protection of natural and exotic forests is actively promoted. The Fiji REDD-Plus Policy is embedded in the National Forest Policy and has the overall objective of "enhancing the national forest carbon balance. Based on carbon-trading mechanisms, the REDD+ program provides financial compensations to countries supporting national reforestation and preventing deforestation and forest degradation. This programme has a two-strategy approach that ensures the protection of forests while concurrently generating financial benefits. The commitment of the Government for Reducing Emissions from Deforestation and Forest Degradation (REDD+) and for the emissions reduction program is indicated in the National REDD+ Policy, the NCCP, the National Forest Policy, and the recently launched Green Growth Framework for Fiji.

Additionally, the **5-Year and 20-Year Development Plan** of Fiji sets sustainable forestry as a priority through various programs led by the Ministry of Forestry. The policy aims to strengthen sustainable forest management through long-term leasing mechanism(s) to support forest conservation, concessions, and plantation leases. It further encourages the private sector participation in plantation development, through a Plantation Policy and the formulation of a National Land Use Plan. The Plan also includes as policy objective the growth of timber product development, through the support of Micro, Small and Medium Enterprises (MSME).

Yet, the use of forests for economic gains and the current lack of financial competitiveness with agricultural land have led to a poorer performance of the sector through increased degradation and conversions to other land uses. A forest area change assessment shows an error-adjusted annual forest loss of around 2500 ha for the period 2006 - 2016. Approximately 1,800 ha were newly forested every year during the same period.[14]

The recently published Emission Reduction Program suggests that the drivers of deforestation and forest degradation vary between the main islands of Fiji[15]. The main drivers identified include forest conversion to agriculture, traditional use of forests, poorly planned infrastructure development, conventional logging, natural disasters, invasive species, and mining.

The various types of national forests experience specific drivers of degradation. First, mangrove forests are highly sensitive when they are cut for fuelwood, or when the land is reclaimed for residential land. Second, forest plantations are sensitive to forest fires caused by droughts and heat spells, or windbreaks caused by cyclones. Lastly, the sensitivity of the natural forest ecosystems is also relatively high, mainly due to population growth and the demand for greater agricultural production for food security.

<u>**Previous assessments of AFOLU emissions**</u>

The agriculture sector contributes to national emissions mainly through the CH_4 emissions from ruminant animals and agriculture and N_2O emissions from managed soils and agriculture.

The **Third National Communication** (TNC) estimates the emissions of methane to 15 Gg/year during the reporting year, and 0.5 Gg/year for nitrous oxide. Once converted to CO_2 equivalent, the CH_4 represents 74% of the total GHG emissions from the agriculture sector, the N_2O representing the last percentages given the negligible CO_2 emissions from urea fertilisation. While the methane emissions have been relatively stable between 2006 to 2011, the nitrous oxide emissions have increased by 10% in 2008 due to large amount of N fertiliser application. Table 95 shows the total emissions from the agriculture sector from 2006 to 2011.

[14] SPC, 2018, *Forest change Detection Fiji*. Suava: SPC

[15] Ministry of Forestry, 2019, *Emission Reductions Program Document (ER-PD)*, Republic of Fiji

Table 96. Emissions from the agriculture sector (source: Third National Communication).

Gas	Unit	2006	2007	2008	2009	2010	2011
CH_4	Gg CH_4	14.78	14.81	14.73	14.6	14.6	14.48
	Gg CO_2eq	413.84	414.68	412.44	408.8	408.8	405.44
N_2O	Gg N_2O	0.55	0.55	0.58	0.54	0.53	0.55
	Gg CO_2eq	145.75	145.75	153.7	143.1	140.45	145.75
CO_2	Gg CO_2	0.091	0.092	0.126	0.19	0.091	0.03
Total	Gg CO_2eq	560	561	566	552	549	551

Second, forestry is by far the most important contributors of emissions in Fiji in the AFOLU sector. Forests have the capacity to both emit and absorb CO_2, as tree growth increases the carbon storage of forests. Afforestation of non-forested areas is particularly suitable for sequestering additional quantities of CO_2 and thus increasing the sink function of the forestry sector.

The **Third National Communication (TNC)** produced by Fiji provided estimates of the total estimated CO_2 emissions from the forestry sector in Fiji from 2006 to 2011. The average CO_2 emissions from Forestry were 380 Gg CO_2, ranging from -250 Gg CO_2 in 2009 to 760 Gg CO_2 in 2010. Such variation exposed the changes in logging volumes for the plantation forests. These emissions represent 15% of Fiji's GHG emissions, ranking Forestry as the second key category after land transport, which accounts for 35% of the total emissions.

In 2019, the first **Forest Reference Level (FRL)** assessment of Fiji's forest was conducted. The FRL covered a reference period of 11 years, from 2006 to 2016. It covered upland and lowland natural forests, as well as softwood and hardwood plantation areas. It includes the carbon pools of above-ground biomass and below ground biomass; and greenhouse gases of CO_2, and CH_4 and N_2O. The accounting area included 90% of Fiji's land mass and approximately 94% of Fiji's forest area.

The activity data generated for the reference period of 2006-2016 was used to estimate the net forest reference level for the Emission Reduction Program. The Emission Reduction Payment Agreement (ERPA) was signed in January 2021. Several technical corrections were brought to the FRL as a result of improvements to quality assurance/quality control procedures relating to the generation of the activity data for deforestation and reforestation and Softwood plantations, as well as the inclusion of new data and methods for estimating Forest Degradation across all natural forests in Fiji.

The contributions of REDD+ activities – deforestation, forest degradation and enhancement of forest carbon stocks to the average annual FRL are presented in the table below:

Table 97. Annual emissions and removals from Fiji's forest calculated by the ER Monitoring Report (ER-MR) (2022).

Forest Reference Emissions Level	Emission / Removal (tCO_2e yr-1)
Deforestation	394,121
Forest Degradation	498,028
Enhancement of Carbon Stocks	590,560
Net FRL	1,482,709

While afforestation and reforestation were not significant for the reporting period of the Second National Communication; the results of the FRL illustrates that they are important components under the REDD+ program and must be reflected in future inventory works.

5.1.2. Summary of AFOLU net emission results

In 2019, the AFOLU was responsible for 34.32% of the total national GHG emissions of Fiji. The Agriculture and FOLU Sectors represented approximately 13.14% and 21.18% respectively. The contribution of the AFOLU sector to the national totals has increased from 20.50% in 2013 to 34.32% to 2019, due to a significant increase in removals in those 6 years.

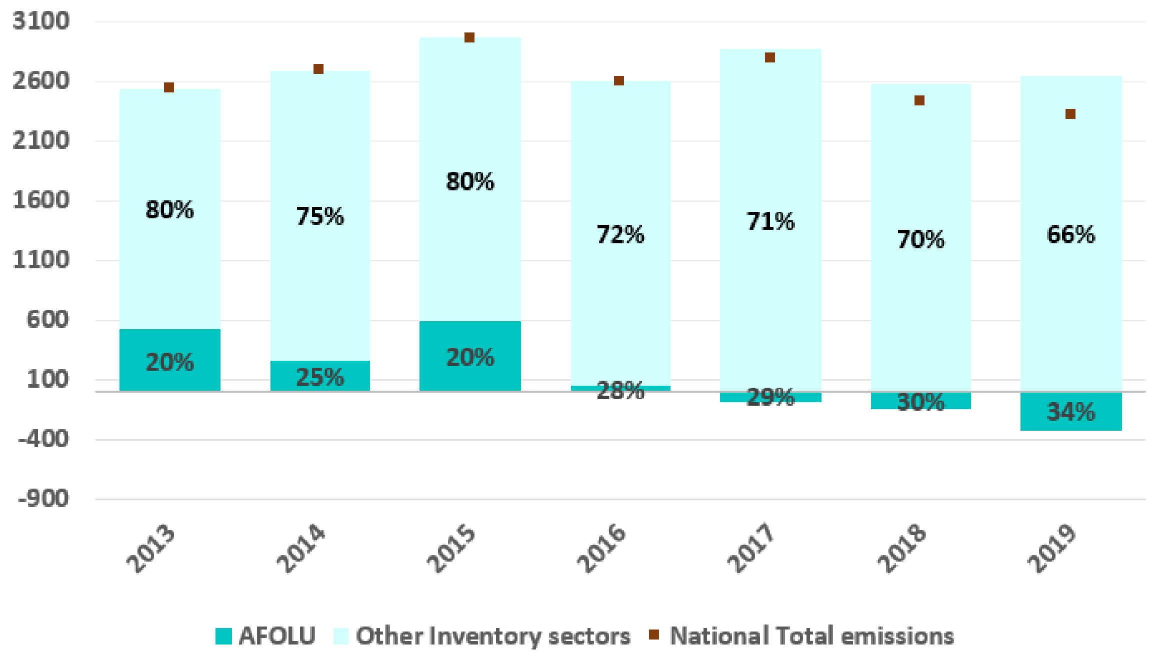


Figure 45. AFOLU Contribution to Total Emissions (Gg CO_{2-eq}).

Being the second major source of GHG emissions, following the Energy Sector, the AFOLU Sector is an important source of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions. The following figures and table summarise the GHG emissions and trends of the AFOLU Sector by source category and by gas. The total GHG emissions from the Agriculture sector were 499.20 Gg CO_2-eq in 2013 and 529.99 Gg CO_2-eq in 2019, illustrating the stability of the total emissions from agriculture recorded from 2013 to 2019. The total GHG emissions from the FOLU sector were 21.15 Gg CO_2-eq in 2013 and -854.68 Gg CO_2-eq in 2019, due to a constant increase in the carbon removals from forests and the reduced rates of annual deforestation between 2016 and 2019.

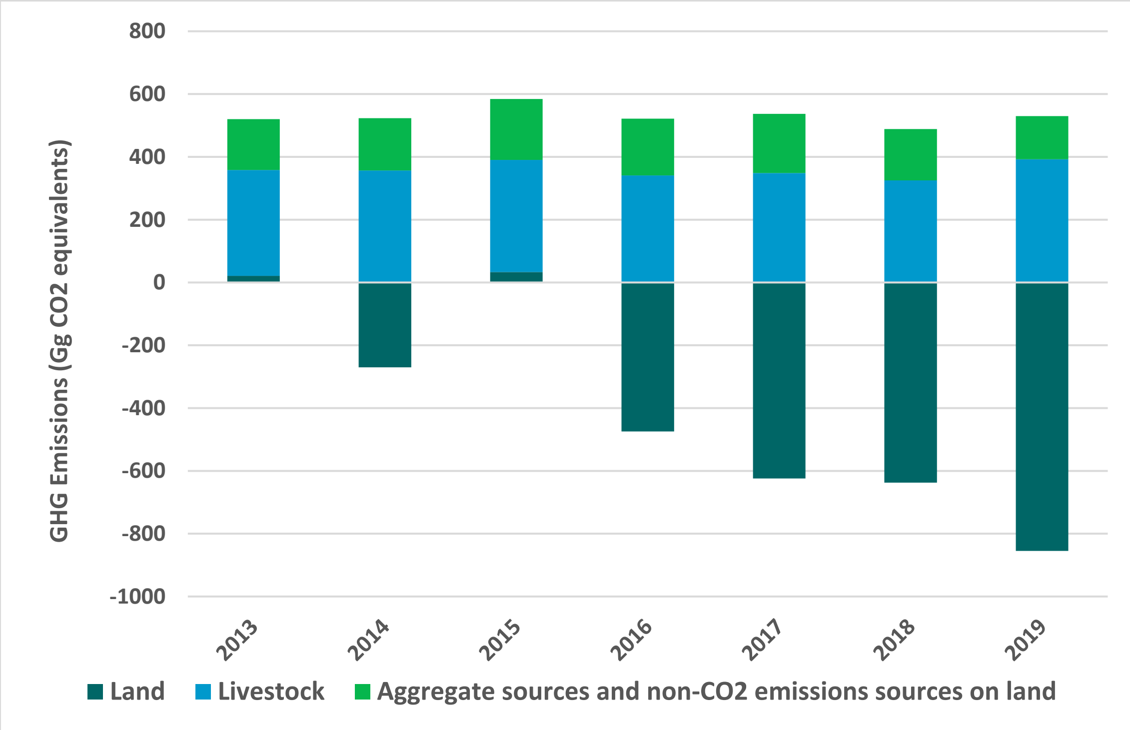


Figure 46. Total GHG Emissions from the AFOLU Sector by Category (Gg CO_2-eq).

The category 3B1a 'Forest Remaining Forest', corresponding to CO_2 removals of forests, was the most important source within the AFOLU Sector, and the second category by size of the inventory. In 2019, estimates of CO_2 removals presented in this GHG inventory contributed as high as -504.47 Gg CO_2-eq, representing 21.7% of the total national emissions.

Within the time period 2013-2019, emissions from livestock (Category 3A) and aggregate sources of and non-CO_2 emission sources on land (Category 3C) have been relatively stable. On the other hand, the emissions from land (Category 3B) have become removals, due to the progressively increasing quantity of carbon stored in forest remaining forests and land converted to forest.

Carbon dioxide (CO_2) was the most important GHG in the AFOLU sector in 2019, whereby net CO_2 was estimated at -854.29 Gg CO_2-eq (61.73 % of the total sectoral emissions[16]), followed by methane (CH_4) with a value of 416.97 Gg CO_2-eq (30.13% of the total emissions). The inventory period covers the years from 2013 to 2019. The results for the AFOLU net emissions demonstrate a significant shift from emissions to removals in these years. The increase is due to the availability, from 2006 onwards, of data from the Forest Reference Level (2006-2016) for deforestation as well as afforestation/reforestation. Since no activity data is available for these activities prior to 2006 (see methodology section for details on data sources), their respective emissions are not estimated in the AFOLU inventory.

[16] Please note the contribution by gas is calculated using emission data in absolute terms.

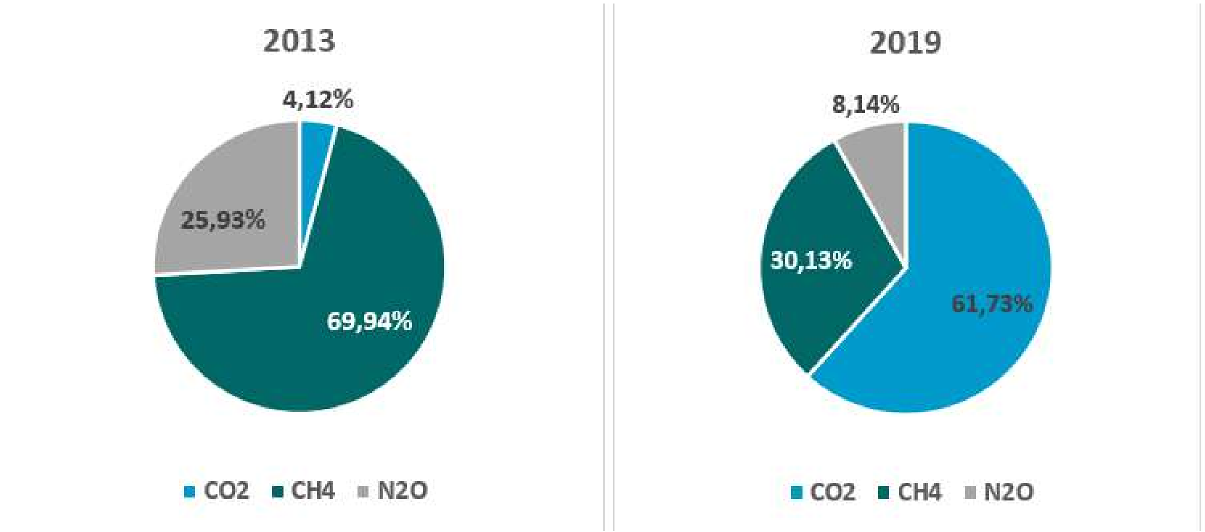


Figure 47. Total GHG Emissions from the AFOLU Sector by Gas (%).

Table 98. Summary of GHG Emissions from the AFOLU Sector.

Category	Gas	GHG emissions in Gg CO_{2eq}						
		2013	2014	2015	2016	2017	2018	2019
3A Livestock	CO_2	-	-	-	-	-	-	-
	CH_4	336.85	356.73	356.82	340.53	348.28	324.89	392.15
	N_2O	0.17506	0.17196	0.16886	0.16576	0.16266	0.15957	0.15647
	Total	337.02	356.90	356.99	340.70	348.44	325.05	392.30
3B Land	CO_2	21.15	-270.10	33.57	-474.64	-623.94	-637.19	-854.68
	CH_4	-	-	-	-	-	-	-
	N_2O	-	-	-	-	-	-	-
	Total	21.15	-270.10	33.57	-474.64	-623.94	-637.19	-854.68
3C Aggregate sources and non-CO_2 emissions sources on land	CO_2	0.32	0.40	0.24	0.29	0.71	0.36	0.39
	CH_4	27.10	34.95	43.64	40.46	42.42	31.82	24.82
	N_2O	134.75	130.78	149.73	140.09	145.44	131.24	112.47
	Total	162.18	166.13	193.60	180.84	188.57	163.42	137.68
TOTAL AFOLU Sector	CO_2	21.46	-269.70	33.81	-474.35	-623.23	-636.82	-854.29
	CH_4	363.95	391.68	400.46	380.99	390.70	356.71	416.97
	N_2O	134.93	130.95	149.89	140.26	145.60	131.40	112.63
	Total	520.35	252.94	584.16	46.89	-86.93	-148.72	-324.69

5.2. Data and Methodology

5.2.1. Data sources and providers

The data used in this inventory comes from a variety of sources from relevant national and international institutions. The datasets had different formats and had varying publishing periods.

Some of the datasets were readily available online, while others were made available to the consultancy team through special requests. In such case, these datasets were provided by the Ministry of Forestry and the Ministry of Agriculture of Fiji.

The consultancy team also benefited from data shared through the GHGMI which collected relevant livestock data from the Ministry of Agriculture through the implementation of an ICAT project dedicated to GHG inventory for agriculture emissions.

Table 98 provides an overview of the data, data sources and data providers.

Table 99. Data sources and providers for the calculations of AFOLU emissions.

Category		Data type	Data Source	Data Providers
All categories of AFOLU		Agricultural data (file name: GHG_Data_Agriculture_Final Combined.xlsx)	Collected by the data provider	Ministry of Agriculture
		2009 Fiji National Agriculture Census	Ministry of Agriculture	
		2020 Fiji National Agriculture Census	Ministry of Agriculture	
3A1	Enteric Fermentation	Livestock characterization used in the TNC of Fiji for estimating the GHG emissions from Enteric Fermentation.	TNC	
		Livestock population (number of heads)	Agriculture Census 2009 & 2020	Ministry of Agriculture
3A2 & 3C6	Manure Management & Indirect N_2O Emissions from Manure Management	Livestock characterization used in the TNC of Fiji for estimating the direct N_2O emissions from the manure management.	TNC	
		Livestock population (number of heads)	Agriculture Census 2009 & 2020	Ministry of Agriculture
3B1A	Forestland Remaining Forestland	Land representation per forest type (2006-2016) Biomass stocks ($tC.ha^{-1}$) per forest type	Technical Corrected Forest Reference Level (ER-MR, 2022)	
		Area planted, logged and stocked for hardwood and softwood plantations	Technical Corrected Forest Reference Level (ER-MR, 2022)	
		The volume of industrial round-wood production per year (2006-2016)	Technical Corrected Forest Reference Level (ER-MR, 2022)	
		Areas affected by fires that led to forest degradation	Technical Corrected Forest Reference Level (ER-MR, 2022)	

Category		Data type	Data Source	Data Providers
3B1B	Land Converted to Forestland	Area forested in lowland and upland forest (2006-2016)	Technical Corrected Forest Reference Level (ER-MR, 2022)	Ministry of Forestry
3B2A	Cropland Remaining Cropland	Area of sugarcane burnt	Unknown source	Ministry of Agriculture
		Mass available for combustion for sugarcane	IPCC 2006 Guidelines	IPCC
3B3B	Forestland converted to Grassland	Area deforested in lowland and upland forest (2006-2016)	Technical Corrected Forest Reference Level (ER-MR, 2022)	Ministry of Forestry
		Biomass stocks ($tC.ha^{-1}$) for grassland	Technical Corrected Forest Reference Level (ER-MR, 2022)	
3C1	Biomass burning	Area burnt of sugarcane	Source unknown	
		Area burnt of softwood plantation	Technical Corrected Forest Reference Level (ER-MR, 2022)	Ministry of Forestry
3C3	Urea application	Urea application data used in the TNC of Fiji for estimating the GHG emissions from urea application	TNC	
3C4 & 3C5	Direct and indirect N_2O emissions from managed soils	Livestock characterization used in the TNC of Fiji for estimating the direct N_2O emissions from managed soils in 2006.	TNC	
		Livestock characterization used in the TNC of Fiji for estimating the indirect N_2O emissions from managed soils.	TNC	
		Complete time series of synthetic fertilizers from FAO	FAO	Internet search by consultancy team
3C7	Rice cultivation	Annual harvested area of rice cultivations in Fiji from 1994 to 2018.	FAO	Internet search by the consultancy team
		2017 review of the development of the rice industry in Fiji	FAO	Internet search by the consultancy team
		Harvested area for irrigated, rainfed/dry, and upland areas from 2018 to 2020	Ministry of Agriculture	Provided through partners (GHGMI)

5.2.2. Methods for Livestock (3A)

Livestock is associated with the emissions of nitrous oxide (N_2O) and methane (CH_4). The type of animal husbandry system and the management practice influence the levels of emissions. The livestock emissions are mainly associated with Enteric fermentation (3.A.1) and Manure management (3.A.2). The factors that influence emissions associated with enteric fermentation include, but not limited to animal feed (quantity and quality) and digestive processes (e.g. ruminant, non-ruminant, animal weight, excretion rate). Emissions from manure management estimates depends on the various livestock management systems (pasture/range/paddock, dry lot, liquid/slurry etc.) and the rate of utilisation.

The main data inputs for estimating N_2O and CH_4 emissions are animal type, population (head), average weight, age and excretion rate and the type of management of the animal manure. In Fiji, enteric fermentation and manure management from domestic animals such as dairy cattle, non-dairy cattle, goats, horses, mules, sheep, breeding swine and market swine are the main sources of emissions in livestock considered in the inventory.

A summary description of methods used to estimate emissions from the Category 3A in Table 99.

Table 100. Main Methodologies Adopted for the category 3A.

Category	Methodology
3A1 Enteric fermentation	The emissions from enteric fermentation are estimated using the tier 1 methodology from the 2006 IPCC Guidelines. Specifically, the equations 10.19 and 10.20 were used along with the default emission factors for Oceania and developing countries in tables 10.10 and 10.11 annex 10. A1 in Vol. 4 Chapter. 10 The activity data used consisted of official census values for 1991, 1999, 2009 and 2020 as well as official data for 2011-2020 from the Ministry of Agriculture for cattle and swine. The livestock population was used rather than the livestock annual average population. The trend between 2006 and a previous year was derived from the FAO data and applied to the 2006 Census values. All the variation previous to 2006 is therefore determined by the FAO data, not national data.
3A2 Manure management	The emissions from manure management are estimated using the tier 1 methodology from the 2006 IPCC Guidelines. The activity data used consisted of official census values for 1991, 1999, 2009 and 2020 as well as official data for 2011-2020 from the Ministry of Agriculture for cattle and swine. For CH_4 emissions, the equation 10.22 was used along with the default emission factors for Oceania and developing with a warm climate in tables 10.14 and 10.15 For direct N_2O emissions, the equation 10.25 was used along with the default emission factors provided in table 10.21. The values for N excretion were obtained thanks to equation 10.30, and the values of TAM and Nrate were obtained from the 2019 IPCC Refinement [2] for Oceania in table 10A.5 and IPCC 2006 guidelines [1] for Oceania in tables from 10.19, respectively. The values for the animal waste managed system fraction were obtained from the

Category	Methodology
	2019 IPCC Refinement (2) for Oceania in table 10.A6, 10.A7, 10.A8 and 10A.9

5.2.3. Methods for Land (3B)

The methods deployed for calculating the emissions for the Category Land differ from the IPCC 2006 Guidelines. Indeed, they incorporate methodological specificities of the Forest Reference Level, such as modified equations, country-specific emission factors and a REDD+ specific land stratification that had to be adjusted to the IPCC requirements. For this category, we therefore provide a more detailed description of the methodologies used for the purpose of reproducibility in the future GHG inventories.

5.2.3.1. Categorization & Land stratification for Land (3B)

The Forestry and Other Land Uses category, designated as 'Land 3B' in the IPCC Guidelines, deals with the emissions and removals from changes in the carbon stocks in each of the six main land use types: Forestland (3.B1), Cropland (3.B2), Grassland (3.B3), Wetland (3.B4), Settlement (3.B5) and Other Lands (3.B6). These sub-categories correspond to the first level of stratification of the IPCC. Within each land uses, the changes of carbon stock are assessed for each of the 3 main carbon pools at the interface between the terrestrial biosphere and the atmosphere: biomass (both above-ground and below-ground), dead organic matter (dead wood and litter) and soil (both mineral and organic).

The fluxes of carbon, nitrogen and phosphorus between these pools are driven by land use specific processes which are influenced by anthropogenic activities. Examples of such processes are changes in forest stocks through timber harvest, changes in soils from land use management, fertilization of mineral soils, biomass burning, flooding of organic soils, or reforestation. In addition to land use specific drivers, the conversions between land use representations can also lead to CO_2 emissions/removals. For example, the conversion of primitive forests for agricultural crops can cause CO_2 emissions by decreasing the carbon stored in the above-ground biomass.

Therefore, the IPCC methodology sub-divides each land uses into two categories. The first one is land remaining the same over a given period. The second is land that has been converted to another land use over a given timeframe. The IPCC default assumption for the time required for a converted land to shift to a new land category is 20 years. For example, if cropland is converted to forests, it will take 20 years for the carbon fluxes to reach the new forest carbon balance after the changes in its biochemical processes.

The country-specific dataset used for the FOLU sector was obtained from the Emission Reduction Monitoring Report (2022) which includes a Technical Corrected National Forest Reference Level (FRL). The original FRL was published in 2019 by the World Forestry and the University of Hamburg. The Technically Corrected FRL of the ER-MR was to a large extent the main data source, and there are differences between the land categorization of the FRL as opposed to the IPCC methodology. These differences are exposed in the Table 100 below. The adopted approach related to the FRL in this report uses the activity data and emission factors provided by the FRL while re-organizing the land stratification according to the IPCC 2006 Guidelines.

Table 101. Relationship between Land GHG inventory and REDD+ FRL.

Item	IPCC Land (Category 3B)	REDD+ FRL
Land use stratification	Forestland	Forests
	Cropland, Grassland, Wetland, Settlement and Other lands	Non-Forests
Land cover change categories	Land Converted to Forestland	Afforestation/reforestation
	Forests converted to Land	Deforestation
	Forestland Remaining Forestland	Degradation, sustainable management, conservation of carbon stocks, enhancement of carbon stocks

The estimation of emissions from the FOLU Sector depended on the appropriate adaptation of the methods prescribed in the IPCC 2006 Guidelines based on the available best information for the sector which came from the Forest Reference Level (FRL).

Concerning the **land stratification**, the FRL does not differentiate between land uses apart from Forest: all other land uses are considered 'Non-Forests'. For land conversions, it is assumed that the land use after deforestation and before afforestation/reforestation are Grasslands (see the improvement plan for suggestion to overcome this assumption).

In terms of the IPCC land use categories, the FRL stratification is therefore equivalent to a set of 4 sub-categories: 'Forestland Remaining Forestland' (3B1A), 'GrassLand Converted to Forestland' (3B1B), 'Forestland converted to Grassland' (3B2B), and 'Grassland Remaining Grassland' (3B3A).

Given the provided activity data on burnt sugarcane areas and the cultivation of woody perennial crops in Fiji, it was decided to include the land use category Cropland in the inventory.

The rational for this decision was to be able to account for the CO_2 and non-CO_2 emissions from biomass burning in cropland and the cultivation of woody perennial crops. It was assumed that burnt sugarcane plantations remained sugarcane after the residues were burnt. The category 'Cropland Remaining Cropland' (CC) was added to the land stratification.

In the absence of data related to land that is not forest nor cropland, which is categorized according to the rational above as 'Grassland Remaining Grassland', no estimations were calculated for this category.

The final set of categories for which the emissions and absorptions were calculated is therefore the following:

- **Forestland Remaining Forestland (3B1A)**
- **Land Converted to Forestland (3B1B)**
- **Cropland Remaining Cropland (3B2A)**
- **Forestland converted to Grassland (3B3B)**

5.2.3.2. Forestland Remaining Forestland (3B1A)

5.2.3.2.1 Biomass gains

The Forest Reference Level represented the principal source of activity data for the FOLU categories, apart for Cropland remining Cropland. For the category Forestland Remaining Forestland, the FRL provided data from 2006 to 2016 for the following variables: logged area for softwood plantations, hardwood plantations and natural forests, planted and stocked area for both plantation types, and finally for natural forests degraded from closed to open canopy.

In addition, the ER-MR included activity data for the year 2019 which was used for the following variables: planted hardwood and softwood plantations, logged natural forests, and all the variables used for estimating biomass losses (volume harvested in natural forests and plantations, softwood area burned, and area of natural forests degraded from closed to open canopies).

The first task was the create consistent time series for the years before 2006 and following 2016. To do so, other sources of data provided were used. However, in certain cases, the data present in the tables of the FRL did not match with data provided in the other files.

In this case, for the years 2006 to 2016, the FRL data was systematically preferred to other sources of data for this period, and the ER-MR data for the year 2019 systematically preferred to other sources of data for this year. This decision was based on the rational that these are the most complete and updated sources of information on land use and forestry currently available in Fiji.

This applies to the difference between area planted in softwood plantations in the FRL and in the provided file from the Fiji Pine Limited: the FRL itself notes that this is erroneous data (page 47).

Where the data not coming from the FRL was deemed of good quality for the years outside of the Reference period of the FRL (2006 to 2016) and the year 2019, the data was used as input for the period 1994 – 2005 and 2017 – 2018. Once the selection of the data sources and the compilation of the available data was done for the entire inventory period 1994 – 2019, interpolation and extrapolation techniques were used in order to fill the years for which data was missing. Table 101 illustrates the main data sources and methodologies for filling data gaps for the entire period.

Table 102. Approach for data selection per forest type and management regime for biomass gains.

Forest type	Natural forest	Hardwood plantation	Softwood plantation
Selection of data sources	The data from the FRL does not match with the data provided in the HAR document for the years 2006-2016 and for 2019. The FRL Data was used for these years and the HAR data for the years before 2006 and 2017-2018.	The data from the FRL matched the data from the FHCL Data for BUR for the years 2006 to 2016. The two sources have been used	The data from the FRL does not match with the data provided by the FPL's Data Biennial Report. The data from the document 'Fiji Pine area 2016' didn't match with any of them and was limited to 2010-2015: this data source was not used. The FRL data was used for the years 2006 – 2016 and the FPL data before 2006 and after 2016

Forest type	Natural forest	Hardwood plantation	Softwood plantation
Logged area	The FRL data was used for 2006 - 2016 and 2019 and the HAR data was used for years before 2006 and 2017 – 2018. For missing data, the HAR data provided no values of logged area for the years 1994, 1995 and 1997. Interpolation was used to estimate the value for the year 1997 based on the values of 1996 and 1998. For the values of 1994 and 1995, the average of the values of1996 and 1997 was taken	The FRL and FHCL data was used for the whole inventory period	The FRL data was used for 2006 to 2016 and the FPL data was used for previous and following years
Planted area		The FRL and FHCL data was used for the whole inventory period	The FRL data was used for 2006 to 2016 and the FPL data was used for previous and following years
Stocked area		It was assessed that the data provided by FHCL was of too low quality to be used, since it indicates a stocking area of 0 hectares for years 1999, 2000 and 2003. For missing data, the average value of stocking area calculated from the FRL values was used for the years outside the FRL reference period 2006-2016	The FRL data was used for 2006 to 2016. The average of the value for the Reference Period was used for the years 1994 to 2015 and data from the FPL was used for the years 2017 to 2019.

While the ER-MR (2022) has brought several technical corrections to the original FRL, these corrections are entirely dedicated to improvements and additions to activity data. The methodologies themselves remained the same and are described in detail in the original FRL document (2019). In the following sections, the references to equations used for the estimations thus refer to equations presented in the original FRL document (2019).

- ✓ **Methodology for natural forests**
  - o The carbon gains in logged natural forest were estimated thanks to the equation 2.15 of the FRL document.
    $\Delta Cfdl, g, t = \delta t \times MAICfdl \times Afdl, t$
  - o Given the change to an inventory period from 1994 to 2019, the term δt was modified as follows
    $$\delta t = 2019 - t + 0.5$$
  - o The FRL equation provides the total amount of carbon absorbed in logged areas from the natural forest on the logging year. However, carbon growth occurs every year for a given number of years. Therefore, the total value estimated was used to distribute the carbon gains per hectare logged each year throughout the years of growth since plantation and until logging.

- From the carbon gains, the CO_2 removals were estimated by multiplying the carbon gains by the default conversion factor 44/12 based on equation 2.16 of the FRL.

✓ **Methodology for hardwood plantations**

- The calculations in the Forest Reference Level account for a reference period of 2006 to 2016. Given the inventory period of 1994 – 2019, the removals from hardwood plantation growth had to be recalculated. It was decided to reproduce the methodologies applied in the FRL but for the new inventory period.
- Adapting the section 2.4.2.2.2 from the FRL to the new inventory period it results those three sources of removals need to be considered for Hardwood plantations:
  - **Source 1.** Removals from plantation compartments that were planted before 1994 and were not harvested until the end of the inventory period.
  - **Source 2.** Removals from plantation compartments that were planted before 1994 and were harvested during the inventory period
  - **Source 3.** Removals from plantation compartments that were planted during the inventory period. As the cutting cycle for Hardwood Plantations exceed the length of the inventory period (37 years for Mahogany trees with an inventory period of 26 years), none of the compartments that were planted during the Reference Period were harvested before 2019.

1. **Methodology source 1**: Following equation 2.41 of the FRL, the area of stocking in 1993 needs to be known in order to estimate removals from plantation compartments that were neither planted nor harvested during the inventory period. The area stocked at the end of 1993 were computed with equation 2.41 adapted to the new inventory year:

$$Ahw,s,1993 = \ Ahw,s,1999 + \sum_{t=1994}^{1998} Ahw,lg,t - \sum_{t=1994}^{1998} Ahw,pl,t$$

   - The area stocked neither planted nor harvested between 1994 and 2019 was calculated from equation 2.42 of the FRL adapted to the new inventory period as follows:

$$Ahw,gr = Ahw,s,1993 - \sum_{T} Ahw,lg,t$$

   - Finally, the annual increase in biomass carbon stock from stocked hardwood was calculated thanks to equation 2.43 from the FRL with MAIChw = 4.14 t ha-1 yr-1.

$$\Delta CG_{hw_{gr}} = Ahw,gr * MAIChw$$

2. **Methodology Source 2**: to calculate the removals from hardwood plantation growth for planted area, the methodology of the FRL was replicated but adapted to the new inventory period. The equation 2.40 was used, where the term δt was modified as follows:

   δt = 2019 − t + 0.5 yrs (Equation 2.40) ;

Equation 2.40 provides the total amount of carbon absorbed by trees planted in a given year until they reach maturity. The total value was used to distribute the carbon gains per hectare planted in a given year throughout the years of growth until maturity.

3. **Methodology Source 3:** to calculate the removals from hardwood plantation growth for logged area, the methodology of the FRL was replicated but adapted to the new inventory period. The equation 2.43 was used, where the term $\delta' t$ was modified as follows:

   $\delta' t = t - 2019 + 25.5$ yrs (Equation 2.43)

   Equation 2.43 provides the total amount of carbon absorbed in logged areas from the plantation year to the logging year. The total value was used to distribute the carbon gains per hectare logged in a given year throughout the years of growth since plantation and until logging.

   The total carbon gains from hardwood plantations were calculated using equation 2.45 and the CO_2 removals using equation 2.46 of the Forest Reference Level for the inventory period of 1994 – 2019

✓ **Methodology for softwood plantations**
- Like for hardwood plantations, the methodology of the FRL was replicated but adapting to the new inventory period of 1994 to 2019.
- In the FRL, the removals from softwood plantations came from 3 sources:
  - **Source 1**: Carbon gains on areas planted
  - **Source 2:** Carbon gains on compartments planted before 1994 and not harvested until the end of the inventory year
  - **Source 3:** Carbon gains on compartments planted before 1994 and harvested in year t
- However, the cutting cycle of softwood plantations is 20 years. Therefore, it is shorter than the inventory time period of 26 years. This implies that the 2nd source of carbon gains cannot theoretically exist since what has been planted before 1994 will necessarily have been harvested during the inventory period.
- Consequently, only the sources 1 and 3 have been calculated for the softwood plantations

1. **Methodology for Source 1:** for the carbon gains on areas planted, it is required to adapt the δt in the equation 2.53 as follows:
   - For the years 1994 to 1999, δt is assumed to reach a maximum of 20 years. The assumption is that after 20 years, the planted compartment will reach maturity and stop growing or will be logged. The equation 2.53 therefore becomes:

$$\Delta CSW,G,t = 20 \times ASW,PL,t \times MAIC\text{sw}$$

   - For the years 2000 to 2019, the term δt was modified as follows:

     $\delta t = 2019 - t + 0.5$ yrs (Equation 2.53) ;
   - Equation 2.53 provides the total carbon gains from planted trees and assigns the value to the year of plantation. The annual increase in carbon gains was calculated by distributing the carbon gains of tree planted in year t throughout the inventory period. The maximum number of years of growth is a constant of 20 years.

2. **Methodology for Source 3**: for the carbon gains on areas logged, it is required to adapt the $\delta't$ in the equation 2.58 as follows:
   - For the years 2014 to 2019, $\delta't$ is assumed to reach a maximum of 20 years. The assumption is that 20 years after plantation, the compartment have stopped growing until the logging. The equation therefore becomes:

     $$\Delta CSW,\text{grh} = 20 \times ASW,\text{LG},t \times MAIC\text{sw}$$

   - For the years 1994 to 2013, the term $\delta't$ was modified as follows:
     $\delta't$ = t – 2019 + 25.5 (Equation 2.58)
   - Equation 2.58 provides the total carbon gains from logged areas and assigns the value to the year of logging. The annual increase in carbon gains was calculated by distributing the carbon gains in logged areas in year t throughout the growing years preceding the logging. The maximum number of years of growth is a constant of 20 years.

3. **Methodology for Source 2**: while the cutting cycle of 20 years should have ensured that no areas stocked before 1994 was not harvested, the calculations of the FRL show that up to 5240 ha correspond to areas stocked that were neither planted nor harvested during 1994 – 2019. As a consequence, the Source 2 was added to the calculations for softwood plantations.
   - The area stocked neither planted nor harvested was calculated with the following equation (combined equations 2.55 and 2.56 of the FRL) :

     $$Asw, gr = (Asw, s, 1994 + Asw,, 1994 - Asw, pl, 1994) - \sum_{T} Asw, lg, t$$

   - The carbon gains from source 2 were calculated using equation 2.57 of the FRL.

The total carbon gains from the softwood plantations were calculated based on equation 2.59 and the CO_2 removals using equation 2.60 of the FRL for the inventory period 1994 – 2019.

5.2.3.2.2. Biomass losses due to harvesting

Carbon stock changes resulting from biomass losses are calculated by summing the changes in carbon stock due to wood removals in hardwood plantations, softwood plantations and natural forest. The following table details the approach for data selection for biomass loss due to harvesting.

Table 103. Approach for data selection per forest type for biomass loss due to harvesting.

Forest type	Natural forest	Hardwood plantation	Softwood plantation
Selection of data sources	The data from the FRL matched the data from the HAR. The data provided values for the years 2001 to 2019.	The data from the FRL matched the data provided by the FHCL. The data provided values	The data from FRL was used for the years 2006 – 2016, the data from the FPL from 2017 to 2018. No data was available for the years

Forest type	Natural forest	Hardwood plantation	Softwood plantation
	In the absence of data for the years 1994 – 2000 it was decided to use the same approach as described above. The ratio of volume harvested on area logged for natural forest was estimated from the FRL data (28m3/ha). It was multiplied by the area of logged natural forest provided by the HAR. For 2019, the value from the ER-MR was used.	for the whole inventory period from 1994 to 2018. For 2019, the value from the ER-MR was used.	1994 to 2005. For 2019, the value from the ER-MR was used. Because a relationship exists between the area logged and the volume harvested, it was decided to estimate the average ratio between the area logged and the volume harvested during the FRL period in order to know the volume harvested per hectare of logged hectare of softwood plantation. The ratio (260m3/ha) was then used to estimate volume harvested before 2006 by multiplying it by the annual area logged (data from FPL for 1994 – 2006).

- ✓ **Methodology**
  - o **Natural forests**: the equation 2.13 of the FRL was used to estimate the annual decrease in carbon stock due to wood removal in tC.yr-1 with the emission factor TEF = 1.05 (Haas, 2015). The carbon loss was then multiplied by the conversion factor C to CO_2 (-44/12) to obtain the annual CO_2 emissions.

$$\Delta Cnf, l, t = Hnf * TEF$$

  - o **Hardwood plantations**: the equations 2.34, 2.35 and 2.36 of the FRL were combined to calculate the emissions from wood removal in hardwood plantations. The carbon loss was then multiplied by the conversion factor C to CO_2 (-44/12) to obtain the annual CO_2 emissions.

$$\Delta Chw, l, t = Hhw * BCEFhw, r * (1 + Rwl) * \eta CF$$

  - o **Softwood plantations:** the equations 2.48, 2.49 and 2.50 of the FRL were combined to calculate the emissions from wood removal in hardwood plantations. The carbon loss was then multiplied by the conversion factor C to CO_2 (-44/12) to obtain the annual CO_2 emissions.

$$\Delta Csw, l, t = Hsw * (\frac{1}{\lambda \mathrm{Pine}}) \times \rho \mathrm{Pine} * (1 + Rdlh) * \eta CF$$

5.2.3.2.3. Biomass loss due to burning

According to the IPCC Guidelines, the category 3B only accounts for the emissions of CO_2 from land use. Biomass burning occurs in both softwood plantations and sugarcane plantations. The emissions of CH_4 and NO2 resulting from burning are reported in the category 3C1 Biomass Burning.

For forest, the Tier 1 counts the CO_2 emissions from biomass burning because they are generally not synchronous with rates of CO_2 uptake. Therefore the CO_2 emissions from the burning of softwood plantations are reported here.

✓ **Activity data for biomass burning in softwood plantations**

Available data for this category spans from 2015 to 2019. For the year 2019, data came from the ER-MR (2022). In order to calculate emissions for the entire inventory period, it was decided to calculate the average of the activity data for the years 2015-2019 and use the average value for the years preceding 2015. The table below summarizes the activity data available from 2015 to 2019 as well as the average used for the other years of the inventory period:

Table 104. Provided and averaged activity data for biomass loss due to burning.

Activity data	2015	2016	2017	2018	2019	Average
Area burnt	1447	830	2709	729	179	1179
Count	79	33	122	60	11	61
Average years since plantation	17.47	16.27	10.21	9.75	2.64	11

✓ **Methodology for biomass burning in softwood plantations**

- To estimate the GHG emissions from biomass burning for CO_2 in softwood plantations, the methodology of the FRL was reproduced.
- For emissions factors, the estimate of 10 tB ha-1.yr-1 for mean annual total biomass increment was taken from Waterloo (1994).
- Both ABG and BGB were estimated by using equations 2.19 and 2.20 of the FRL, respectively. CO_2 emissions from AGB and from BGB were calculated thanks to equation 2.21 and 2.22, respectively.
- The sum of the emissions from AGB (CO_2, CH_4 and N_2O) and from BGB (CO_2 only) was finally computed in Gg of CO_2eq for every year of the inventory period (1994 – 2019).

5.2.3.2.4. Biomass loss due to natural forest degradation

In addition to technical corrections, the ER-MR added a source of emissions from natural forest degradation. The methodology for estimating of Forest Degradation has been expanded to include transitions from Closed to Open forest in Natural Forest other than areas subject to time harvest. This improvement to the FRL means that Fiji is more comprehensively accounting for emissions related to Forest Degradation using what is considered direct measurement approaches.

✓ **Activity data & emission factor for degraded (closed to open canopy) natural forests**

Degradation from Closed to Open forest was defined as "A non-cyclone disturbance in a forest that results in a reduction of canopy cover from 40-100% to 10-40%". The activity data was generated using the same Landsat archive and reference data set as that used to estimate deforestation. The process estimated an annual average of degraded area of **875 ha/yr** for the Reference Period. The value for 2019 was available from the Monitoring Period, which estimated 214 ha/yr. Interpolation was used to estimate the values for 2017 and 2018. Given the absence of data prior to the Reference Period, it was not possible to estimate the emissions for the period 1994 to 2006.

The country was divided into Open and Closed forests using the forest type classification, and the difference between the two classes is considered the emission factor. This process led to the development of an emissions factor of **121 tCO_2e +/-22 tCO_2e** resulting from the transition from Closed to Open Forest.

- ✓ **Methodology for degraded natural forests, from closed to open canopy**
  - o The methodology of the FRL was reproduced, according to which the activity data is multiplied by the emission factor to provide annual emissions.

5.2.3.3. Methods for Land Converted to Forestland (3B1B)

The following table details the approach followed for the Land Converted to Forestland, outlining the activity data, emission factors and methodology used.

Table 105. Activity data, emission factors and methodology for Land Converted to Forestland.

Category	Approach
Activity data	For the category 'Land Converted to Forestland', which corresponds to both afforestation and reforestation in the REDD+ stratification, no data other than the one provided in the FRL was available. The corrected FRL provides the average values of forestation both in lowland and in upland forests for the Reference Period. The Monitoring Period provided data for the last year of the inventory period, 2019. Thus, linear interpolation was used to estimate the activity data for 2017 and 2018. Given the absence of proxy data and the large time period without data prior to 2006, it was decided to consider the years from 1994 to 2006 as 'Not Estimated' (NE).
Emission factors	The emission factors used were extracted from the FRL, Section 2.4.1 on afforestation/reforestation. They include the carbon fraction of dry matter (CF), the mean annual volume increment (MAIVar), the biomass conversion and expansion factor for volume increments (BCEFar_i). To calculate MAICar, the FRL provides equation 2.31. However, there was a mismatch between the MAICar value computed with the equation (6.02 tC.ha-1.yr-1), and the value reported in the text (2.63 tC.ha-1.yr-1). After performing a quality check on the final emissions, it was verified that the value used by the FRL for equation 2.30 was 2.63 tC.ha-1.yr-1. This value was therefore used for our calculations.
Methodology	The methodology followed was a replication from the methodology of the FRL document. The equation 2.30 was used to calculate carbon gains from the area for both upland and lowland, the MAICar value and δt Given the inclusion of the year 2005 in the series, the value of δt was modified as follows: $\delta t = 2016 - t$, with $T = \{2005, 2007, \dots, t, \dots, 2016\}$; yrs The value obtained with equation 2.30 allocates all the gains from a planted parcel to the year of plantation. However, this doesn't reflect that only a portion of the total growth occurs per year. For this reason, it was decided to distribute the gains to the subsequent years after plantation.

5.2.3.4. Methods for Cropland remaining Cropland (3B2A)

Given the impossibility to estimate emissions from perennial crops and the fact that residue burning is reported but not counted under Tier 1 (see Table 105 below), the emissions for cropland are memo items.

Table 106. Activity data, emission factors and methods for cropland remaining cropland.

Category	Activity data	Emission factor	Methods & Accounting
Perennial Woody crops	The emissions from perennial woody crops could not have been estimated for this inventory due to the lack of appropriate emission factors. Indeed, the default EF from the IPCC 2006 Guidelines (Volume 4 Chapter 5 Table 5.1) provide estimates of biomass loss assuming that the whole perennial crop is removed. However, the data available from Fiji, coming from the FAO as well as the Agricultural Census 2009 and 2020, provide data on the bearing area, that is, the area where fruits are harvested. Because it can't be assumed that the biomass of harvested fruits is equivalent to the biomass loss from complete crop removal, the use of the IPCC emission factor from available data leads to over-estimating emissions from perennial crop systems in Fiji. Appropriate recommendations to fix this issue and estimate the CO_2 emissions from perennial woody crops are provided in the AFOLU improvement plan below.		
Sugarcane residue burning	The data provided area of burnt sugarcane in hectares from 1992 to 2019. The source of the data remains unknown.	The emission factor and combustion factor for CO_2 were obtained from the Volume 4 Chapter 2 Table 2.6 of the 2006 IPCC Guidelines. The emission factor specific to sugarcane, which is the mass available for combustion, was obtained from the V4C2 Table 2.4.	According to the IPCC Guidelines, the category 3B only accounts for the emissions of CO_2 from land use. Biomass burning occurs in both softwood plantations and sugarcane plantations. The emissions of CH_4 and NO2 resulting from burning are reported in the category 3C1 Biomass Burning. For cropland, the Tier 1 assumes that the carbon burnt is replaced during the next growing season through the growth of crop. Hence, the CO_2 emissions from cropland burning are reported in the inventory but not counted in the final emissions.

5.2.3.5. Methods for Forestland converted to Grassland (3B3B)

The following table details the approach followed for the Forestland Converted to Grassland, outlining the activity data, emission factors and methodology used.

Table 107. Activity data, emission factors and methods for Forestland converted to Grassland.

Category	Approach
Activity data	For the category 'Forestland converted to Grassland', which corresponds to deforestation in the REDD+ stratification, no data other than the one provided in the FRL was available. The corrected FRL provides the average values of deforestation both in lowland and in upland forests for the Reference Period. The Monitoring Period provided data for the last year of the inventory period, 2019. Thus, linear interpolation was used to estimate the activity data for 2017 and 2018. Given the absence of proxy data and the large time period without data prior to 2006, it was decided to consider the years from 1994 to 2006 as 'Not Estimated' (NE).
Emission factors	The emission factors used were the biomass stocks (tC.ha-1) for grassland, lowland forest and upland forest. Their values were taken from Table 2.4 in the original Forest Reference Level for natural forests and from Rounds (2013) for grassland. It was assumed that the biomass growth rate and biomass loss rate of grassland are equal. That is, no annual changes, gains or losses, are assumed in the post-deforestation land-use (i.e., grassland). Therefore, only the carbon change due to the land conversion is accounted for.

Category	Approach
Methodology	The methodology followed the IPCC methodology for Tier 1. It assumes that all the emission from deforestation occurs during the year of cutting. The equation 2.16 was used to estimate the biomass carbon stock change on Forestland converted to Grassland, based on the emission factors, the annual deforested areas for both upland and lowland forests. Because the emission factors Bafter and Bbefore from the FRL were provided in tC.ha-1, the CF factor (carbon fraction of dry matter) of equation 2.16 was omitted in the calculation. The final emissions were obtained by multiplying the value of carbon change by the default IPCC conversion factor C to CO_2.

5.2.4. Methods for Aggregated and Non-CO_2 Emissions Sources (3C)

The “Aggregated sources and Non-CO_2 emission sources from Land” (3C) category comprise of sources of emissions which are not covered under 3A or 3B. For example, for biomass burning occurring in forest land the emissions emanate from the fires and emissions from all forest fires in managed land have to be reported. In addition, the fires used in land preparation under cropland (agricultural residues) also results in CH_4 and N_2O emissions.

The GHG emissions sources under 3C are subdivided into:

1. Biomass Burning (3.C.1);
2. Liming (3.C.2);
3. Urea application (3.C.3),
4. Direct N_2O emissions from managed soil (3.C.4);
5. Indirect N_2O emissions from managed soil (3.C.5);
6. Indirect N_2O emissions from manure management (3.C.6); and
7. Rice cultivations (3.C.7).

The category 3C2 Liming was not estimated in the GHG inventory due to lack of data. Liming of soils in agricultural land is a common practice in Fiji and information on the application of lime in soils could be collected using as a proxy lime imports (as there is no production of lime in Fiji) or lime applied to soils through the Agriculture census. A summary description of methods used to estimate emissions from the Category 3C in the following table.

Table 108. Summary of methodologies used for the category 3C.

Category	Methodology	Assumptions
3C1 Biomass burning	Concerning biomass burning in forests, the CO_2 emissions are reported in the category 3B (see above). The emissions for CH_4 and N_2O are reported in category 3C1. As explained in section 5.3.2 of this chapter, the activity data provided covered the years 2015 – 2018. An average was used for the years of the inventory period outside of 2015 – 2018. The equations from the FRL were used to calculate the emissions of CH_4 and N_2O (equations 2.19, 2.20, 2.21, 2.22, 2.23, 2.24). The sum of the emissions of CO_2 and N_2O from above-ground biomass was finally computed.	Under Tier1, it is assumed that the emissions from burning in cropland are compensated by removals from growth in the following growing year. Therefore, the emissions from sugarcane residue burning are reported but not added to the final emission calculations.

Category	Methodology	Assumptions
	For sugarcane residue burning, as explained in section 5.3.4, the emission factor and combustion factor for CO_2 were obtained from the Volume 4 Chapter 2 Table 2.6 of the 2006 IPCC Guidelines. The emission factor specific to sugarcane was obtained from the V4C2 Table 2.4.	
3C3 Urea application	The activity data consisted of imported urea data from FAOSTAT for the years 2002 to 2018. Values for the years 1994 – 2001 and 2019 were obtained through linear extrapolation. The emission factors used are the default values from the IPCC 2006 Guidelines from Section 11.4.2. The equation used was equation 11.3 from the 2006 IPCC Guidelines	Fiji does not have activity data on urea applied to soils. However, it is possible to do the estimation using the assumption that all urea imports are utilised in the year they were imported (in reality, the actual consumption per the imported year may be less or more than what was imported due to surpluses or deficit from the previous year stock).
3C4 Direct N_2O emissions from managed soils	Direct N_2O emissions from managed soils are estimated with the tier 1 methodology from the 2006 IPCC Guidelines. The emission factors used are the default values of the Guidelines found in table 11.1. Values for FON, FAM, FPRP, and FCR were derived thanks to equations 11.3, 11.4, 11.5, 11.6 respectively. The factor Nmms_avb used in equation 11.4 is derived in coordination with reporting for N_2O emissions from manure management (Chapter 10 Section 5.4 of the IPCC 2006 Guidelines) and is obtained thanks to equation 10.34. The FCR factor was obtained for both 2009 and 2020 from the two respective Agriculture Census. Interpolated values were used between 2009 and 2020, while the 2009 value was used for the years previous to 2009 The final N_2O emissions were obtained with equation 11.1.	
3C5 Indirect N_2O emissions from managed soils	Indirect N_2O emissions from managed soils are estimated with the tier 1 methodology from the 2006 IPCC Guidelines. The emissions factors used are the default values of the Guidelines found in table 11.3. FSN was obtained from FAOSTAT. In the absence of data on average annual loss of soil carbon, the FSOM would not be computed. The emissions for N_2O-N (Atmospheric deposition) and N_2O-N (Leaching) were obtained thanks to equation 11.9 and 11.10 respectively.	
3C6 Indirect N_2O emissions from manure management	Indirect N_2O emissions from manure management are estimated with the tier 1 methodology from the 2006 IPCC guidelines. The activity data consists of the livestock populations, the annual average N excretion and the fraction of total annual nitrogen excretion for manure management system.	

Category	Methodology	Assumptions
	The average N excretion was obtained thanks to equation 10.30 with the TAM and N rate values obtained from the 2019 IPCC Refinement [2] for Oceania in table 10A.5 and the IPCC 2006 guidelines [1] for Oceania in tables from 10.19, respectively. The N volatilization was calculated with equation 10.26 using the default values for nitrogen loss due to volatilisation of NH3 and NOx from manure management by the IPCC 2019 Refinement guidelines [2] in Table 10.22 The emissions were calculated thanks to equation 10.25 of the 2006 IPCC Guidelines, using the default emission factors found in table 10.21.	
3C7 Rice cultivation	The Methane emissions from rice cultivations are estimated with the tier 1 methodology from the 2006 IPCC Guidelines. The annual harvested area of rice per water regime was obtained from the data from 2018 to 2020 broken down in water regimes. The average proportions were derived, and together with the total annual harvested area data from the FAO, estimates were calculated for the period 1994 to 2017 per water regime (irrigated, rainfed/dry, upland). from the total harvested area, the rate of water regimes in Fiji and the water regime cultivation period. All were obtained from FAO. The emission factors were the default factors from the IPCC 2006 Guidelines found in tables 5.11, 5.12, 5.13, and 5.14. They were used to calculate a scaling factor thanks to equation 5.3, from which the adjusted daily emission factor for a particular water regime was calculated thanks to equation 5.2. For SFo (organic amendment), the data provided suggests that in irrigated/wetland, the straw is incorporated after 30 days, The emissions were calculated for each water regime with equation 5.1.	

5.3. Livestock (3A)

According to the last Third National Communication, the emissions from the two categories of livestock, enteric fermentation (3A1) and manure management (3A2), largely dominate the emissions from agriculture. These are moreover characterized by the large proportion of methane emissions in the total: in 2011, 405 Gg CO_2eq of methane were emitted out of 551 Gg CO_2eq in total, corresponding a share of methane of 74%.

The main activity data for the livestock category is the annual livestock population in number of heads for all the species and sub-groups of the country. In Fiji, the data collection allowed to gather the activity data for the following livestock groups: dairy cattle, other cattle, ducks, goats, chickens, horses, pigs – market and breeding swine, and sheep. Data from the agricultural census was the main input to the estimations as well as official data from the Ministry of Agriculture for the years 2011-2020 for cattle and swine. For other categories, census data except for 2006 and 2020 wasn't available: data before 2006 was estimated through extrapolation and data between 2006 and 2020 by interpolation, leading the linear trends of the evolution of all livestock population except cattle and swine during the inventory period.

Table 109: Summary of activity data for livestock from 2006 to 2020 based on the Agriculture Census and official data from the Ministry of Agriculture

Livestock	2006	2010	2015	2020
Dairy Cattle	22502	19464	30742	32620
Other Cattle	168051	142238	109972	87071
Chickens	3668326	3023919	2218410	1412901
Ducks	66509	58065	47511	36956
Goats	101196	113384	128618	143853
Horses	27124	27727	28339	28702
Pigs - market swine	25382	23782	21783	19784
Pigs – breeding swine	9660	9052	8291	7530
Sheep	14068	20744	29090	37435

The estimations for the livestock category are summarized in the following table. The enteric fermentation represents in 2019 more than 83% of the total emissions for this category, with 326 Gg CO_2eq emitted against 66 Gg CO_2eq from manure management. Figure 48 presents the emissions from both categories.

Table 110. Summary of GHG emissions from livestock (3A).

Category	GHG emissions in Gg CO_{2eq}							Uncertainty
	2013	2014	2015	2016	2017	2018	2019	
Enteric Fermentation	295.43	308.70	308.03	292.55	296.57	276.82	326.27	45%
Manure Management	41.60	48.20	48.96	48.15	51.87	48.23	66.03	N/A

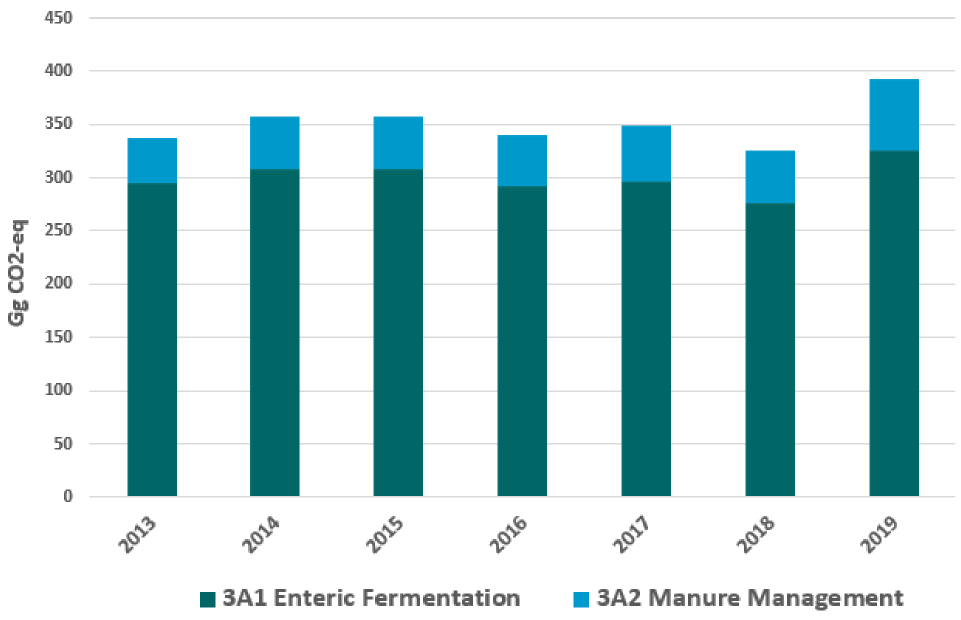


Figure 48. GHG emissions from livestock from 2013 to 2019.

5.3.1. Enteric Fermentation (3A1)

Enteric fermentation produces methane as part of the digestion process in the alimentary canal of herbivores. Microbes in the animal's digestive system ferment feed ingested by the livestock which generates methane. Methane production is dependent on animal population, weight, and age of the animals as well as the quantity and quality of feed. The type and efficiency of the animals' digestive system also influence methane production. The quantity of methane production in ruminant livestock is more than that produced by non-ruminant livestock.

The digestive system influences the rate of methane emissions because ruminants have an expansive chamber, the rumen, where intensive microbial fermentation takes place. The breaking down of food is done with the help of methanogens resulting in a process called methanogenesis. While this yields nutritional advantages, it leads to higher methane-producing fermentation than non-ruminant livestock and monogastric livestock. The feed also influences the emissions: generally, the higher the feed intake, the higher the methane emission. The amount of methane produced also depends on:

- **Animal age**: older animals tend to emit less methane
- **Animal weight**: heavier animals tend to emit more methane
- **Quality of feed consumed**: lower quality feed consumed tends to result in more methane
- **Quantity of feed consumed**: higher quantities of feed consumed tend to result in greater emissions

To estimate the emissions from livestock in Fiji, the Tier 1 methodology was used: it consists of multiply the livestock population for each animal category by the default emission factors. The sum provides the total emission in Gg CH_4 / year which are finally converted to Gg CO_2eq / year using the IPCC Global Warming Potential for CH_4.

In Fiji, the livestock sub-groups were composed from the livestock populations of the country which included: dairy cattle, other cattle, goats, horses, pigs and sheep. Given the high emission factors of cattle, they dominate the emissions of CH_4 from enteric fermentation from livestock: in 2019, dairy cattle and other cattle were responsible for 44% and 43% of the CH_4 emissions for this category.

The linear increase of the emissions from 2003 onwards is caused by the increase in the dairy cattle population. From 20,000 heads in 2000, it reached close to 50,000 heads in 2020, as exposed by the 2020 Agriculture Census. In the same period, other cattle have been decreased with a comparable trend, from 122 000 heads to 84 000: but the higher emission factor of dairy cattle explains the constant growth of CH_4 emissions from enteric fermentation. The following table and figure present the CH_4 emissions from Enteric Fermentation in Fiji between 2013 and 2019.

Table 111. Summary of CH_4 emissions from Enteric Fermentation.

Gas	Category	Unit	GHG emissions in Gg CH_4							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
CH_4	Enteric Fermentation	Gg CH_4	10.55	11.03	11.00	10.45	10.59	9.89	11.65	45%

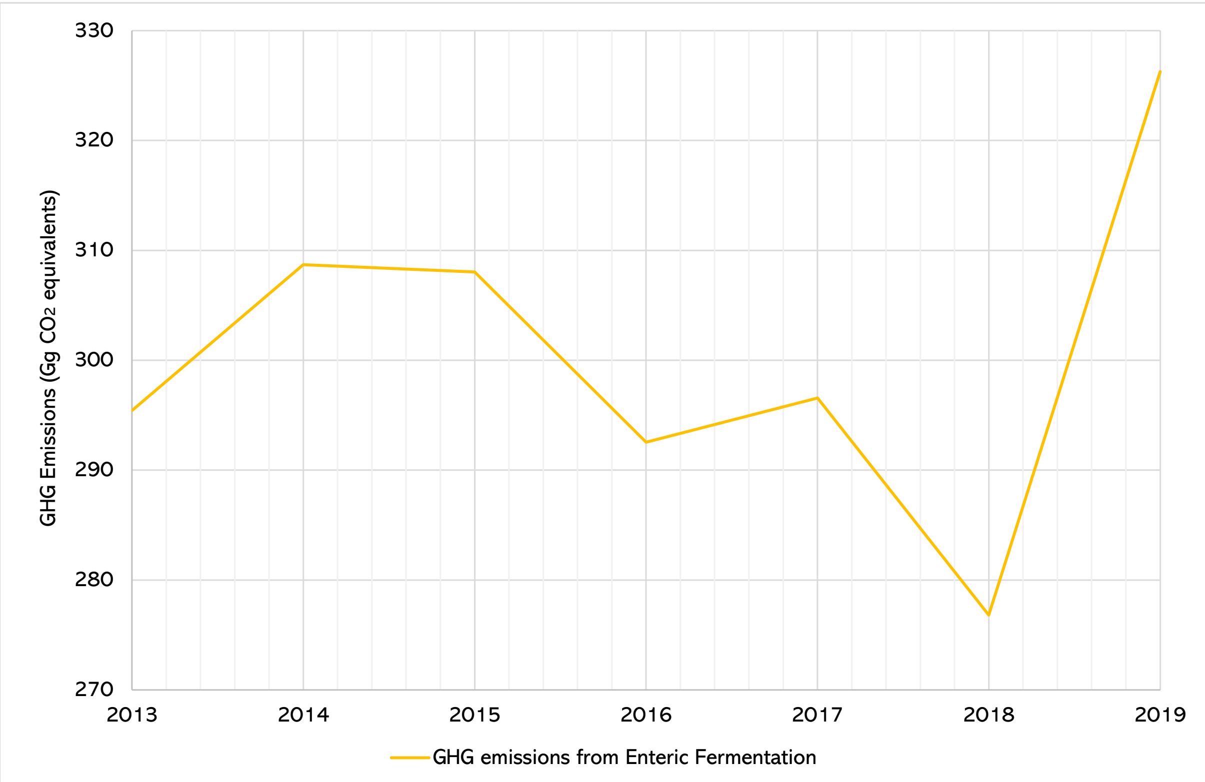


Figure 49. CH_4 Emissions from Enteric Fermentation in Gg CO_2eq.

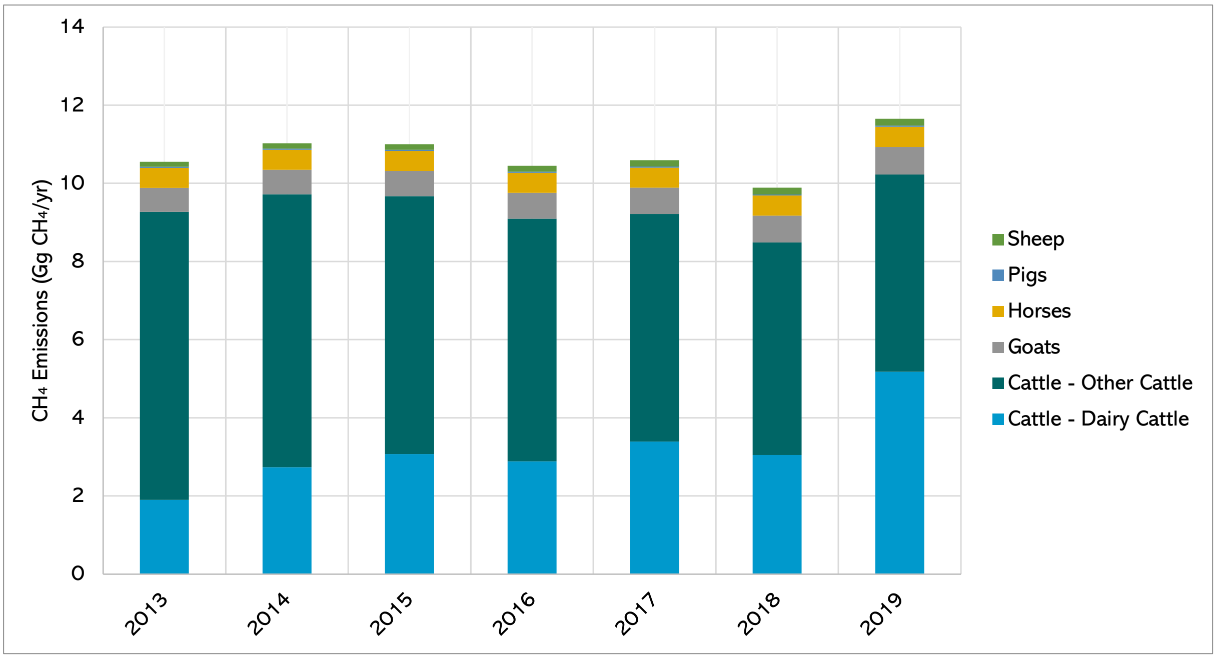


Figure 50. CH_4 Emissions from Enteric Fermentation by Livestock (Gg CH_4/year).

5.3.2. Manure Management (3A2)

The 'manure' refers to both the dung and the urine produced by livestock. The GHG emissions for this category vary depending on the type of system and associated conditions. Emissions in the manure management category are mainly methane and nitrous oxide:

- **Methane**: The decomposition of manure under anaerobic conditions, which refers to the absence of oxygen, during the storage and the treatment of manure, produces methane. These conditions occur mostly when large numbers of animals are managed in a confined area and where the manure is disposed of in liquid-based systems, such as waste ponds or lagoons. The amount of methane produced greatly depends on temperature and retention time in the storage unit. The methane emissions are estimated with Tier 1 methodology, where the emissions are estimated by multiplying the livestock population by the emission factor for the defined livestock population.
- **Nitrous oxide**: Direct N_2O emissions occur under aerobic conditions (with oxygen) via combined nitrification and denitrification of the nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Indirect emissions of N_2O which do not occur directly on the management site are treated in category 3C6. The emissions associated with manure applied to pastures, ranges and paddocks occur from the soil and are therefore treated in category 3C4 & 3C5.

The methane emissions are estimated with Tier 1 methodology, where the emissions are estimated by multiplying the livestock population by the emission factor for the defined livestock population. In Fiji, these emissions are largely driven by the dairy cattle whose emissions have been steadily increasing from 2011 onwards, as in the case of enteric fermentation. Contrary to dairy cattle, other cattle have low emission factors in this category, closer to the factors for pigs, and therefore they are not major drivers of the emissions, as opposed to enteric fermentation (Figure 52). The emissions reached 65.88 Gg CO_2eq/year in 2019, as opposed to 41.42 Gg CO_2eq/year in 2013.

The direct nitrous oxide emissions are also estimated with Tier 1. They depend on the livestock population, the average N excretion per head per type of livestock, the fraction of total annual nitrogen excretion that is managed in manure management systems, and the emission factors for the manure management systems. In the case of Fiji, based on default factors for Oceania where 91% of the manure from pigs is managed in lagoon, pigs are the only livestock contributing the N_2O emissions (Figure 53). The quantities remain however relatively small, around 0.00059 Gg N_2O/year which is equivalent to 0.16 Gg CO_2eq/year. The following table and figure present the emissions from Manure Management in Fiji between 2013 and 2019.

Table 112. Summary of GHG emissions from Manure Management.

Gas	Category	Unit	GHG emissions in Gg CO_{2eq}							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
CH_4	Manure management	Gg CH_4	1.48	1.72	1.74	1.71	1.85	1.72	2.35	36%
		Gg CO_2eq	41.42	48.02	48.79	47.98	51.71	48.07	65.88	
N_2O	Manure management	Gg N_2O	0.000661	0.000649	0.000637	0.000626	0.000614	0.000602	0.00059	128%
		Gg CO_2eq	0.18	0.17	0.17	0.17	0.16	0.16	0.16	

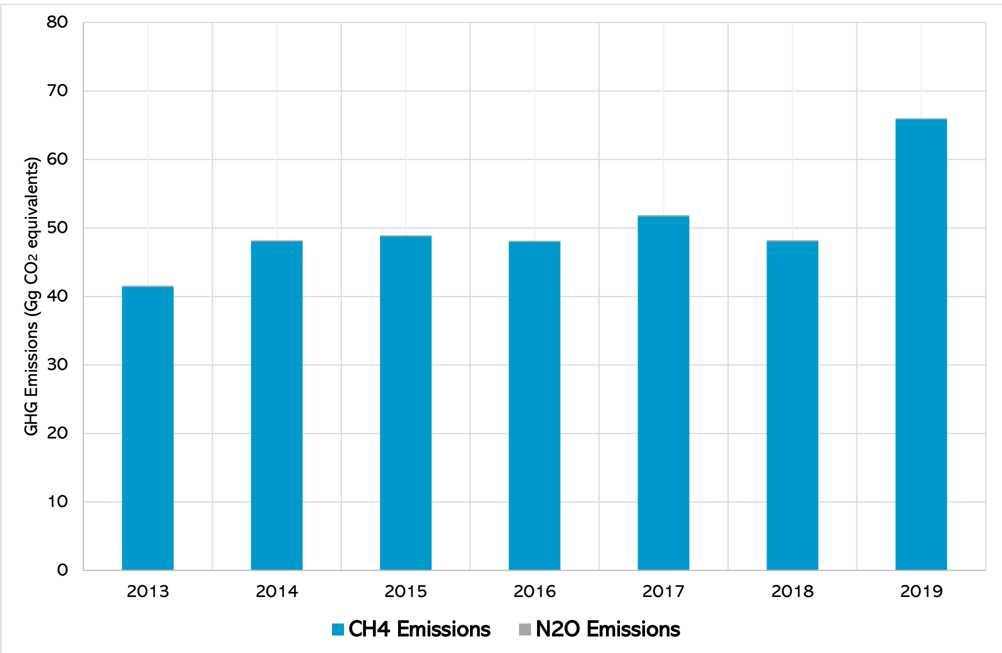


Figure 51. GHG Emissions from Manure Management in Gg CO_2eq.

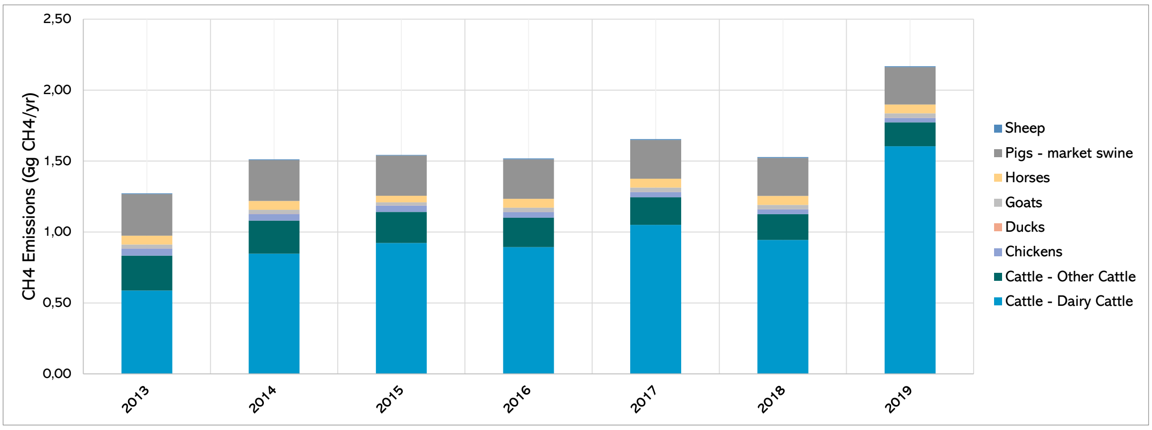


Figure 52. CH_4 Emissions from Manure Management by Livestock in Gg CO_2eq.

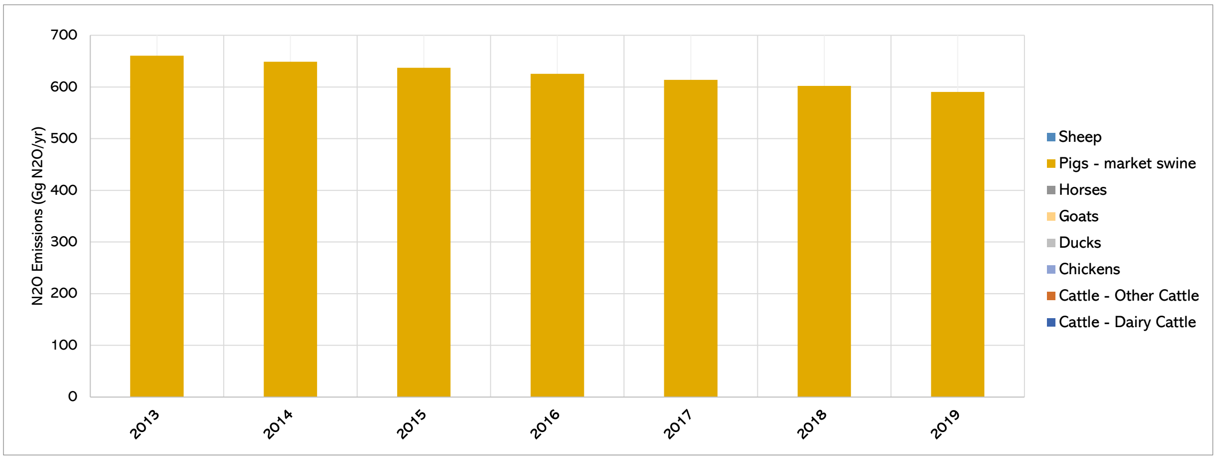


Figure 53. N_2O Emissions from Manure Management by Livestock in kg N_2O/year.

5.4. Land (3B)

Concerning the category 3B on Land removals and emissions, the existing documents, and data sources from which these estimations are based, such as the Forest Reference Level and the Emission Reductions Program Document, are largely focused on forests, given the strategic importance of this ecosystem for the population's livelihood, the national economy and the strategies of mitigation and adaptation to climate change.

These documents refer to `Non-Forest Land' all the areas that are not classified as `Forest Land'. However, `Non-Forest Land' is not an IPCC land-use category. For the FRL, the land-use category `Non-Forest Land' includes all IPCC land-use categories, i.e., `Grassland', `Cropland', `Wetlands', `Settlements' and `Other Land', except the category `Forest Land'. The following estimations have adapted the existing stratification to the IPCC categories, as explained in the methodology section, leading to estimates for Forest land, Cropland, and Grassland. The other categories are gathered in the Other Land section.

Based on available data, removals and emissions have been estimated for the category 3B1, both 'Forestland Remaining Forestland' and 'Land Converted to Forestland' (afforestation / reforestation). The category 3B3B 'Land converted to Grassland' accounts for emissions from deforestation in natural forests. As explained in the methodology section, 'Cropland remaining Cropland' has been added to account for emissions from biomass burning.

To estimate activity data for the FRL, all forest cover transitions were mapped for the entire annual time series from mid-2005 to mid-2016. Yet only activity data related to (a) annual areas of deforestation (Category 3B3B) in natural forest; and (b) annual areas of reforestation (Category 3B1B) in natural forest were extracted for use in the FRL estimation. Activity data related to forest degradation and enhancement of carbon stocks (Category 3B1A) were sourced from logging and replanting self-reported data.

Appropriate values of root-to-shoot ratios (R) from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4] were selected based on an aridity index providing a numerical indicator of the dryness of the climate at a given location (the Global Aridity Index (AI); Zomer et al., 2008). A threshold value of 2 was used to differentiate between wet and dry areas (i.e., for < 2 = dry; ≥ 2 wet). The threshold value was selected based on expert judgement.

The following table and figure present the summary of emissions from Land (3B) in Fiji between 2013 and 2019.

Table 113. Summary of GHG emissions from Category 3B.

Category	GHG emissions in Gg CO_{2eq}						
	2013	2014	2015	2016	2017	2018	2019
3B1a	-82.27	-339.84	-3.85	-481.76	-501.90	-396.26	-504.47
3B1b	-290.85	-324.52	-356.84	-387.15	-407.02	-416.63	-416.63
3B2a*	89.70	129.40	127.69	183.05	124.02	170.33	151.49
3B3b	394.26	394.26	394.26	394.26	284.98	175.71	66.43
Net total	**21.15**	**-270.10**	**33.57**	**-474.64**	**-623.94**	**-637.19**	**-854.68**

Category	GHG emissions in Gg CO_{2eq}						
	2013	2014	2015	2016	2017	2018	2019
(*) Category 3B2A is a memo item of the inventory, reported for transparency purposes but not counted for in the sectoral emissions (see section 5.2.6.4 for details).							

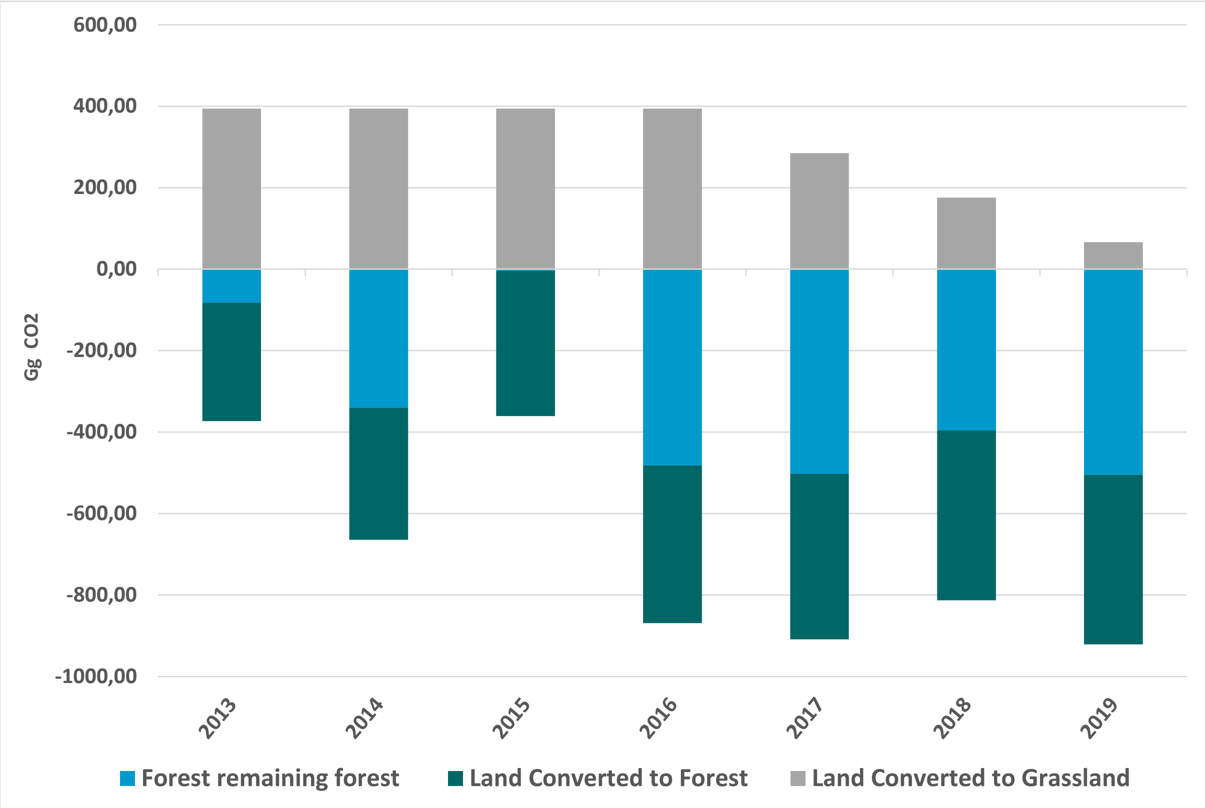


Figure 54. CO_2 emissions and removals from Land from 2013 to 2019 (Gg CO_2-eq).

5.4.1. Forest land (3B1)

The emissions and removals from forest cover both the category 3B1A 'Forestland Remaining Forestland' and 3B1B 'Land Converted to Forestland'. The former covers net emissions of CO_2 resulting from the biomass gains in natural forests and plantation forests, the biomass loss from harvest and the biomass burning from fire. The latter covers the removals of CO_2 from the atmosphere resulting from the afforestation and reforestation programs in lowland and upland forests.

In Fiji, 60% of the land is covered by forest, representing 1.16 million hectares. Fiji's main forest cover is wet/humid tropical forest. The definition adopted for the FRL is the same as that reported to the FAO; 10% canopy cover, min 0.5ha and min 5m height.

Native forests represent 87% of the total forest cover. Significant differences in carbon stocks were found between the three. Mueller-Dombois & Fosberg (1998) identified significant changes in structural and floristic characteristics in forests in Fiji below and above approximately 600 m above sea level. Above 600 m, Fijian forests tend to show characteristics typical for mountain forests systems, whereas forest located below 600 m show characteristics of either tropical rain forests or tropical moist deciduous forests.

The IPCC Guidelines explain that only the emissions and removals from managed forests should be included in the inventory. Therefore, for natural forests, the estimations will cover only the processes with a human intervention. These include carbon gains from growth after logging (3B1A) and from reforestation (3B1B) and in following sections carbon loss from deforestation (3B3B).

The forest plantations cover the remaining 13% of the national forests. Rather than land cover, the forest classification for plantations is based on land use: areas not currently stocked with trees (crown cover percent is zero) but which are situated within lease area are classified as forests. They are also split in two: hardwood and softwood plantations.

The stratum `Softwood plantation' includes all areas leased by Fiji Pine Limited (FPL). Data on softwood plantations (mostly *Pinus caribaea var. hondurensis*; Caribbean pine) were provided by Fiji Pine Limited (FPL) to the Fiji REDD+ Unit. FPL is a private company of which the Government of Fiji is the majority shareholder. It currently manages a lease area of slightly more than 72,663 ha. FPL reported that about 49,503 ha of the lease area were stocked with pine trees on December 31, 2006.

The stratum `Hardwood plantation' includes all areas leased by Fiji Hardwood Corporation Limited (FHCL). Data from hardwood plantations were provided by Fiji Hardwood Corporation Limited (FHCL). FHCL is currently managing a lease area of about 58,997 ha. Most of the lease area is stocked with *Swietenia macrophylla King* (Honduran or big-leaf mahogany). However, by far greatest share of FHCL lease area is stock with mahogany; plantations of other species account for less than 15% of the area.

5.4.2. Forestland remaining Forestland (3B1a)

The category 3B1A estimates emissions and removals from forest from the changes in carbon stock from five carbon pools: above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter (SOM). In this assessment, due to the lack of data concerning dead wood, litter and (SOM), only the carbon stock changes in biomass are assessed.

Assessing the net emissions requires to estimate both the carbon removal from growth and carbon losses from forest. These losses have several origins and include roundwood removal/harvest, fuelwood removal/harvest/gathering, and losses from disturbances by fire, insects, diseases and other disturbances. In this section, growth is estimated for natural forests, hardwood plantations and softwood plantations, while carbon losses include the roundwood removal from the 3 forest types as well as fire in softwood plantations.

A summary of the removals and emissions is provided in the following table.

Table 114. Net emissions from Forestland Remaining Forestland from 2013 to 2019 in Gg CO_2eq.

Sub-category	Removals/ emissions	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
Removals from forest	Removals from	-1328	-1285	-1249	-1222	-1211	-1202	-1175	235%

Sub-category	Removals/ emissions	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
	forest gains								
	Emissions from forest loss	1352	1051	1351	846	788	858	696	
	Net total	24	-234	102	-376	-423	-344	-479	

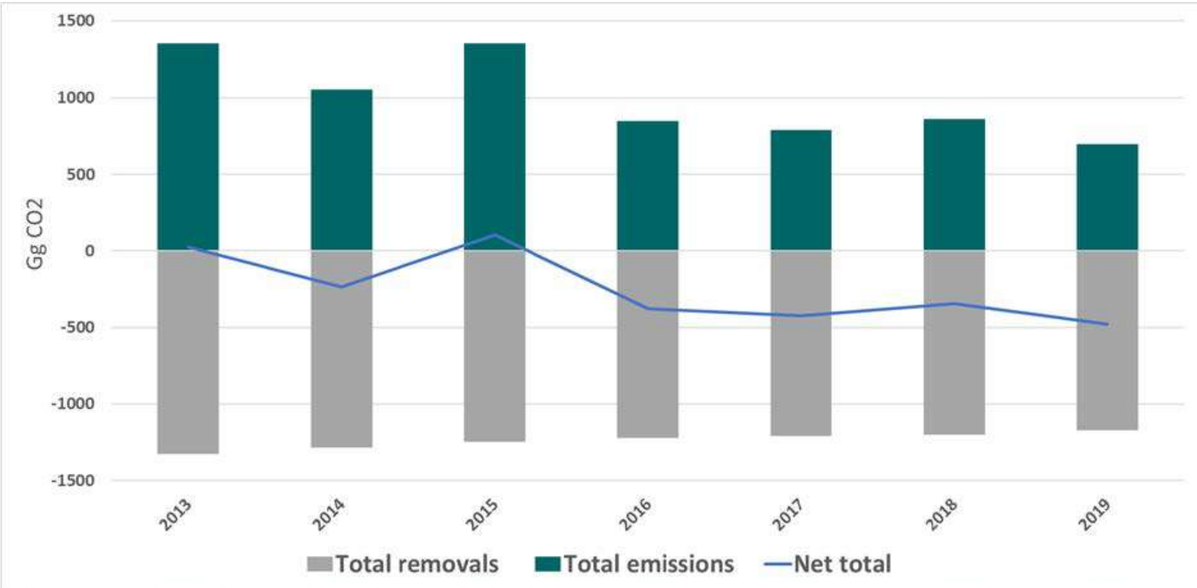


Figure 55. CO_2 Emissions from Forests Remaining Forests from 2013 to 2019 (Gg CO_2).

- **Carbon gains from forest growth**

The removals from forest growth were estimated for all the forest types included in the inventory. For natural forests, only emissions from logged areas were included, referring to removals from forest growth between the year of logging and the final year of the inventory (2019). Fully managed plantations have been split according to their management status (stocked, planted, logged) and removals from each were estimated based on the methodologies described above.

For natural forests, hardwood and softwood plantations, the removals have been distributed throughout the inventory period to better reflect the growth dynamic of forest ecosystem. The results show that the annual removal of CO_2 from the atmosphere from forests has been comprised between -1462 Gg CO_2 (in 2003) and -1175 Gg CO_2 (in 2019). The trend is positive, meaning than annually the absorptions from forests are decreasing every year.

That trend is driven by the reduction of removals in softwood plantations. On the contrary, hardwood plantations have regular annual removals. One possible explanation for this difference is the different cutting cycle and hence period of growth between the two types. Softwood plantations have cutting cycle of 20 years, as opposed to 37 years for hardwood plantations.

Consequently, hectares planted before 1999 stop contributing the CO_2 removals in softwood after a 20-year period, which is not the case in hardwood.

The following table and figure present the summary of emissions from Forestland Remaining Forestland in Fiji between 2013 and 2019.

Table 115. Emissions from Forestland Remaining Forestland 2013 – 2019.

Sub-category	Forest type	GHG emissions in Gg CO_{2eq}						
		2013	2014	2015	2016	2017	2018	2019
Removals from forest growth	Natural forest	-231	-236	-242	-246	-255	-259	-262
	Hardwood plantation	-832	-827	-821	-816	-813	-808	-799
	Softwood plantations	-265	-222	-186	-160	-143	-135	-114
	Total removals	-1328	-1285	-1249	-1222	-1211	-1202	-1175

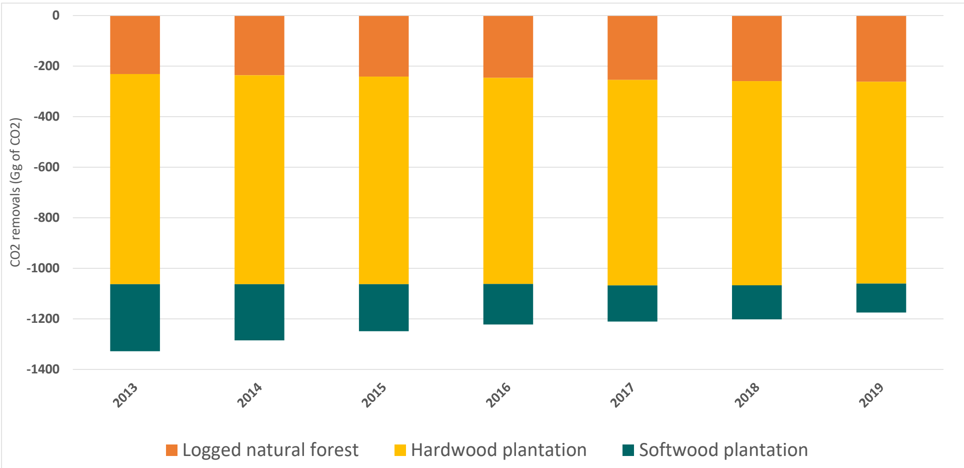


Figure 56. Annual CO_2 removals due to forest regrowth from 2013 to 2019 for natural forests and plantations (softwood & hardwood).

❖ Carbon losses from wood harvest

The estimations of CO_2 from wood removal and harvesting in Fiji's forests are summarized in in the following figure and table. Most of the Fiji's wood removal comes from softwood plantations: it represents 82% of the volume harvested during the inventory period, against 7% for hardwood plantations and 11% for natural forests. On average, the total emissions from wood harvesting during the inventory period is 726 Gg $CO_2.yr^{-1}$. The emission values and trends are dominated by the harvesting in softwood plantations, which reached a maximum emission in 2013 with 884 Gg CO_2 emitted due to an annual harvest of 668833 m^3.

Fuelwood harvesting usually constitutes a source of biomass loss in forests. It has been a traditional source of energy in Fiji as a fuel for cooking in rural areas. Yet its use is on the decline due to rapid shift to modern fuels for cooking. Estimations of associated emissions have been performed for the ER-PD and is described in Annex 4 of the document. Findings show that the emissions have been declining and are insignificant at the end of the reference period. Hence, it was decided to exclude the emissions from fuelwood of this inventory, in accordance with the FRL decision.

The following table and figure present the summary of emissions from wood harvesting in Fiji between 2013 and 2019.

Table 116. Summary of emissions from wood harvesting from 2013 to 2019 per forest type (Gg CO_2).

Sub-category	Forest type	GHG emissions in Gg CO_2						
		2013	2014	2015	2016	2017	2018	2019
Emissions from wood removal	Natural forest	104	179	197	196	191	139	106
	Hardwood plantation	157	145	135	99	5	39	49
	Softwood plantations	884	520	720	343	301	574	511
	Total emissions	1144	844	1052	637	497	752	667

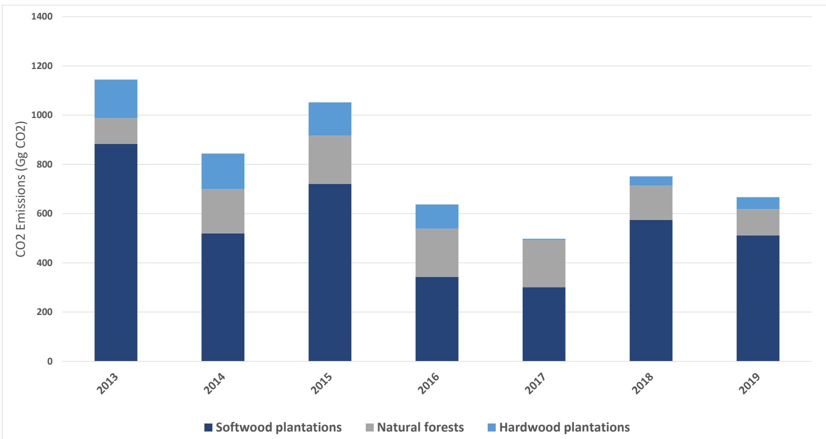


Figure 57. CO_2 emissions from wood removal from 2013 to 2019 (Gg CO_2).

- **Carbon loss from softwood fire**

The data available for this category was restricted to fire in softwood plantations from 2015 to 2019. The average value was used for the years prior to this period, leading to a constant activity data for the years before 2015. In this category, only CO_2 emissions are reported. Non-CO_2 emissions are estimated and reported in the category 3C1 'Biomass burning'. The following table and figure present the emissions softwood fire between 2013 and 2019.

Table 117. Summary of CO_2 emissions for softwood fire from 2013 to 2019.

Sub-category	Gaz	GHG emissions in Gg CO_2						
		2013	2014	2015	2016	2017	2018	2019
Emissions from fire in softwood plantations	CO_2	101.51	101.51	193.19	103.20	211.37	54.32	3.61

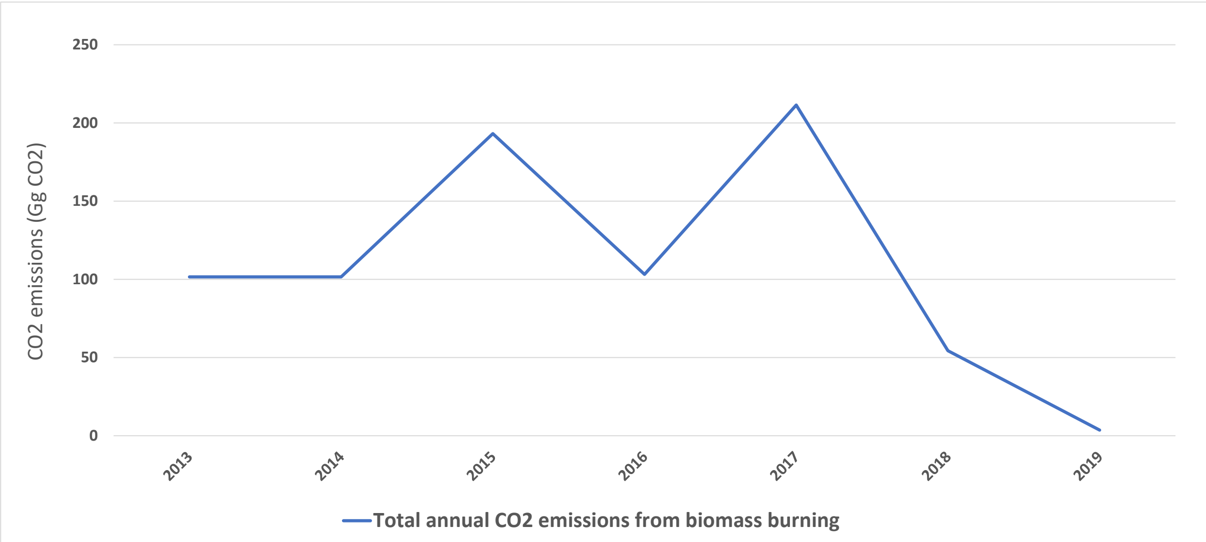


Figure 58. CO_2 emissions from fire in softwood plantations from 2013 to 2019.

5.4.3. Land Converted to Forestland (3B1b)

Fiji has adapted the national REDD+ programme, which supports reforestation of native and exotic forests. This programme has a two-strategy approach that ensures the protection of the forest while concurrently generating financial benefits under carbon-trading mechanisms.

The afforestation and reforestation efforts have been concentrated in lowland forest which represent 80% of the planted hectares. Concerning emission factors, the mixed use of the FRL and the IPCC default parameters didn't lead to differentiating growth rates between the two forest types. Therefore, the removal trends are entirely driven in these estimations by the number of hectares being planted or planted.

Unlike emissions from deforestation and disturbances, the CO_2 removals are gradual: once planted, a hectare of forest will absorb CO_2 progressively throughout its phase of active growth, until an equilibrium point. In this case, given the time period of available data (from 2006 to 2019), it is assumed that natural forests do not reach an equilibrium and keep on growing until the end of the inventory year.

Given these data, growth rates and assumptions, it is estimated that while the hectares planted in 2006 absorbed 38 Gg CO_2. By the end of the inventory period, the entire area planted from 2006 to 2019, at a, average rate of 2259 hectares per year, absorbs 260 Gg CO_2 annually.

It is important to note that the amount of absorbed CO_2 is expected to continue to rise for a period determined by the growth period until maturity in natural forests. Such parameter remains unknown in Fiji.

The following table and figure present the summary of emissions from Land Converted to Forestland in Fiji between 2013 and 2019.

Table 118. Net emissions from Land Converted to Forestland 2013 – 2019.

Sub-category	Forest type	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
Removals from natural forest growth	Lowland + Upland	-291	-325	-357	-387	-407	-417	-417	46%

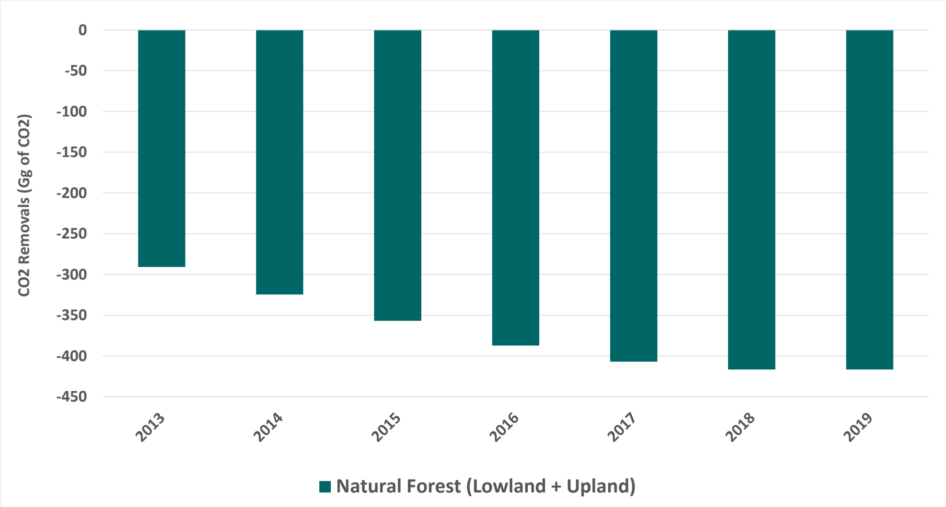


Figure 59. CO_2 removals from afforestation & reforestation of natural forests from 2013 to 2019 (Gg CO_2).

5.4.2. Cropland remaining Cropland (3B2a)

The category 3B2 corresponds in the IPCC land stratification to the land use Cropland. Given the data available, emissions were only calculated for Cropland remaining Cropland (3B2A), specifically from sugarcane burning.

The CO_2 emissions from sugarcane residue burning are categorized as memo items (notation key IE). Fire is typically used in Fiji as a cropland management tool to manage grasslands for agriculture production, particularly where sugar cane is the predominate crop.

It is indeed assumed that the emissions coming from the biomass burnt will be compensated by the removals coming from biomass growth in the next growing season. For this reason, the CO_2 emissions are reported but not added to the total emissions of the sector and by extension of the GHG inventory of Fiji.

This however does not apply to the non-CO_2 emissions resulting from biomass burning: the CH_4 and N_2O emissions from sugarcane burning are reported and included in the totals of category 3C1.

The following table and figure present the summary of emissions from Cropland Remaining Cropland in Fiji between 2013 and 2019.

Table 119. CO_2 emissions from biomass burning in cropland remaining cropland from 2013 – 2019.

	Biomass type	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
MEMO ITEMS	Sugarcane residue	90	129	128	183	124	170	151	111%

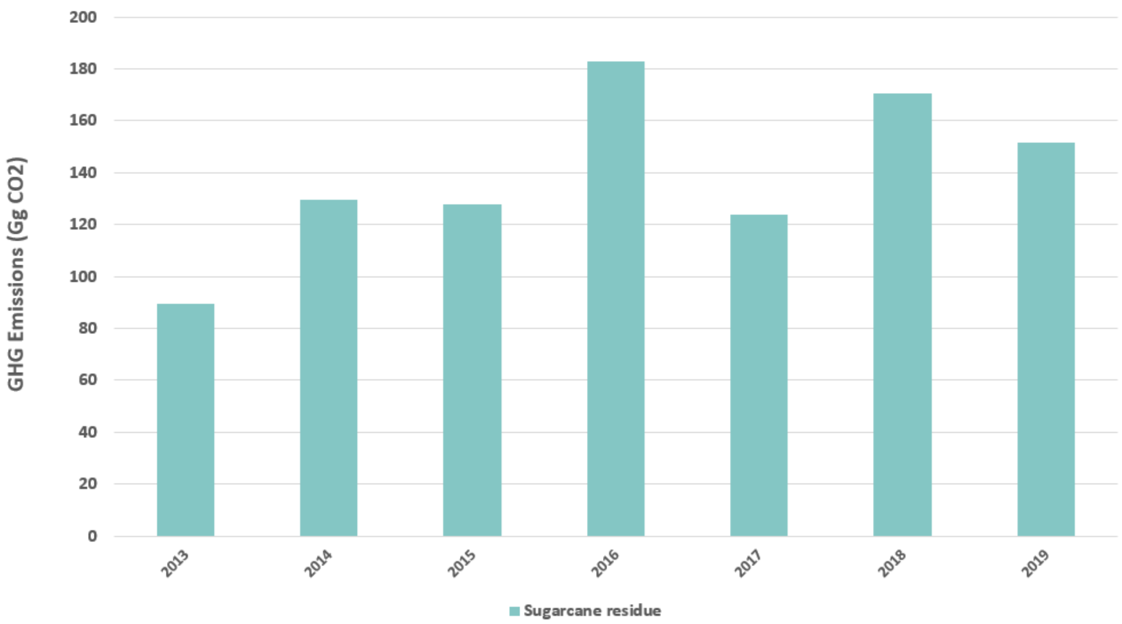


Figure 60. CO_2 emissions from biomass burning (memo items) from 2013 to 2019.

5.4.3. Land converted to Grassland (3B3b)

The category 3B3 corresponds to the land use 'Grassland'. As explained in the data and methodology section, the activity data used in this category corresponds to the deforestation of both lowland and upland forests. The emissions from grassland are therefore limited to the sub-category 'Land converted to grassland' (3B3B). For this category, the updated FRL activity data from the Emission Reduction Monitoring Report (ER-MR) as well as the emission factors have been used. More than 96% of the emissions from deforestation came from lowland forest, the 4% remaining from upland forests. This imbalance is caused by two factors:

- The higher number of estimated deforested hectares in lowland compared to upland forests (an average of 1287 hectares as opposed to 68 in upland forests).
- The superior biomass stock of lowland forest, in tonnes of C per hectare, caused by the higher primary productivity of ecosystems with tropical rainforest.

The following table and figure present the summary of emissions from Land Converted to Grassland (deforestation) in Fiji between 2013 and 2019.

Table 120. Net emissions from Land Converted to Grassland 2013 – 2019.

Sub-category	Forest type	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
Emissions from natural forest deforestation	Lowland	378	378	378	378	274	170	66	55%
	Upland	16	16	16	16	11	6	1	

Sub-category	Forest type	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
	Total	394	394	394	394	285	176	66	

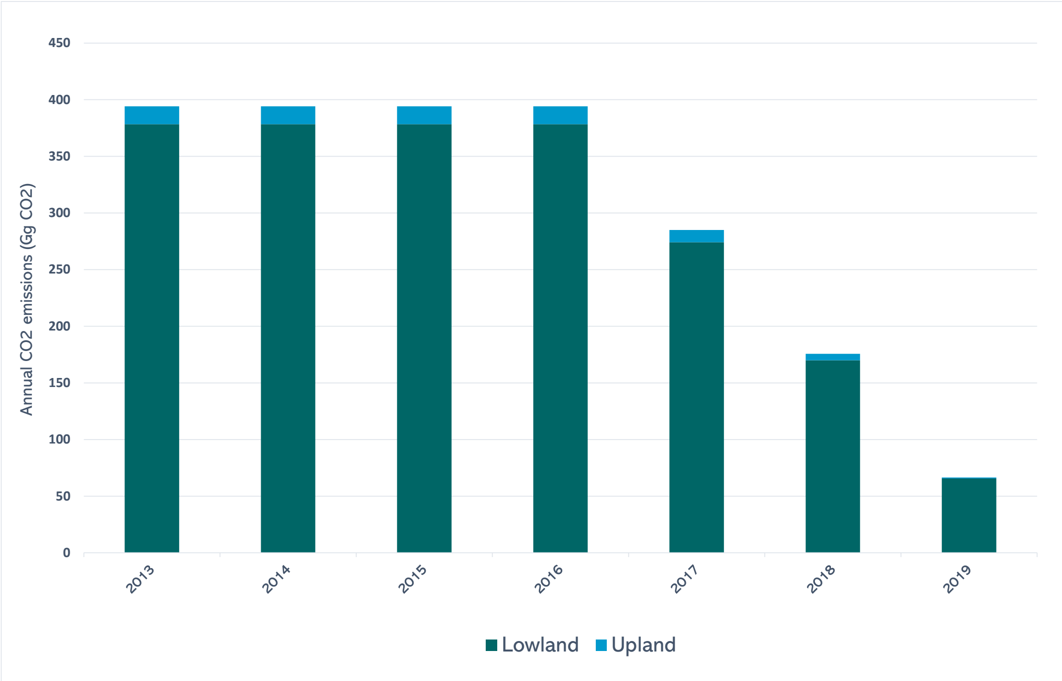


Figure 61. CO_2 emissions from deforestation from 2013 to 2019.

5.4.4. Other land (Settlements, Wetlands, Other Land)

In the absence of activity data pertaining to land use other than forestland, cropland and grassland, no emissions have been calculated for settlements, wetlands, and other land in Fiji for the inventory period.

5.5. Aggregated sources and non-CO_2 emissions sources on land (3C)

The category of 'Aggregated sources and non-CO_2 emissions sources on land' regroups several categories linked to Agriculture but not counted for in Livestock (3A) nor in Cropland (3B2). Except the categories accounting for the emissions from application of synthetic fertilizers such as urea or lime, the categories of 3C account for emissions of CH_4 and N_2O only. In Fiji, the category is largely dominated by the direct N_2O emissions from managed soils which reflects the amount of nitrogen added to the soils in its various forms. In 2019, this category alone has emitted more than 62% of the GHG of category 3C. It must be noted that the category 3C1 Biomass burning includes the non-CO_2 emissions of softwood plantation burning. These are the only emissions not directly linked to agricultural land use and associated practices.

The following table and figure present the summary of emissions from Aggregated sources and non-CO_2 emissions sources on land (3C) in Fiji between 2013 and 2019.

Table 121. Summary of GHG emissions from category 3C from 2013 to 2019.

Category	GHG emissions in Gg CO_{2eq}						
	2013	2014	2015	2016	2017	2018	2019
3C1	26.21	32.33	43.26	40.80	44.91	32.87	23.78
3C3	0.32	0.40	0.24	0.29	0.71	0.36	0.39
3C4	102.45	98.39	110.83	103.90	107.20	98.40	85.67
3C5	26.59	25.35	29.47	27.30	28.45	25.68	21.62
3C6	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3C7	6.60	9.66	9.80	8.54	7.29	6.11	6.22

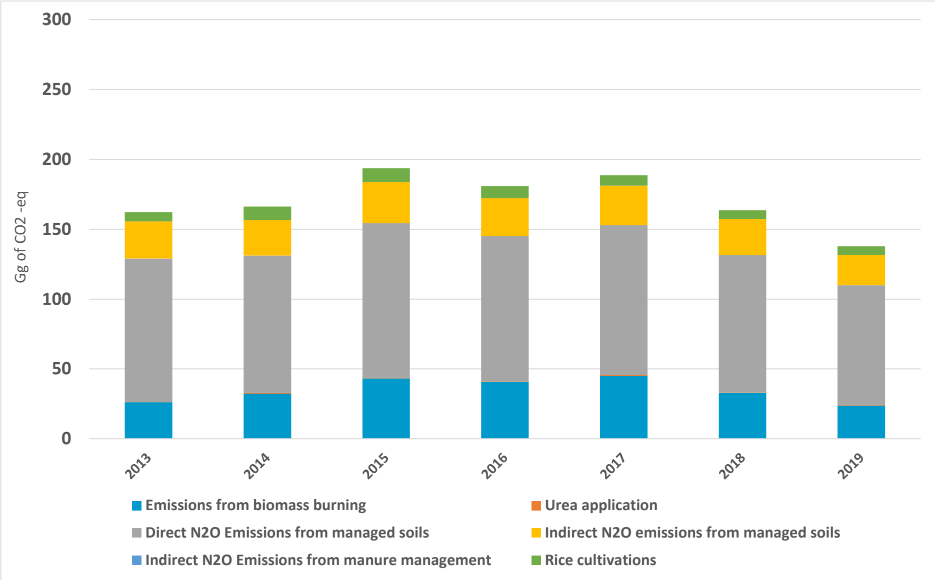


Figure 62. Non-CO_2 emissions from Category 3C from 1994 to 2019 ().

5.5.1. Biomass burning (3C1)

The burning of biomass is a practice that can occur in several ecosystems and for several reasons. In the case of Fiji, biomass burning occurs in both cropland and forestland. Therefore, while CO_2 emissions from biomass burning is included in the category Land 3B, the non-CO_2 emissions are included in the section 3C1. The following table summarizes the non-CO_2 emissions from the two sources accounted in this inventory.

Table 122. Summary table for non-CO_2 emissions from biomass burning.

Gas	Category	GHG emissions in Gg CO_{2eq}							Uncer-tainty
		2013	2014	2015	2016	2017	2018	2019	
CH_4	Biomass burning	20.50	25.29	33.84	31.91	35.13	25.71	18.60	176%
N_2O	Biomass burning	5.71	7.04	9.42	8.88	9.78	7.16	5.18	176%

3C1a. Emissions from biomass burning in forestland

Biomass combustion due to wildfires is a source of the following GHG gases: CO_2, N_2O and CH_4. CO_2 is accounted for since the CO_2 emissions and removals for the biomass pool are not assumed equivalent in the reporting year. In Fiji, biomass burning concerns only the softwood plantations, for which data was provided from 2015 to 2019 including annual information on the number of plots burned, the average time since planting of the plots and the total annual area being burned. The methodology deployed for this section followed the steps described in section 2.3.4 of this chapter. Given the use of averages for the years prior to 2015, the emissions are constant from 1994 to 2014. The following table and figure present the summary of emissions from biomass burning in forestland between 2013 and 2019.

Table 123. Non-CO_2 emissions from softwood burning.

Gas	Category		GHG emissions in Gg CO_{2eq}						
			2013	2014	2015	2016	2017	2018	2019
CH_4	Biomass burning	Forest	9.69	9.69	18.45	9.86	20.19	5.19	0.34
N_2O	Biomass burning	Forest	2.70	2.70	5.14	2.74	5.62	1.44	0.10

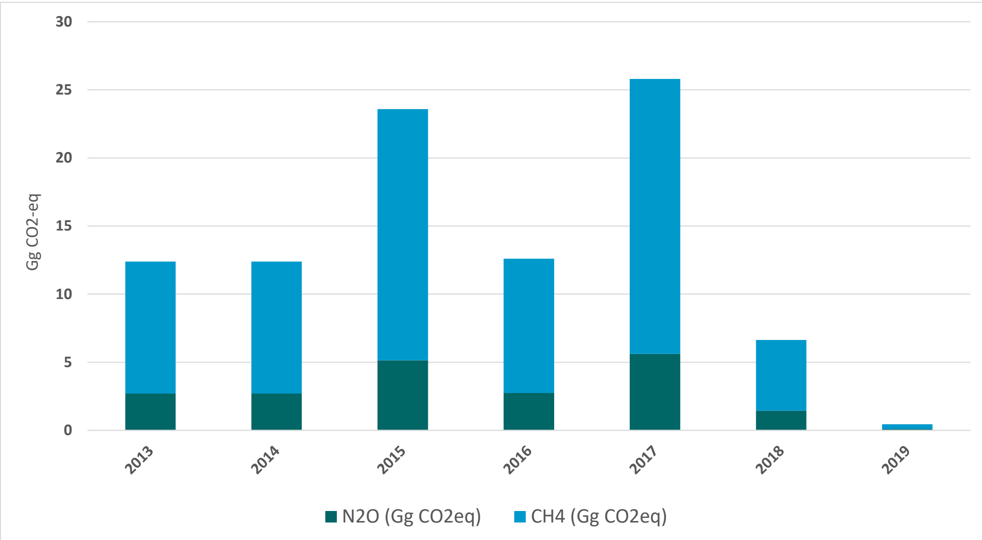


Figure 63. GHG Emissions from woody biomass burning in softwood plantations.

3C1b. Emissions from biomass burning in croplands

Non-CO_2 emissions from Cropland Remaining Cropland (particularly CH_4, CO, NOx and N_2O) are usually associated with burning of agriculture residues, which vary by country, crop, and management system. CO_2 emissions from biomass burning do not have to be reported, since the carbon released during the combustion process is assumed to be reabsorbed by the vegetation during the next growing season (see emissions from Cropland in section 4.4.2 of this chapter).

To estimate emissions from biomass burning of agricultural residue, the mass of fuel available for burning needs to be estimated. Tier 1 methodology was applied, using equation 2.27 for both CH_4 and N_2O emissions. The data available only referred to sugarcane residue burning: hence, the default emission factor for sugarcane of Table 2.6 of the IPCC guidelines was used (6.5 tons / hectare).

The following table and figure present the summary of emissions from biomass burning in cropland between 2013 and 2019.

Table 124. Non-CO_2 emissions from sugarcane burning.

Gas	Category		GHG emissions in Gg CO_{2eq}						
			2013	2014	2015	2016	2017	2018	2019
CH_4	Biomass burning	Cropland	10.81	15.59	15.39	22.06	14.95	20.53	18.26
N_2O	Biomass burning	Cropland	3.01	4.34	4.28	6.14	4.16	5.71	5.08

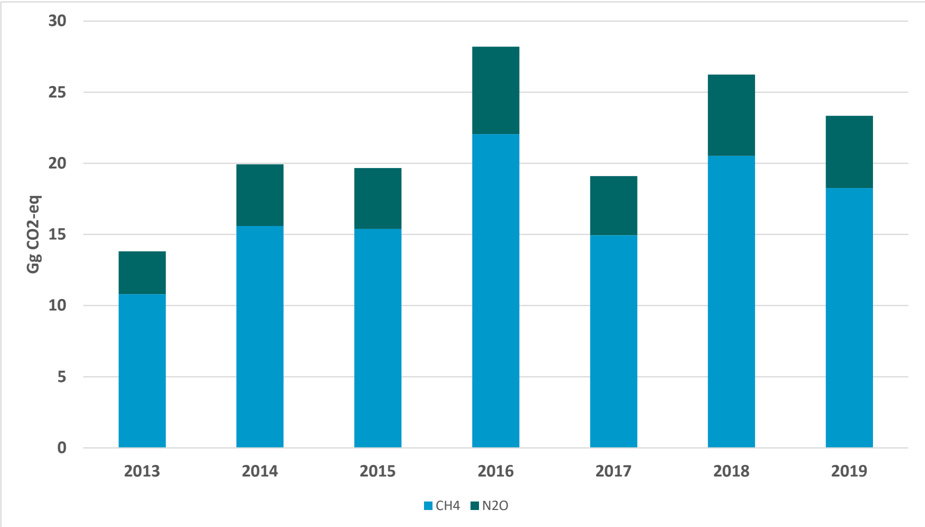


Figure 64. GHG emissions from sugarcane residue burning in cropland (Gg CO_2-eq).

5.5.2. Urea application (3C3)

Urea is a form of nitrogen fertilizer used in agriculture that can cause CO_2 emissions when applied to the soil. During the manufacturing process of urea, CO_2 is removed from the atmosphere. This CO_2 is accounted for in the IPPU Sector. Therefore, the emissions resulting from urea application are included in the emissions of the AFOLU sector. After the application of urea (CO(CH2)2) is converted to ammonium (NH4+), which is the fertilizing chemical, hydroxyl ion (OH-) and bicarbonate (HCO3-). Following soil chemical reactions, bicarbonate evolves into CO_2 and water.

The Tier 1 estimations for CO_2 emissions from urea requires to know the amount of urea fertilizer applied per year. Data on imported urea in Fiji was available on FAOSTAT from 2002 and 2018. Extrapolation was used to estimate the quantities for years outside of this period. For urea, the default emission factor estimates that 0.2 ton of carbon are lost as CO_2 emissions per ton of urea applied.

The following table and figure present the summary of emissions from urea application in Fiji between 2013 and 2019.

Table 125. CO_2 emissions from Urea Application.

Gas	Category	Unit	GHG emissions in Gg CO_2							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
CO_2	Urea application	Gg CO_2	0.32	0.40	0.24	0.29	0.71	0.36	0.39	50%

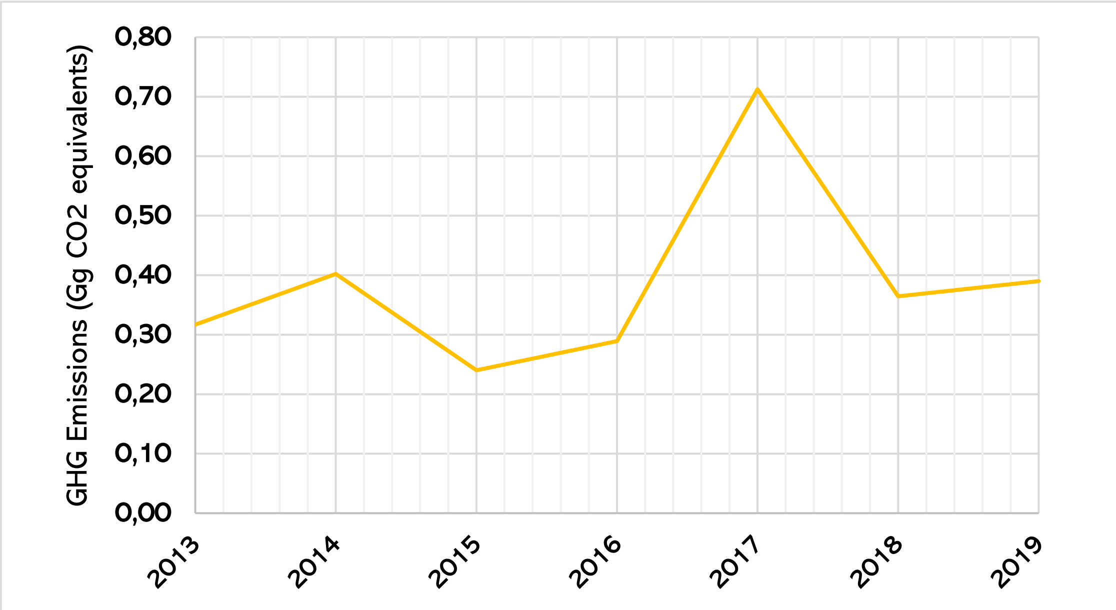


Figure 65. CO_2 emissions from Urea Application (Gg CO_2-eq).

5.5.3. N_2O emissions from Managed Soils

N_2O emissions naturally occur in soils. Nitrous oxide is produced through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N_2). One of the main controlling factors in this reaction and the resulting emissions is the availability of inorganic N in the soil.

Therefore, the estimations of emissions require the estimations of human-induced net N additions to soils. Different sources comprise nitrogen inputs from crop residues, application of synthetic nitrogen fertilisers, organic N input, N inputs from grazing animals, drainage of organic soils and land-use practices associated with land-use change.

The emissions of N_2O that result from anthropogenic N inputs or N mineralisation occur through both a direct pathway (i.e., directly from the soils to which the N is added/released), and through indirect pathways. For both categories, the activity data consists of the amount of nutrients added to soils: manure, urine and dung form grazing animals and crop residues.

5.5.3.1. Direct N_2O emissions from managed soils (3C4)

In most soils, the addition of nitrogen enhances the two processes responsible for N_2O emissions: nitrification and denitrification. The addition of nitrogen can come from several sources. The IPCC methodology includes the following:

- synthetic N fertilisers (FSN);
- organic N applied as fertiliser (e.g., animal manure, compost, sewage sludge, rendering waste) (FON);
- urine and dung N deposited on pasture, range and paddock by grazing animals (FPRP);
- N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal (FCR);
- N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils (FSOM);
- drainage/management of organic soils (FOS).

In the case of Fiji, the Tier 1 methodology was used first to estimate the factors cited above (expect the factor for drainage/management of organic soils given the absence of management system on such soil in Fiji). The organic N applied as fertilizer (FON) was equivalent in this case to the amount of animal manure N applied to soils (FAM) given the absence of data on total sewage N and total compost N applied to soils. The total direct N_2O emissions is the sum of emissions produced from nitrogen inputs and from urine and dung inputs to grazed soils.

The following table and figure present the summary of direct emissions from N_2O Emissions from Managed Soils in Fiji between 2013 and 2019.

Table 126. Direct N_2O Emissions from Managed Soils

Gas	Category	Unit	GHG emissions							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
N_2O	Direct N_2O emissions from managed soils	Gg N_2O	0.39	0.37	0.42	0.39	0.40	0.37	0.32	201%
		Gg CO_2eq	102.45	98.39	110.83	103.90	107.20	98.40	85.67	

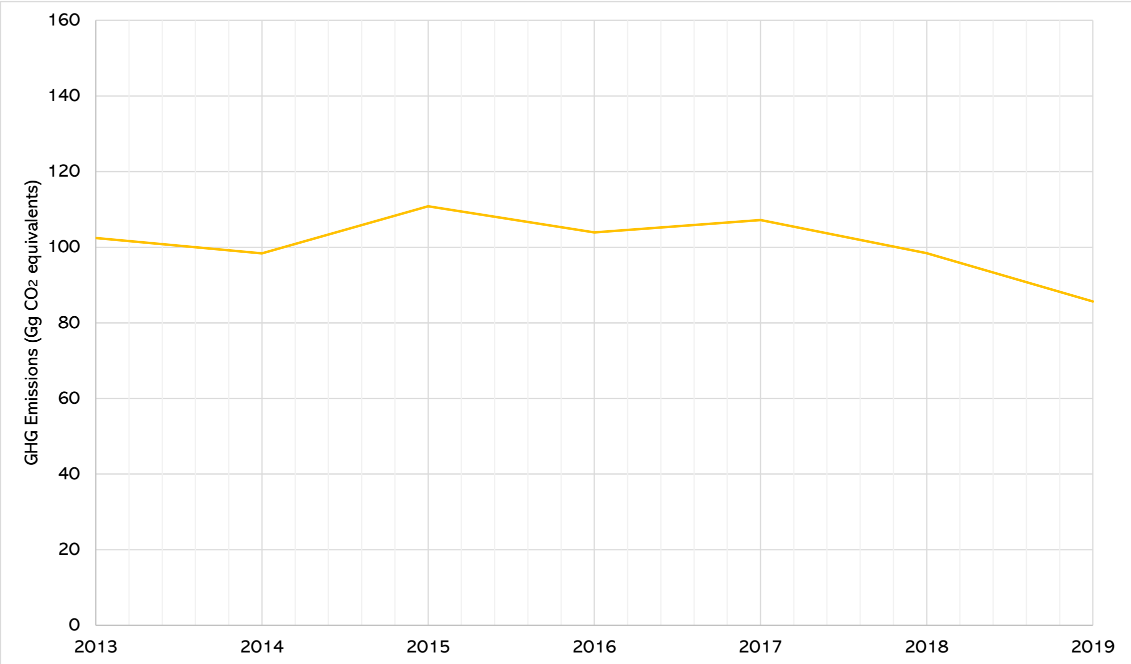


Figure 66: Direct N_2O Emissions from Managed Soils (Gg CO_2-eq)

5.5.3.2. Indirect N_2O emissions from managed soils (3C5)

There are two paths for indirect emissions of N_2O from managed soils: 1. following **volatilisation** of NH3 and NOx from managed soils and from fossil fuel combustion and biomass burning, and the subsequent redeposition of these gases and their products NH4 + and NO3 - to soils and waters; and 2. after **leaching and runoff** of nitrogen from managed soils. The nitrification and denitrification processes transform some of the NH4 + and NO3 - to N_2O. This may take place in the groundwater or in riparian zones or in the ditches, streams, rivers and estuaries into which the land drainage water eventually flows.

For Fiji, the estimations followed the Tier 1 methodology based on equations 11.9 and 11.10. In addition to the default emission factors provided in Table 11.3, the following N sources of indirect N_2O emissions from managed soils arising from agricultural inputs of N:

- synthetic N fertilisers (FSN);

- organic N applied as fertiliser (e.g., applied animal manure, compost, sewage sludge, rendering waste and other organic amendments) (FON);
- urine and dung N deposited on pasture, range and paddock by grazing animals (FPRP);
- N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (FCR); and
- N mineralisation associated with loss of soil organic matter resulting from change of land use or management on mineral soils (FSOM)

The following table and figure present the summary of indirect emissions from N_2O Emissions from Managed Soils in Fiji between 2013 and 2019.

Table 127. Indirect N_2O Emissions from Managed Soils

Gas	Category	Unit	GHG emissions in Gg CO_{2eq}							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
N_2O	Indirect N_2O emissions from managed soils	Gg N_2O	0.10	0.10	0.11	0.10	0.11	0.10	0.08	463%
		Gg CO_2eq	26.59	25.35	29.47	27.30	28.45	25.68	21.62	

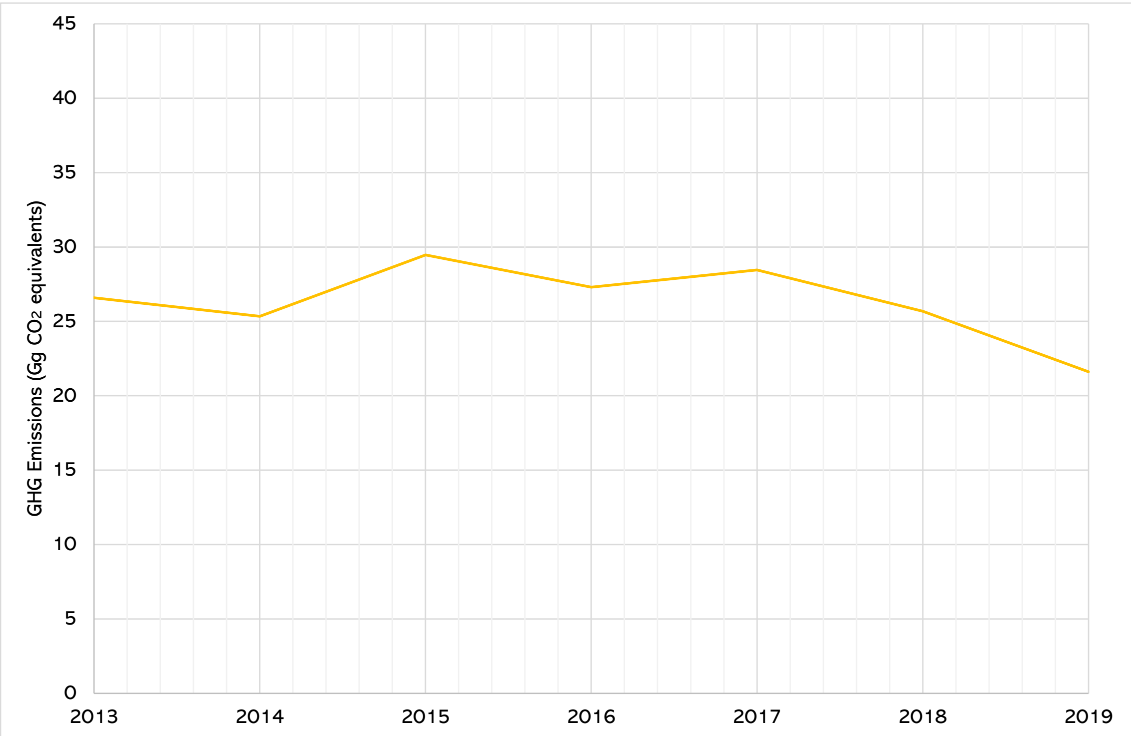


Figure 67: Indirect N_2O Emissions from Managed Soils (Gg CO_2-eq)

5.5.4. Indirect N_2O emissions from Manure Management (3C6)

In addition to the emissions from manure management treated above, nitrogen losses can occur indirectly, primarily in the form of ammonia and NOx. During manure collection and storage, a fraction of excreted organic nitrogen is mineralized to ammonia nitrogen. The quantity depends on the time of storage and to a lesser degree on temperature. Ammonia nitrogen is however very volatile, meaning it easily diffuses in the air. This process, called volatilization, is the first cause of indirect N_2O emissions. The second process, through leaching or run-off, occurs when nitrogen is transported outside of the manure management system.

In the case of Fiji, the estimations were realized with the Tier 1 methodology. In addition to the activity data and emission factors used in the category 3A2, default values for nitrogen loss due to volatilization of NH3 and NOx from manure management systems were used. Based on these factors, the calculations reveal that two livestock categories cause the majority of indirect N_2O emissions from manure management: dairy cattle and pigs.

In the case of dairy cattle, these emissions come from a combination of factor: the non-negligible proportion of dairy cattle whose manure is treated in lagoons (5%), the high nitrogen loss due to volatilization of this system (35%) and the constant increase of the dairy cattle population from 2011 to 2020 in Fiji.

In the case of pigs, these emissions come from a combination of factor: the high proportion of pigs whose manure is treated in lagoons (91%), the high nitrogen loss due to volatilization of this system (40%) and the high annual number of pigs produced in Fiji (27 866 heads in 2019).

The following table and figure present the summary of indirect emissions from N_2O Emissions from Manure Management in Fiji between 2013 and 2019.

Table 128. Summary of indirect N_2O emissions from manure management.

Gas	Category	Unit	GHG emissions							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
N_2O	Manure management	Gg N_2O	0.0056	0.0060	0.0061	0.0058	0.0059	0.0056	0.0067	318%
		Gg CO_2eq	0.01	0.01	0.01	0.01	0.01	0.01	0.01	

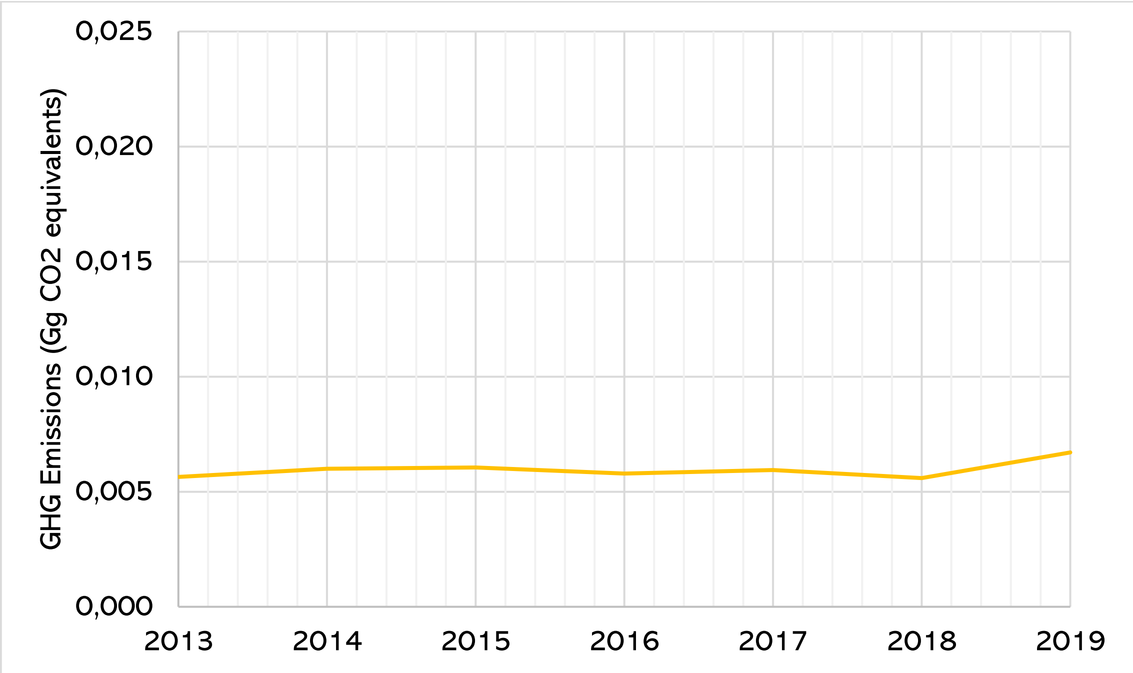


Figure 68. Total direct N_2O Emissions from Manure Management (Gg CO_2eq).

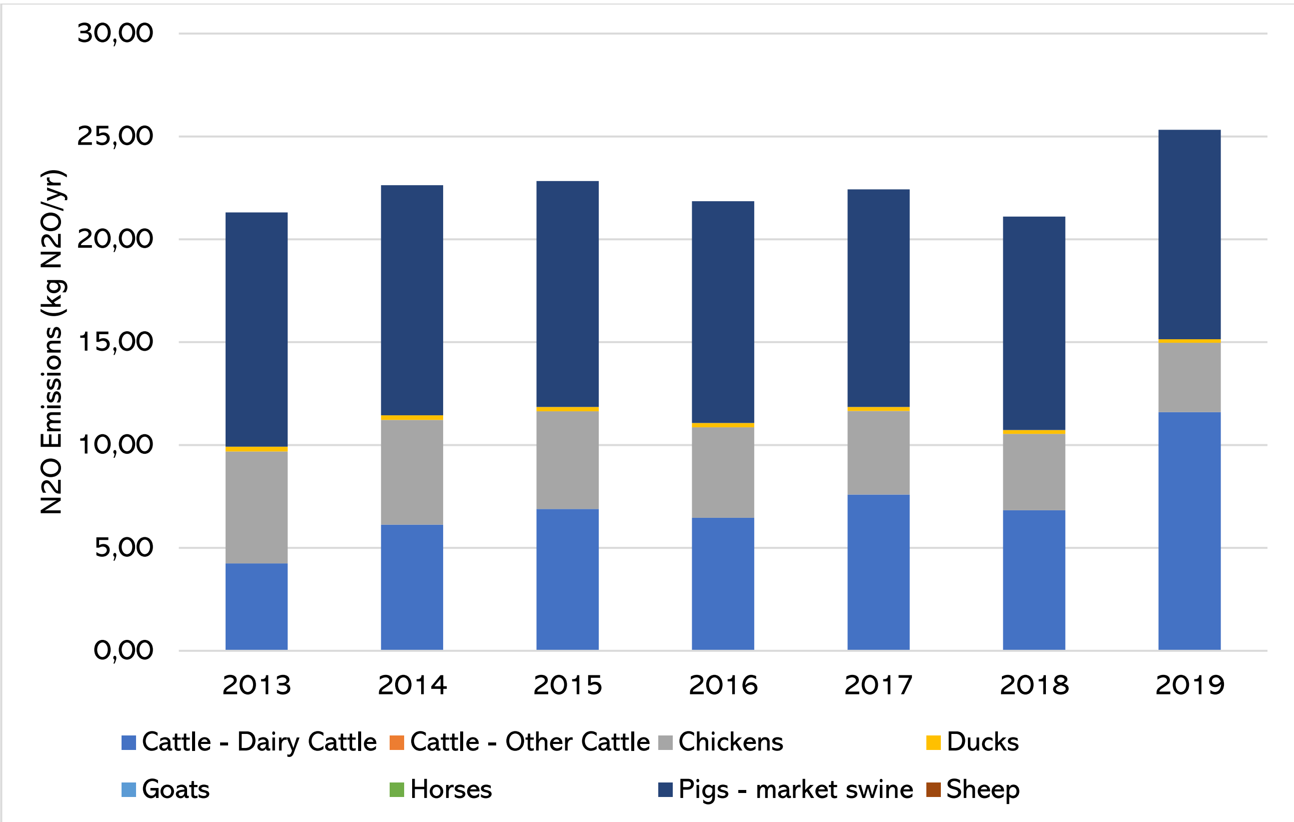


Figure 69. Indirect N_2O emissions from manure management by Livestock (Gg N_2O).

5.5.5. Rice Cultivation (3C7)

Rice production in different ecosystems can produce methane emissions at varied levels depending on flooded soil environment and agricultural practices. The emissions are caused by anaerobic decomposition of organic material in flooded rice fields which escape to the atmosphere by transport through the rice plants. Those cultivated in lowland have the higher potential to produce methane because of the aerobic condition created by intermittent inundation of the rice field. The determining factors of methane emission in upland rice system or under irrigation are the slope and the dwell time of available water to the rice.

Therefore, the potential of methane emissions from rice cultivation is influenced by the fraction of the total rice cultivation areas under rain fed, irrigation and upland, the prevailing management practices which include the number and duration of crops grown, water regimes before and during cultivation period, and organic and inorganic soil amendments and the environmental conditions such as soil type and temperature.

Data on annual rice cultivation areas can be obtained from agricultural statistics and the percentage area under different systems can be obtained using expert judgement if it is not available. In the case of Fiji, the harvested area was obtained from the FAO, as well as the proportion of the water regimes (irrigated, regular rainfed and drought prone), and the water regime cultivation period.

The Tier 1 methodology was deployed for estimating emissions from rice in Fiji, in particular equations 5.1 and 5.2 and the default parameters provided in the tables of the Section 4 of the Chapter 5 of the AFOLU Sector dedicated to Cropland.

Given the large areas of rice that are regularly rainfed and the intermediate level of its adjusted daily emission factor, the results show that regular rainfed rice fields contribute most to the total emissions from rice. Overall, the trend is negative on the inventory period (Figure 70).

The following table and figure present the summary of CH_4 emissions from Rice Cultivation in Fiji between 2013 and 2019.

Table 129. Methane emissions from Rice Cultivation.

Gas	Category	Unit	GHG emissions							Uncertainty
			2013	2014	2015	2016	2017	2018	2019	
CH_4	Rice cultivation	Gg CH_4	0.24	0.35	0.35	0.31	0.26	0.22	0.22	84%
		Gg CO_2eq	6.60	9.66	9.80	8.54	7.29	6.11	6.22	

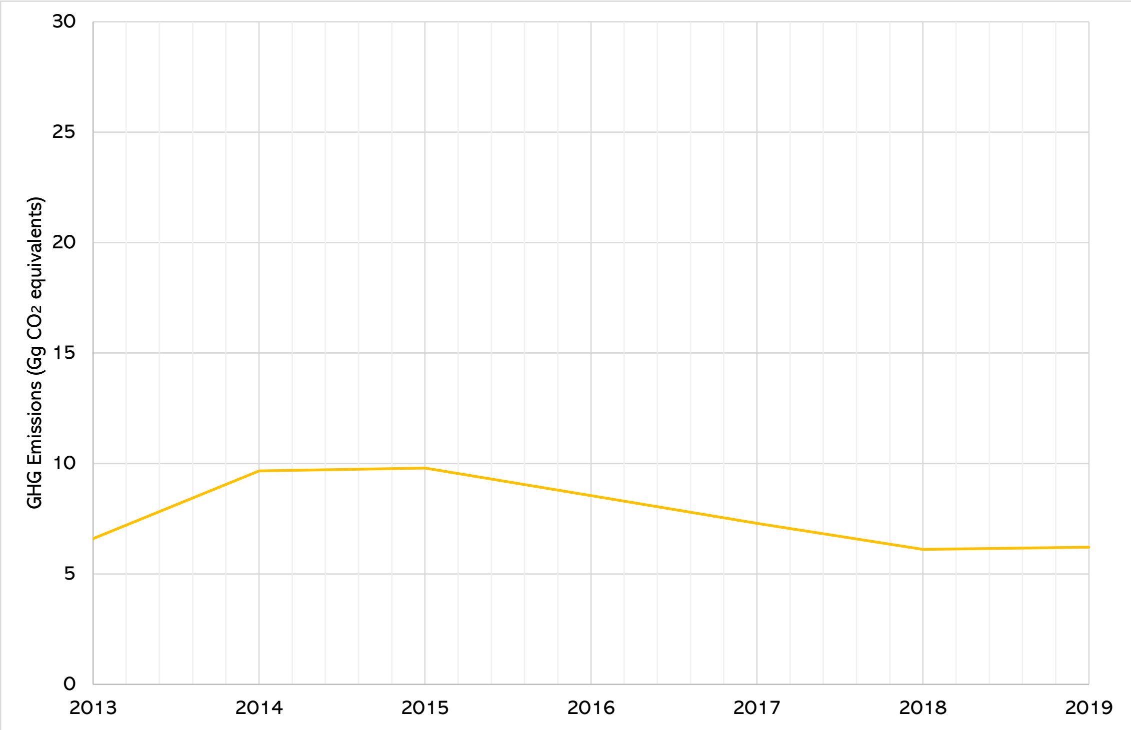


Figure 70. CH_4 Emissions from Rice Cultivation (Gg CO_2-eq).

5.6 AFOLU Planned improvements

During the inventory compilation, certain areas were identified for future improvements to ensure building greater confidence in the inventory estimate by reducing uncertainties to the extent possible. The widespread lack of data in the AFOLU sector led to the numerous assumptions, and the use of data filling techniques (extrapolation and interpolation) which hamper the accuracy and precision of the estimations.

Fiji is already underway in increasing data quality and availability. Efforts should be prioritized to enhance country-specific activity data collection systems that will greatly increase the accuracy of the inventory, focused primarily on the key categories of forests (3B1) corresponding to forest management and forestation, and grassland (3B3) corresponding to deforestation.

❖ **Category 3A: Livestock**

To estimate the methane (CH_4) and nitrous oxide (N_2O) emissions from livestock according of the tier 1 method form the 2006 IPCC Guidelines, it is fundamental to create an annual inventory of the annual livestock population in the country.

The inventory should compile the following information on an annual basis:

- Livestock population considering all the species (animal types) present in Fiji.
- Days alive per year for all the species present in Fiji

- Annual average temperature/year
- Average animal liveweight
- Annual amount of manure produced per animal type/year (kg of manure/animal type/year)
- % of Manure management system used per type of animal (please, see definitions in the following table)

The data used for the inventory gathered survey data, the livestock characterization used for the TNC, combined agriculture data and the agriculture census of 2009 and 2020. These files were however insufficient to obtain a consistent annual livestock population. It is highly recommended to collect a consistent time series on the annual livestock population for all reporting years

The days alive for all the species were not available either. While IPCC defaults values and expert judgments could be used, it is recommended to develop country-specific estimates.

More broadly, it is recommended to ensure that the default emission factors used correspond to the country circumstances and obtain more detailed information allowing to move to higher tier methodologies.

- **Category 3B: Land**

The emissions and removals resulting from the Land sector depends on the quality of the spatial activity data. The main activity data for the sector is the area of each of the 6 IPCC land use, as well as the transitions from one land use to another at a certain point in time. The level of refinement of the spatial distribution and land use change largely determines the Tier that can be used for the calculations.

The previous work upon which the activity data used was sourced are the FRL and the ER-PD document, which follow a REDD+ land stratification. In addition, the land cover estimations have been focused on forests, without differentiating between the 'non-forests' types of land uses.

This situation has led to the assumption that forested area were previously grassland, and deforested area were turned into grassland. This may be false in numerous cases leading to high levels of uncertainty of emissions from land use transitions in national forests. Additionally, no data was available for settlements, wetlands and other lands, leading to zero emissions from these categories despite their potential contribution.

It is highly recommended to develop land use and land cover estimations using remote sensing techniques deployed for the FRL with the appropriate IPCC land stratification. This spatial assessment will allow the use of higher tier methodologies and lead to uncertainty reduction and more accurate estimations.

A long-term land use monitoring strategy for all land uses create robust, consistent, comprehensive, and cost-effective data with high resolution both for REDD++ and national GHG inventories. Recent advances in remote sensing such as lidar technology have the potential for C stock estimation through correlation between lidar canopy metrics and biomass quantities.

Only the carbon stock changes from biomass (gains and losses) were included in the estimations for this category. The lack of data on dead wood, litter and soil organic carbon is the main reason. It is highly recommended to perform country-specific estimations of these stocks of carbon for natural forests and plantations in order to improve the exhaustivity of the inventory.

- Category 3B1

The data on biomass gains and losses from forests, both natural and plantations, have been insufficient both spatially and temporally to make consistent and exhaustive estimations of associated CO_2 emissions. Overall, the area of forest included in the Forest Reference Level cover 94% of Fiji's forest area. It would be a good practice towards exhaustivity to include and to estimate emissions from 100% of the forest area. The estimations of forests could furthermore include specific estimations for managed mangroves. Coconut plantations could also be considered if they fulfil the criteria for defining forests in Fiji.

Concerning logging, currently limited data are available for volume and carbon increments for natural forests. For the FRL unpublished data from the REDD+ Pilot site at Nakavu were used to determine mean annual increments of carbon (0.99 tC ha^{-1} yr^{-1} including above- and below-ground biomass). This important, obtained through expert judgement by Mussong (personal communication) is valuable as it is country specific. Yet, adjustments and/or confirmation of this value should be realized through sampling efforts in natural forests.

In plantations, it has been reported that log-scalers may have missed stems (e.g., stems have been cut by a logging company but were not hauled to the landings) leading to a small downwards "bias" of published volumes. Timber that was purposefully not hauled to the log landings is considered illegal logging, which is, because of lack of data, not covered in the FRL. However, omitting this quantity may lead to an underestimation of emissions from logging. While data collection for these types of harvested wood may be difficult to gather, it is recommended to make an estimation of the potential underestimation and derive a factor that could be applied to future data on official harvested volumes.

Then, the timer / fuel wood harvesting has not been included in the estimations for biomass loss, since data on fuelwood use during the reference period is limited. Therefore, it is recommended to design and implement a systematic fuelwood collection protocol to add this traditional mode of harvesting in the totals.

- Category 3B2

As exposed in the methodology section, estimating the emissions from perennial wood crops required too many assumptions given the data available and so it was decided to not include this source. However, as shown in the Agriculture Census, numerous perennial crops are cultivated in Fiji, leading to an underestimation for this category. Calculating these emissions is therefore a priority. It is recommended to estimate the average years of crop field for each crop type.

- Category 3B3

The emissions from deforestation were based on the average values used for the FRL. The lack of data outside of the reference period meant the emissions from 1994 to 2006 could not get estimated. It is highly recommended to develop annual system of land use analysis to capture the spatial dynamics of deforestation.

❖ Category 3C: Aggregated sources and non-CO_2 emissions sources on land

This group of activities include several practices related to Agriculture and Forestry activities that may occur in Fiji related to managed soils.

Concerning biomass burning, data was made available for sugarcane residue burning, which is likely to be the most relevant crop in terms of emissions from burning. Nonetheless, the source of the data was not indicated. In addition, other crops could be subject to similar management techniques involving emissions from fire. It is recommended to systematically provide the source for data provided, and to collect additional information on fire burning for all types of crops.

Liming constitutes an important source of CO_2 emission in the category 3C. However, due to absence of data these emissions could not be estimated in Fiji. It is recommended to determine the amount of calcic limestone and of calcic dolomite applied to the agricultural soils, or imported in the country, from which emissions could be derived.

Similarly, the application of urea leads to CO_2 emissions that need to be estimated. The data provided covering only the urea fertilization between 2006 to 2011, it is recommended to extend the urea fertilization time series to the complete inventory period.

Concerning emissions from managed soils, the amount of synthetic fertilizers applied to soils was sourced from the FAO databases. While the data is of high quality, it is recommended to collect national data on synthetic fertilizers applied to soils. This is even more important in the case of organic nitrogen fertilizer since no data from international sources is available.

Estimations of the CH_4 emissions from rice could benefit from additional information for the water regime before the cultivation period of each rice production areas as well as indications on the national average cultivation period of rice.

The following table summarises the improvement areas, institutions responsible, and proposed period of implementation for the AFOLU Sector.

Table 130. Improvement Plan for the AFOLU Sector in Fiji.

AFOLU Sector: Improvements for Category 3A			
Identified fields of improvement			
Develop of a livestock population monitoring tool to collect more detailed information on livestock population, ensure that the default emission factors correspond to national circumstances, obtain more detailed information on management regimes to deploy high tier methodologies			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Assess the days alive for all the species present in Fiji and responsible for GHG emissions	2023	Ministry of Agriculture

2	Ensure that the default EFs used correspond to the country circumstances by checking the background information used for the development of the default EFs. Such information is available in the annexes and also in tables 10.10 and 10.11 of the 2006 IPCC Guidelines (e.g. weight, average milk production).	2023	Ministry of Agriculture
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Develop an annual livestock population monitoring tool to collect consistent and precise data for all types of livestock. For 3A1, enhance characterization and estimate the gross energy intake with methane conversion factors and emission factors for significant livestock categories, particularly dairy cattle and other cattle, to deploy a Tier 2 methodology. For 3A2, for CH_4 emissions, collect the information, stratified by temperature (average annual), and use the manure characteristics (equation 10.23 of the 2006 IPCC Guidelines) and manure management systems allowing to move to a tier 2 and for N_2O emissions, develop country specific N excretion rates and EFs focusing in priority on pig production systems allowing to move to a tier 2.	2024	Ministry of Agriculture
AFOLU Sector: Improvements for Category 3B			
Identified fields of improvement			
Produce a spatially explicit land use map of Fiji terrestrial land based on the 6 IPCC categories and develop a long-term land use monitoring tool designed to estimate the land cover and land use transitions for the 6 categories annually. Develop empirical estimate of dead wood and litter amounts for each major forest types. Develop a detailed soil assessment of land types in Fiji and quantify the soil organic content per land use. These improvements will avoid the use of assumptions and expert judgments to increase the accuracy of the estimates			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Assess the mean annual increments of carbon in natural forests	2023	Ministry of Forestry
2	Quantify the proportion of wood harvested omitted per logging areas and adjust the emission estimates	2023	Ministry of Forestry
3	Collect data on the cutting cycle of perennial woody crops to estimate the annual biomass loss from cropland and derive emission estimates	2023	Ministry of Forestry & Ministry of Agriculture
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Develop a land use map of Fiji terrestrial land surface using the IPCC land stratification. Produce annual estimates of area for each land use and quantify land use transitions annually to move to tier 3 methodology.	2024	Ministry of Forestry
2	Collect annual data on disturbances from fires, hurricanes, droughts, and other types of carbon losses (area, and average carbon stocks in the area affected).	2024	Ministry of Forestry & Ministry of Agriculture
3	For forests, area, coverage and height minimum thresholds should be provided and used in the classification of lands and information should be collected on growth (biomass growth or increment), carbon losses, especially from biomass (wood removals, wood fuels, disturbances) and growing stock	2024	Ministry of Forestry

	information in forestland on a routine basis. One possibility is to establish data sharing agreements with FPL and FHCL companies to deliver data on their use of the plantation area on a yearly basis		
Long-term Actions		Proposed period of implementation	Institution responsible
2	Estimate the dead wood and litter content per hectare for natural forests, both upland and lowland, and for plantations, both softwood and hardwood.	2025	Ministry of Forestry
3	Quantify the reference carbon stock in mineral soils per climate and soil combination to include gains / loss of mineral soil carbon due to land use transitions. Include an assessment of management changes for estimating carbon stock changes in soils (this should consist of estimates of initial and final land use areas as well as the total area of land that is unchanged by category for each year of the inventory)	2025	Ministry of Forestry
AFOLU Sector: Improvements for Category 3C			
Identified fields of improvement			
Improve data collection efforts on biomass burning and fertilization in cropland (liming, urea, synthetic & organic fertilizers) and gather country-specific parameters for rice cultivation. Use expert judgement from local agriculture experts on the proportions of animal manure by animal type applied to soils			
Medium-term Actions		Proposed period of implementation	Institution responsible
1	Collect survey data on the use of fire management techniques per crops in Fiji and consolidate existing data on sugarcane residue burning	2024	Ministry of Agriculture
2	Use expert judgement from local agriculture experts on the proportions of animal manure by animal type applied to soils.	2024	Ministry of Agriculture
3	Assess the quantities of fertilizers being applied to the soils, or imported through international trade, for liming, urea, as well as N fertilizers (both synthetic and organic) to estimate the CO_2 and N_2O emissions from human inputs to soils	2024	Ministry of Agriculture
4	Gather information on rice cultivation periods and water regimes before cultivation for the main rice cultivation areas and use country-specific emission factors	2024	Ministry of Agriculture

CHAPTER 6: WASTE SECTOR

6.1. Overview of the waste sector

The Waste Sector includes all greenhouse gas (GHG) emissions arising from the decomposition of the degradable matter in solid and liquid wastes, as well as the GHG emissions arising from the burning and incineration of wastes of fossil origin.

6.1.1 Description of the waste sector

The Waste Sector of Fiji has undergone a transformational change since the beginning of the 21st century and continues evolving towards the attainment of national long-term sustainable and low-carbon development goals[17].

Solid waste

There are four main types of solid waste generated and managed in Fiji, namely municipal solid waste, clinical waste, quarantined waste and industrial waste. The definition of each type of waste is provided as follows:

- **Municipal Solid Waste (MSW):** Municipal solid waste refers to all waste that is typically collected by local authorities and includes waste from households, commercial institutions, public institutions, as well as construction and demolitions sites. Over 73% of the MSW generated in Fiji is organic waste, including food residues and park wastes with the remaining 27% comprised of paper/cardboard, plastics, and textiles, among other inter wastes, as shown in Figure 71. For the most part, MSW is not segregated prior to final disposal, with the exception of recent recycling and compost initiatives.
- **Clinical waste:** Clinical waste refers to residues generated via healthcare services, including both inside and outside hospitals and healthcare facilities, including sharps, pharmaceutical/cytotoxic waste, syringes, vials, mortuary waste, pathology waste, and general healthcare waste such as bandages. District Divisional Hospitals in Fiji implement clinical waste segregation procedures, whereby infectious and pathological wastes are placed in yellow garbage bags, used sharps are placed into yellow rigid containers, pharmaceutical/cytotoxic wastes are placed in purple bags, empty vials are placed in cardboard boxes, and general healthcare waste is placed in clear or black bags. With the health crisis provoked by the COVID-19 pandemic, wastes from isolation and quarantine health centres have also become an important component of clinical wastes generated and treated in Fiji Starting in 2020. The

[17] *Note – the information provided in section 6.1.1 provides a description of the waste sector using the activity data and results of the inventory. Therefore, for the specific data used, methodologies followed and results obtained please refer to the below methodological sections.

additional clinical wastes generated by the COVID-19 pandemic will need to be accounted for accordingly in future editions of the GHG emissions inventory of Fiji.

- **Quarantined waste:** Quarantined waste refers to all waste that is typically collected by the Biosecurity Authority of Fiji through the main import gateways for goods and services such as the King´s Warf and the King´s Warf. As shown in Figure 72, its composition is similar to that of MSW, whereby food waste accounts for nearly 50% of all quarantined waste, wood and garden waste correspond to 23% and the remaining 27% is comprised of paper/cardboard, textiles, and other inter wastes.
- **Industrial waste:** Industrial waste refers to all waste generated by manufacturing industries or factories, as well as construction and demolition. In Fiji, industries and factories are responsible for managing their own waste, and the majority of waste generated by industries in rural areas and councils are uncollected. Due to a lack of data on industrial waste generation rates, composition, and treatment processes in Fiji, the treatment and disposal of this type of waste has been excluded from the present edition of the GHG inventory. For future improvement, it is planned to commence investigations and data collection on Fiji´s industrial waste generation, characteristics, and handling in order to include them in future GHG emissions inventories.

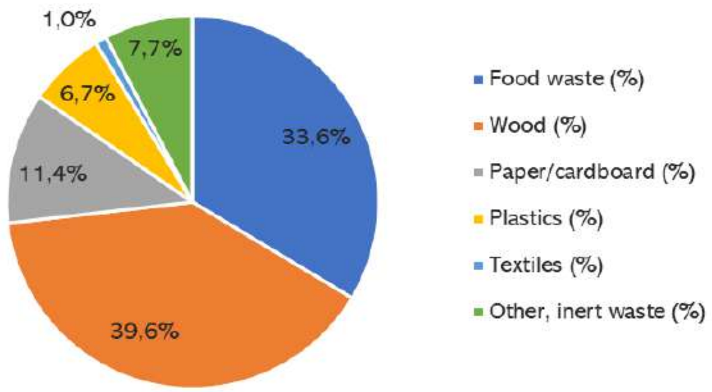


Figure 71. Composition of MSW in Fiji by IPCC Waste Categories.

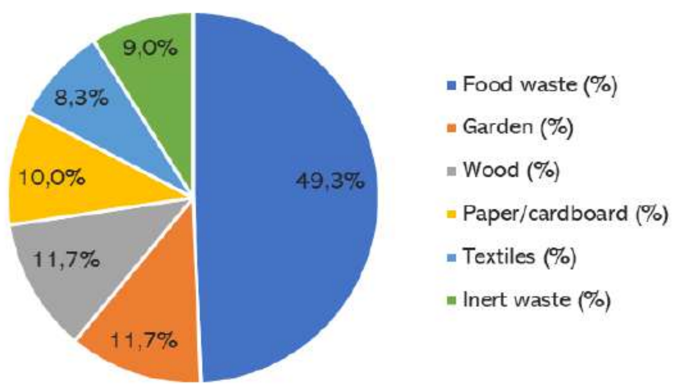


Figure 72. Composition of Quarantined Waste in Fiji by IPCC Waste Categories.

There is a clear differentiation in the MSW generation rates and management practices between the urban and rural population. Detailed waste generation surveys were carried out in 2009 under a JICA Project in Lautoka City and Nadi City. According to this survey, Nadi City Council generates 0.42 Kg/person/day of household waste, 0.4 Kg/person/day of MSW in rural areas and 1.9 Kg/person/day of MSW in urban areas. On the other hand, Lautoka City Council generates 0.46 Kg/person/day of household waste, 0.4 Kg/person/day of MSW in rural areas and 1.1 Kg/Person/day of MSW in urban areas. For the purpose of GHG emission inventory preparation, it is assumed that rural communities in Fiji generate MSW at a daily rate of approximately 0.4 Kg/person/day while the urban population generates MSW at a daily rate of 1.5 Kg/person/day, assumed to remain constant throughout time. In addition to a greater consumption and purchasing power, urban populations have a higher waste generation rate due to the contributions of commercial, institutional, and tourism activities.

There are a total of nine (9) solid waste disposal sites (SWDS) in Fiji, eight (8) of which are currently operational, as described in Table 130. A solid waste disposal site is defined as any area where solid waste is deposited after it is used, including both managed and unmanaged sites. The 2006 IPCC Guidelines define these SWDS in the following way:

- **Managed SWDS:** Landfills which have controlled placement of waste and cover material, mechanical compacting, or levelling of the waste, whereby treatment may be aerobic or anaerobic. Some sites may also have a leachate drainage system, a regulating pondage, or a gas ventilation system.
- **Unmanaged SWDS:** Formal open dumps and/or informal dumping in above-ground piles, holes in the ground, or natural ravines, with uncontrolled waste deposition.
- **Uncategorized SWDS:** Solid waste disposal sites that cannot be categorized as either managed or unmanaged.

Table 131. Solid Waste Disposal Sites in Fiji.

SWDS	Years Active	Type of Treatment	Open Burning	Methane Recovery	Sludge Disposal
Naboro Landfill	2005-2019	Anaerobic well-managed	No	No	No
Sigatoka Dump	1950-2019	Uncategorized open dump	Yes	No	No
Lautoka (Vunato) Dump	1950-2008	Unmanaged shallow open dump	Yes	No	No
Lautoka (Vunato) Dump	2009-2019	Managed semi-aerobic	No	No	No
Ba Dump	1950-2019	Uncategorized open dump	Yes	No	No
Rakiraki Dump	1950-2019	Uncategorized open dump	Yes	No	No
Savudavu Dump	1950-2019	Uncategorized open dump	Yes	No	No
Labasa Dump	1950-2019	Unmanaged shallow open dump	Yes	No	No
Levuka Dump	1950-2019	Uncategorized open dump	Yes	No	No

SWDS	Years Active	Type of Treatment	Open Burning	Methane Recovery	Sludge Disposal
Lami Dump	1950-2005	Unmanaged deep open dump	Yes	No	No

The Lami Dump is an uncontrolled waste dumpsite serving the Suva area for more than 50 years, posing a serious threat to human and environmental health through leachate leakage and high risk of fire. The Lami Dump was ultimately closed in July 2005 following the breakout of a major fire which emitted highly toxic smoke and replaced by the Naboro Landfill in October that same year. The Naboro Landfill constitutes Fiji's first and only modern anaerobic sanitary engineered landfill, featuring a selective placement and compaction of waste, a compacted clay protective liner, and a leachate collection system. It is operated by HG Leach, a private company awarded the contract for the operations and management of the Naboro Landfill for the Department for Environment, catering to areas around Suva, Nasinu, Nausori, Navua and Korovou. Waste deposition at the site will occur in four stages, with stage 1 filled in 2016 (Figure 73). Although feasibility studies have been conducted on the methane recovery and flaring potential at the Naboro Landfill, this technology has not yet been adopted by Fiji.

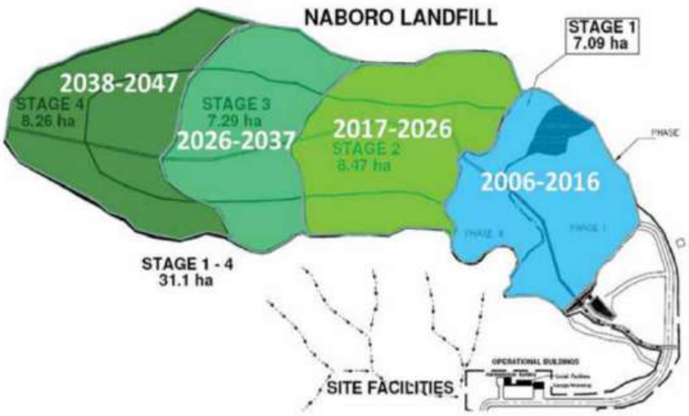


Figure 73. Four Stages of the Naboro Landfill[18]

Since its opening in 2005, the Naboro Landfill disposes weighbridges and maintains detailed records of monthly waste deposition quantities by waste category. Under the Waste Minimization and Recycling Promotion Project funded by the Japan International Cooperation Agency (JICA), improvements were made in 2009 to the Vunato Waste Disposal Site, servicing Nadi Town and Lautoka City, including the installation of a weigh bridge, data collection systems, composting facilities, green waste chipping, and special waste disposal areas. Since this date, the Vunato Site operates as a managed open anaerobic method. All other seven SWDS in Fiji do not dispose of weighbridges of robust data collection systems.

[18] Pre-feasibility study for methane recovery at Naboro Landfill, Suva, Fiji Islands: Final Report on projects funded by PACE-Net Plus seed funding grants 2015. Dr. Francis Mani. The University of the South Pacific. (2016).

With the exception of the Naboro Landfill and the Vunato Site, open burning of waste occurs frequently among Fiji´s SWDS. Both registered and uncontrolled waste pickers frequently work to collect recyclable materials such as plastic bottles, hard plastics, metal and aluminium from Fiji´s SWDS, with an estimated recovery rate of 1% of all the deposited waste at each site.

Under the Local Government Act, city and town councils are responsible for the management of solid waste, including the enforcement of the Litter Decree 2010, Public Health Act, and Open Fires by-laws, the collection of garbage, and the operation of composting and recycling programmes. Until the year 2011, approximately 82% of the urban population had access to waste collection services, increasing to a value of 92% after 2012. Municipal solid waste is stored by residents and commercial establishments in small bins and plastic bags kept outside the house on raised platforms. With the amalgamation of Rural Local Authority Areas with Municipal Council in October 2008, Municipal Councils are responsible for providing extended service for the collection of household garbage from densely populated periurban/rural areas. For instance, Lautoka City Council provides garbage collection services to additional rural 4734 households and 2649 loads amounting to 4138 tons of garbage had been collected from November 2008 to October 2021.

Until 2012, nearly all the collected MSW has been deposited at SWDS. Through the 2009 JICA Waste Minimization and Recycling Promotion Project, approximately 13% of collected wastes are diverted away from solid waste disposal sites each year for composting and recycling. Large-scale composting campaigns have begun operation in 2012 whereby household organic waste is collected, composted, and sold by several town/city councils and municipal markets throughout Fiji. Currently, there are five major organic waste composting programs in the following municipal areas: Ba, Lautoka, Nadi, Sigatoka and Suva[19]. Centralized composting facilities are currently in operation at the Suva Market and the Lautoka Market. Composting facilities are established in Lautoka and Suva City to recycle market organic wastes generated from Suva and Lautoka Markets respectively. Lautoka City Council sold 121.09 tons of compost and recycled total of 2208 tons of market organic waste since 2011. Home composting has also been recently promoted under national Home Compost Subsidy Programme whereby citizens are encouraged to purchase compost bin at subsidized rate of $30.00.

Recycling initiatives have also gained strength since 2012. Under a joint partnership between Coca Cola-Amatil and Fiji Water, 60 kg sacks are provided to households and institutions for the collection of plastic bottles and aluminium cans, offering F$0.75 ($0.41 USD) to F$1 ($0.54 USD) per Kg of recycled material, depending if the bottles and cans are picked-up on location or delivered to the central factory, respectively. The collected recyclables are then exported to New Zealand. Approximately ten (10) licensed scrap metal dealers buy scrap metals like iron, copper, and aluminium, for export. South Pacific Recyclers is the only licensed wastepaper recycling company in Fiji, operational since January 2012. Beer bottle collection services are also provided by local beer producers for reutilization. Nevertheless, it shall be noted that low recycling or resource recovery rates in Fiji is

[19] Cleaner Pacific 2025 – Pacific Regional Waste and Pollution Management Strategy 2016-2025. ISBN 978-982-04-0571-4.

attributed to lack of financial incentives like Container Deposit scheme and lack of enforcement on container deposit Legislation.

Wastes generated by informal and squatter settlements peripheral to city and town boundaries are not collected by the councils because they do not pay town rates. Uncollected waste among the urban population is managed through various informal handling methods, including household-level recycling, composting, open burning, and illegal dumping. The rural population has very limited (if any) access to waste collection services. Rural waste management practices include a combination of open burning, reuse, burial, composting, littering, and feeding of pigs, with the most common practice being open burning. However, very limited quantifiable data currently exists on rural and uncollected urban waste management practices in Fiji. Due to a lack of data, it has been assumed that 100% of the rural population of Fiji and 100% of the population without access to waste collection services (including informal and squatter settlements) conducts open burning, as per the default method in the 2006 IPCC Guidelines.

Under Open Fires by-laws and the 2008 Littering Act, open burning of waste and littering are illegal in Fiji. “Litter prevention officers” have the power to impose on-the-spot fines of F$40 ($21.60 USD) for littering in public spaces. However, there is no fixed penalty for open burning of wastes. Nevertheless, illegal dumping and burning of waste are still very common due to inadequate enforcement. Whilst the 2008 Litter Act is adequately enforced by most municipalities, lack of enforcement on burning of waste is due to lack of fixed penalty mechanism for offences related to burning of wastes. The Lautoka City Council, for example, issues an average of 250 litter offence notices per year with more than 2000 litter warnings which are complied with.

It must be noted that open burning and accidental fires are commonly observed in Fiji´s open dumpsites. In fact, Lami Dump´s closure was partly motivated by the massive fire that broke out in 2005, releasing highly toxic smoke which was a threat to both human and environmental health. As per the 2006 IPCC Guidelines, it has been assumed that open burning occurs throughout all of Fiji´s open dumpsites.

For the purpose of preparing the national GHG inventory of Fiji, MSW management practices in Fiji have been divided into four periods, differentiated by the main changes in the Waste Sector as follows:

- **1950-2004:** The Lami dump is operational.
- **2005-2008:** The Lami Dump is decommissioned, and the Naboro Landfill is opened.
- **2009-2011:** The Vunato Site begins operation as a managed aerobic site under JICA improvements.
- **2012-2019:** Recycling and large-scale composting initiatives are introduced through the JICA Waste Minimization and Recycling Promotion Project.

The following four figures illustrate the MSW management pathways and systems in Fiji considering the four time periods described above.

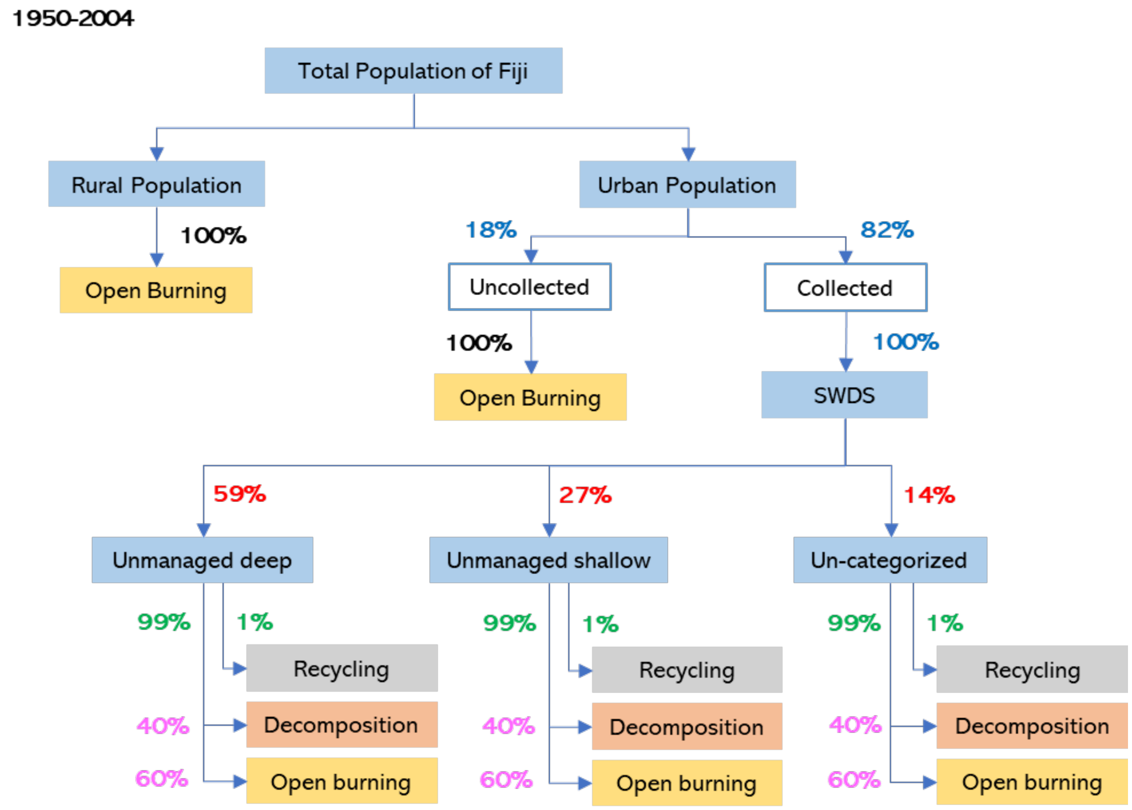


Figure 74. MSW Management Pathways and Systems in Fiji, 1950 to 2004.

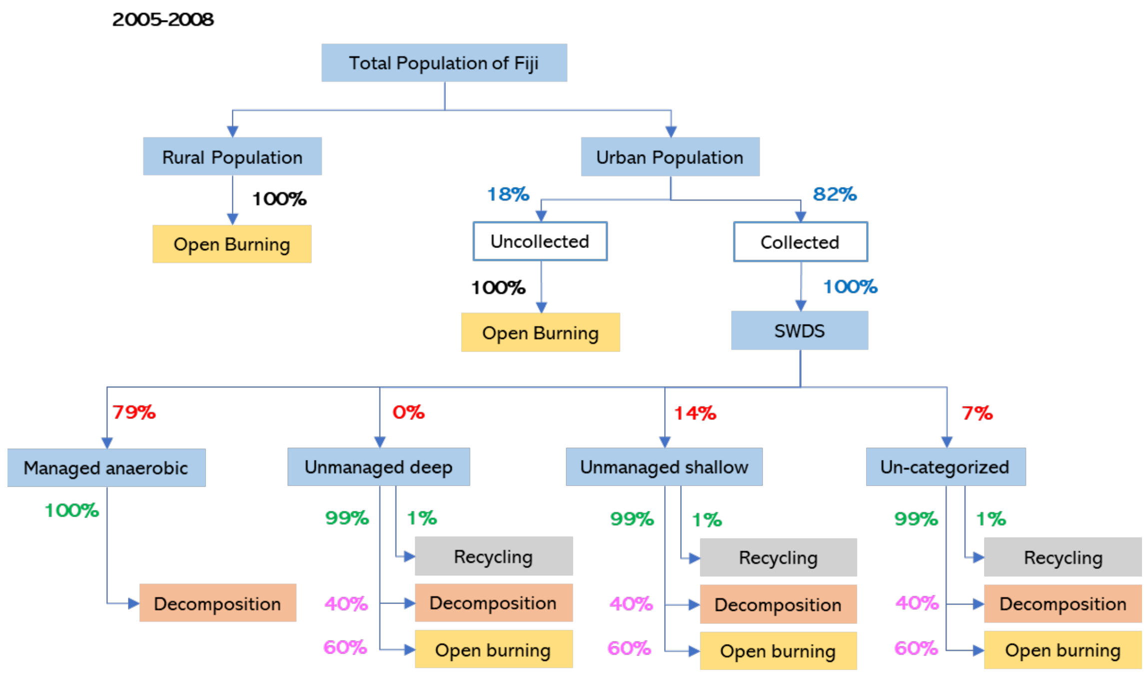


Figure 75. MSW Management Pathways and Systems in Fiji, 2005 to 2008.

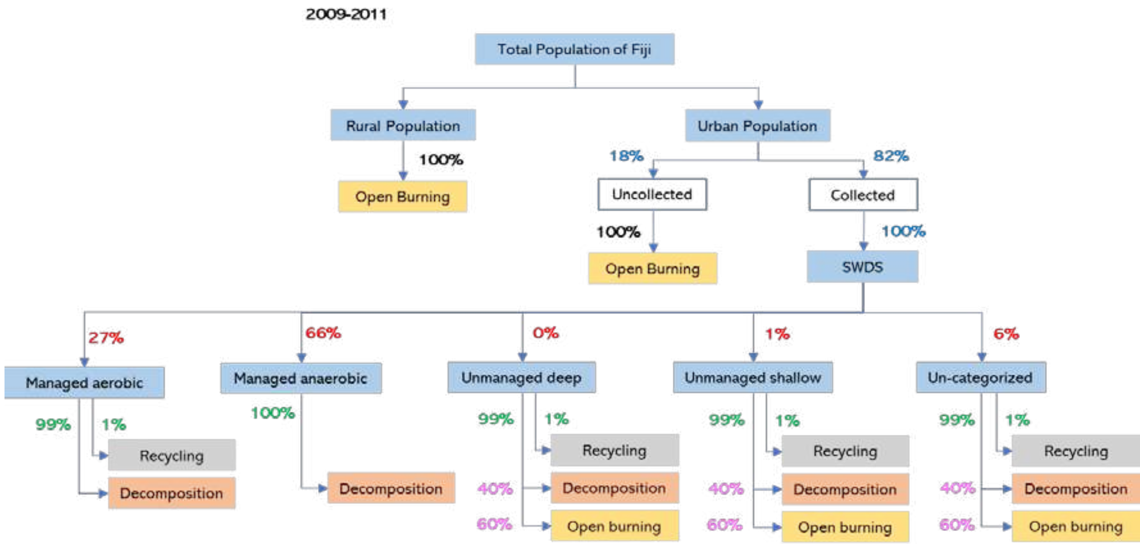


Figure 76. MSW Management Pathways and Systems in Fiji, 2009 to 2011.

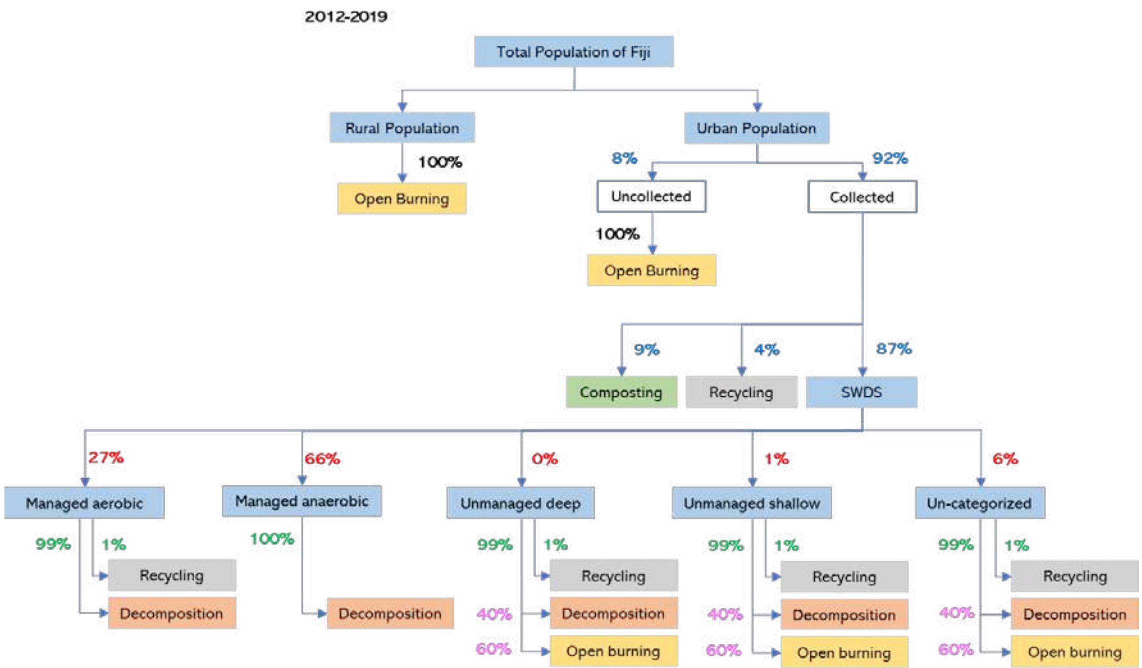


Figure 77. MSW Management Pathways and Systems in Fiji, 2012 to 2019.

The Central Board of Health (CBH) is responsible for the collection and management of clinical waste in Fiji through waste incineration methods. Although waste incinerators for have been installed in various locations thanks to donor funding, due to elevated maintenance and operational costs, the only incinerators remaining under operation in the 2013-2019 period are those installed in Fiji´s three Divisional Hospitals, namely the Colonial War Memorial (CWM) Hospital in Suva, the Lautoka Divisional Hospital, and the Labasa Divisional Hospital. All three hospitals incinerate clinical waste via batch-type stroker technology and dispose the residual ash at the Naboro landfill, maintaining clinical waste incineration records since 2011.

Concerning quarantined waste, the Biosecurity Authority of Fiji incinerates quarantined waste in the country´s main import gateways, with incineration records available for the King´s Warf and the Queen´s Warf since 2017.

Wastewater

There are currently three main types of wastewater treatment and discharge pathways in Fiji: wastewater treatment plants, septic systems, and direct disposal.

The public sewerage system consists of the collection of wastewater from houses, commercial and industrial facilities, institutions, and hotels through an underground sewerage piping network flowing into wastewater treatment plants (WWTPs). Households, commercial entities, and hotels that are not connected to the public sewerage system either implement underground septic tanks or directly release wastewater into the environment, including the ground, waterways, and the sea. In Fiji, most of the industrial wastewater flux is connected to the public sewer lines or discharged into natural waterways. No information is available on in-situ industrial wastewater treatment systems within industrial facilities.

In 2013, the coverage of the public sewerage system encompassed approximately 26% of Fiji´s total population, gradually increasing to 28% by the year 2019. Among the remaining 74%-72% of the country´s population that is not connected to the public sewerage system, 52% implement septic systems and 48% dispose wastewater directly into the environment without treatment. Refer to the following figure for an illustration of the wastewater treatment and discharge streams in Fiji.

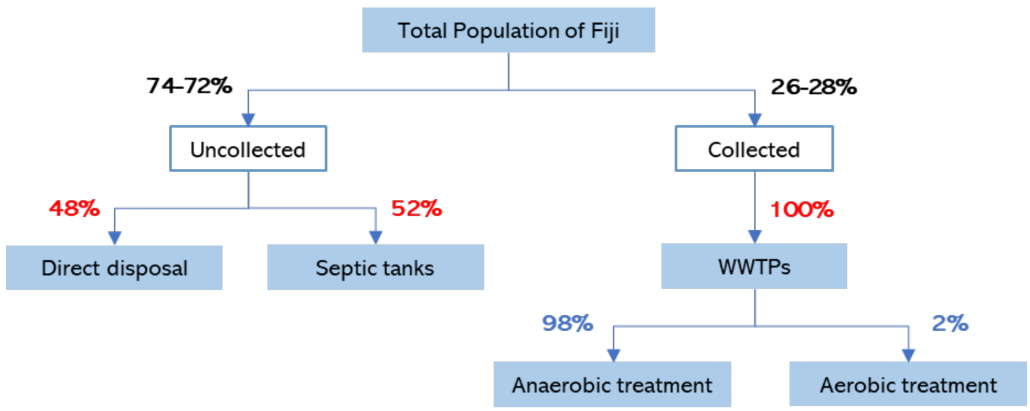


Figure 78: Wastewater treatment and Discharge Streams in Fiji.

There are a total of eleven (11) wastewater treatment plants (WWTPs) in Fiji, managed and operated by the Water Authority of Fiji (WAF). Only Kinoya and Nadi WWTPs employ anaerobic treatment mechanisms, whereas the rest of the country´s WWTPs utilize efficient aerobic treatment systems. As Kinoya and Nadi are the country´s two most important wastewater treatment plants with the greatest number of sewerage connections, anaerobic wastewater treatment systems in Fiji are an important source of GHG emission is Fiji. The Asian Development Bank has recently funded the Clean Development Mechanism (CDM) project entitled the Kinoya Sewerage Treatment Plant GHG Emission Reduction Project. Under this CDM project, methane recovery and flaring were initiated at the Kinoya WWTP in the year 2014 through the incorporation of flaring technology with a 90% efficiency rating, which recently received Certified Emission Reductions (CERs) Credits.

The following table presents further details of Fiji´s wastewater treatment plants. No data is available regarding sludge management practices, for which it is assumed that no sludge recovery takes place in Fiji, as per 2006 IPCC Guidelines.

Table 132. Wastewater Treatment Plants in Fiji.

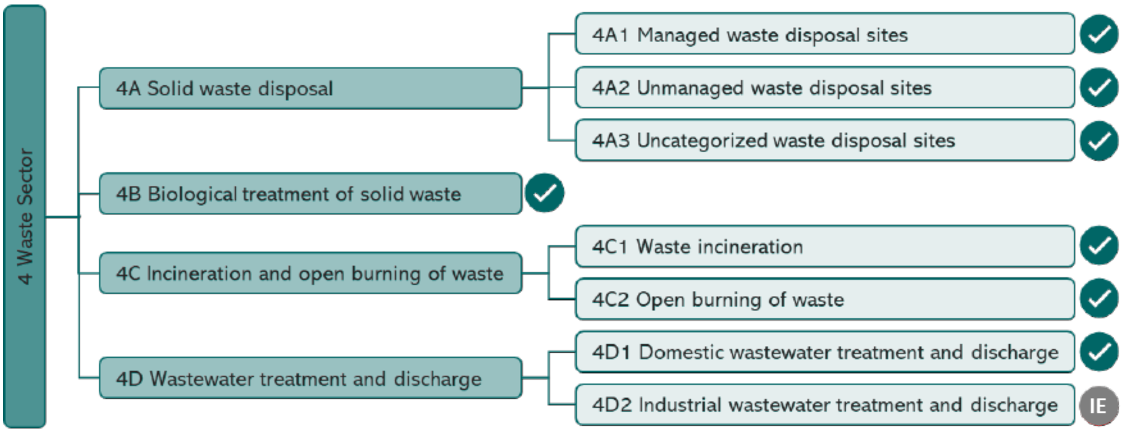
WWTP	Population Connected as of 2007	Treatment Type	Methane Recovery and Flaring	Sludge Recovery	Energy Recovery
Suva (Kinoya)	120,000	Anaerobic: Primary clarifiers, tricking filters, secondary clarifiers, sludge digestor, sludge lagoons drying beds	Yes (since 2014)	No	No
ACS	1,000	Aerobic: Imhoff tank, trickling filters, secondary clarifier, drying beds	No	No	No
Wailada (Lami)	1,000	Aerobic: Package plant, aeration, clarifier	No	No	No
Nausori Airport (Nadali)	2,000	Aerobic: Activated aeration ditch, sludge lagoon, facultative pond, maturation pond	No	No	No
Pacific Harbour (Deuba)	2,000	Aerobic: Primary clarifier, high rate trickling filters, secondary clarifier, drying beds	No	No	No
Sigatoka (Olosara)	1,200	Aerobic: Oxidation pond system	No	No	No
Naboro	2,000	Aerobic: Pasveer ditch, clarifier, drying beds	No	No	No
Nadi (Navakai)	2,3000	Anaerobic: IDEA lagoons, final polishing ponds, sludge dewater plant	No	No	No
Lautoka (Natabua)	35,000	Aerobic: Oxidation pond system	No	No	No
Ba (Votua)	3,000	Aerobic: Oxidation pond system	No	No	No
Labasa (Namara)	4,500	Aerobic: Oxidation pond system	No	No	No

High-resolution biochemical oxygen demand (BOD) measurements only exist for Kinoya WWTP, indicating that the per-capita BOD of Fiji is 60 g/person/day, in agreement with the 2006 IPCC Default value for Oceania.

6.1.2 Waste categories covered in the inventory

According to the 2006 IPCC Guidelines, the following categories (see Figure 79) are covered in the Waste Sector of Fiji:

- **Category 4A: Solid Waste Disposal:** This category covers the methane (CH_4) emissions from the anaerobic decomposition of degradable fractions of municipal solid waste (MSW) in Fiji´s eight (8) SWDS currently in operation and one (1) decommissioned SWDS.
  - **Category 4A1:** Of all SWDS in Fiji, one (1) is anaerobic and one (1) is aerobically managed
  - **Category 4A2:** Of all SWDS in Fiji, two (2) are unmanaged.
  - **Category 4A3:** Of all SWDS in Fiji, five (5) are uncategorized.
- **Category 4B: Biological Treatment of Solid Waste:** This category includes the methane (CH_4) and nitrous oxide (N_2O) emissions from composting of organic solid waste under centralized large-scale composting initiatives conducted by several town councils and municipal markets in Fiji.
- **Category 4C: Incineration and Open Burning of Waste:** This category includes the carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from the open burning and incineration of solid waste.
  - **Category 4C1:** Incineration includes the controlled burning of clinical wastes in Fiji´s three (3) Divisional Hospitals, as well as the incineration of quarantined waste by Fiji´s ports and Biosecurity Authority.
  - **Category 4C2:** Open burning occurs as an informal practice among the rural population, as well as the urban population without access to waste collection services. It is also a common practice among all unmanaged and uncategorized SWDS in Fiji.
- **Category 4D: Wastewater Treatment and Discharge:** This category includes the direct methane (CH_4) emissions from the treatment of domestic and industrial wastewater in Fiji´s eleven (11) wastewater treatment plants. It also includes the direct CH_4 emissions from the de-centralized treatment of domestic wastewater in septic tanks, as well as the direct disposal of domestic and industrial wastewater into the environment. Furthermore, it covers the indirect nitrous oxide (N_2O) emissions from the decomposition of nitrogen compounds in effluent. It is important to note that the majority of industrial wastewater in Fiji is either treated at municipal WWTPs or discharged directly into the environment without previous treatment. No information is available on the existence of in-situ industrial wastewater treatment within industrial sites. As such, **Category 4D2** has not been included in the present 2013-2019 edition of the National GHG Inventory of Fiji. Instead, industrial wastewater emissions have been included within **Category 4D1** using the correction factor for additional industrial matter discharged into domestic sewers.



NE – Not estimated; NO – Not occurring; IE – Included elsewhere

Figure 79: Categories of the Waste Sector

In comparison with previous editions of Fiji´s national GHG inventories, for the first time, Categories 4B and 4C are being included in the present 2013-2019 edition for the following reasons:

- **Category 4B:** Large-scale composting initiatives across several city councils and municipal markets throughout Fiji began operation in the year 2012 as part of the JICA Waste Minimisation and Recycling Promotion Project. Large-scale composting was not conducted before that date, and associated emissions considered negligible in previous editions of the inventory.
- **Category 4C1:** While previous editions of the inventory recognized the incineration of clinical waste was a common practice across Fiji´s three Divisional Hospitals, this category had not been previously estimated due to a lack of data. The introduction of clinical waste incineration records at each of these tree hospitals in the year 2011 thus permitted the inclusion of this category in the present 2013-2019 edition of the national GHG emissions inventory of Fiji.
- **Category 4C2:** In terms of completeness, the inclusion of open burning in the present 2013-2019 edition is of fundamental importance in order to account for emissions arising from waste management practices throughout Fiji´s rural population and urban population without access to waste collection services, as well as the known presence of open burning occurring throughout the country´s dumpsites.

6.1.3 Summary of waste sector emission results

In 2019, the Waste Sector represented 9.70% of total GHG emissions of Fiji. Being the third major source of GHG emissions, following the Energy and Agriculture, Forestry and Other Land Use Sectors, the Waste Sector is an important source of methane (CH_4) and nitrous oxide (N_2O) emissions. The Waste Sector accounts for 46.11% of the total national CH_4 emissions, 9.84% of the total national N_2O emissions, and only 0.56% of the total national CO_2 emissions. The following figure shows the trends of the GHG emissions of the Waste Sector Compared to the national total.

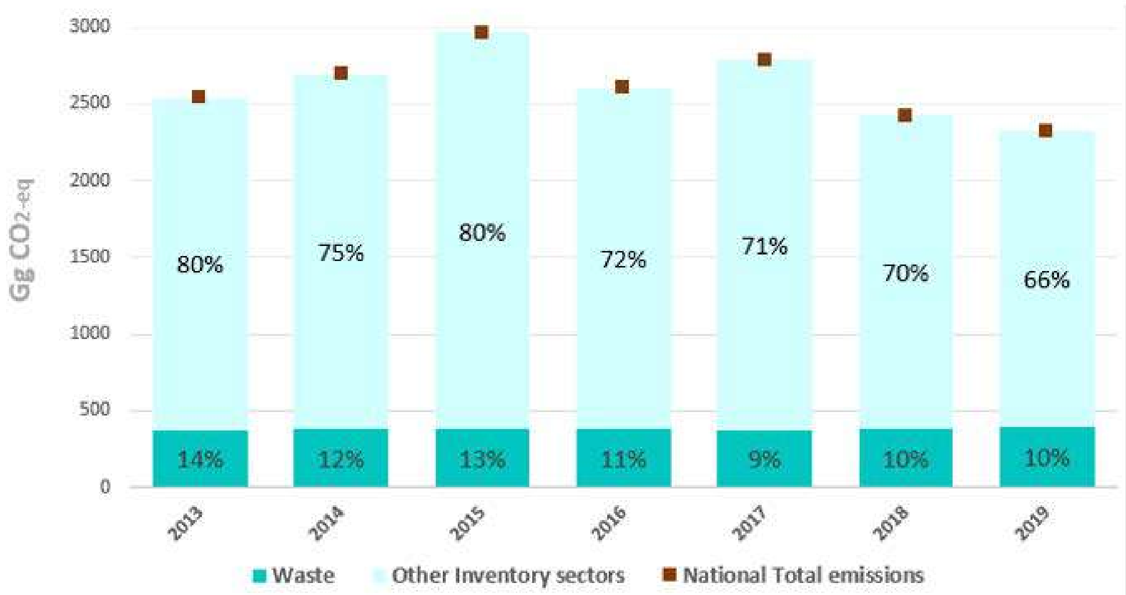


Figure 80: Waste Contribution to National Total Emissions (Gg CO2eq).

The following table and figure summarise the GHG emissions and trends of the Waste Sector by source category and by gas. The total GHG emissions for the Waste Sector were 0.391 $MtCO_{2e}$ in 2019 and 0.368 $MtCO_{2e}$ in 2013, representing an increase of 6.25% on total sectoral emissions recorded from 2013 to 2019. Methane (CH_4) was the most important GHG in the Waste Sector in 2019, whereby CH_4 emissions were 0.369 $MtCO_{2e}$ (93% of total emissions), followed by nitrous oxide (N_2O) at a value of 0.015 $MtCO_{2e}$ (3.8% of the total emissions). Categories 4A and 4D are the two most important sources of emissions within the Waste Sector, accounting for 61.67% and 31.80% of the total sectoral emissions in 2019 and constituting two of the national key categories.

Within the time period 2013-2019, emissions from biological treatment (Category 4B) and incineration and open burning (Category 4C) remain relatively constant. On the other hand, an important increasing trend can be observed for solid waste disposal (Category 4A), corresponding to a total increase of 26% between 2013 and 2019. While the increase of emissions from SWDS is closely linked to population growth, the main growth in CH_4 is attributed to the opening of the Naboro Landfill in 2005. Conversely, between the period of 2013 and 2019, a decrease of 19% of emissions from wastewater treatment and discharge (Category 4D) can be observed, attributed to the initiation of methane capture and flaring initiative at the Kinoya Wastewater Treatment Plant in 2014.

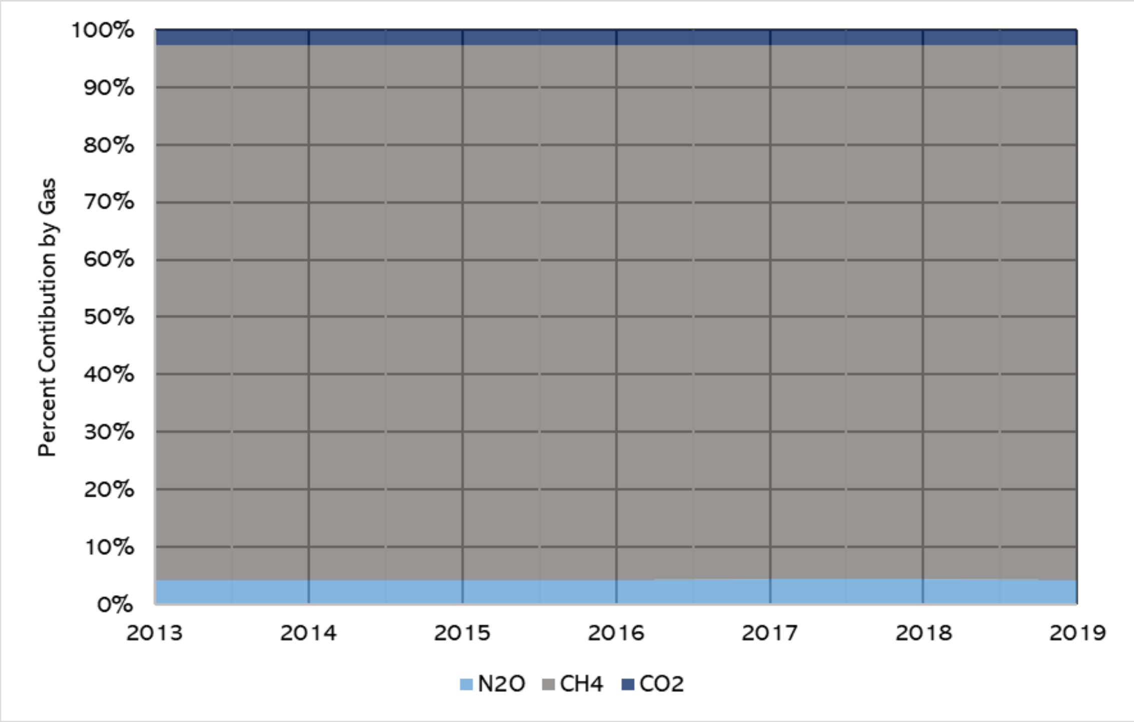


Figure 81: Total GHG Emissions from the Waste Sector by Gas.

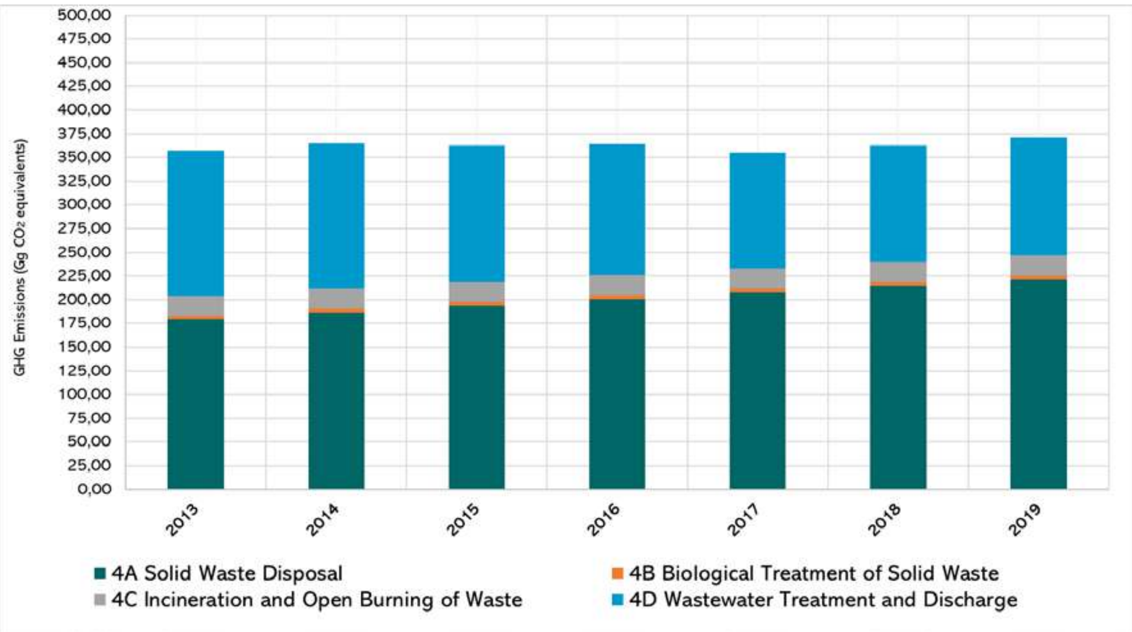


Figure 82: Total GHG Emissions from the Waste Sector by Category.

Table 133. Summary of GHG Emissions from the Waste Sector.

Category	Gas	GHG emissions in Gg CO_{2eq}						
		2013	2014	2015	2016	2017	2018	2019
4A Solid Waste Disposal	CO_2	-	-	-	-	-	-	-
	CH_4	190.77	199.76	208.45	216.92	225.20	233.32	241.32
	N_2O	-	-	-	-	-	-	-
	Total	190.77	199.76	208.45	216.92	225.20	233.32	241.32
4B Biological Treatment of Solid Waste	CO_2	-	-	-	-	-	-	-
	CH_4	2.36	2.40	2.43	2.47	2.50	2.54	2.58
	N_2O	1.34	1.36	1.38	1.40	1.42	1.44	1.46
	Total	3.70	3.76	3.81	3.87	3.92	3.98	4.04
4C Incineration and Open Burning of Waste	CO_2	6.82	6.85	6.88	6.91	6.94	6.97	7.00
	CH_4	12.23	12.28	12.33	12.38	12.43	12.49	12.54
	N_2O	1.92	1.93	1.93	1.94	1.95	1.96	1.97
	Total	20.97	21.06	21.15	21.24	21.33	21.41	21.50
4D Wastewater Treatment and Discharge	CO_2	-	-	-	-	-	-	-
	CH_4	141.42	141.71	132.34	126.40	110.15	110.92	112.62
	N_2O	11.44	11.50	11.56	11.63	11.69	11.75	11.81
	Total	152.86	153.21	143.90	138.03	121.83	122.67	124.43
TOTAL Waste Sector	CO_2	6.82	6.85	6.88	6.91	6.94	6.97	7.00
	CH_4	346.78	356.14	355.55	358.17	350.28	359.27	369.05
	N_2O	14.69	14.79	14.88	14.97	15.06	15.15	15.24
	Total	368.30	377.78	377.31	380.05	372.28	381.39	391.29

6.2. Data and methodology used

The emissions estimates for the Waste Sector were prepared on the basis of country-specific activity data and default emission factors and other parameters from the 2006 IPCC Guidelines. Numerous studies, waste management project reports, national statistics, international data bases, regional waste management studies, and default 2006 IPCC Guidelines were consulted to collect all the necessary data for preparing the GHG emission estimates in the most representative manner fit for the national context and its timeline evolution. Through the Data Quality Assessment Report for the Waste Sector, this data was evaluated in terms of availability, completeness, accuracy, and timeline coherency, all while comparing domestic data sources against international information. From the results of such assessment report, the final data was then selected to prepare the emission estimates from the Waste Sector. To the extent possible, national statistics were prioritized in the data selection process, indicating areas of improvement for the future to increase its coverage and quality.

The following table below presents the main data sources used for the preparation of emission estimates from the Waste Sector.

Table 134. Data Sources for the Waste Sector.

Category	Type of data	Data source	Data providers
Cross-cutting issues in the waste sector	Total population of Fiji	2017 Fiji Population and Housing Census: Release 3 - Administration Report.	Fiji Bureau of Statistics
	Percentage of rural and urban population	Population Totals of Fiji.	World Bank Data
	Municipal Solid Waste (MSW) per capita generation rates by urban and rural populations	JICA 2009 Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands.	Research by inventory compilers on project documents from JICA
	MSW composition	JICA 2009 Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands.	Research by inventory compilers on project documents from JICA
4A Solid Waste Disposal	Climate Zone of Fiji	Default values in Figure 3A.5.1 of Volume 4 from the 2006 IPCC Guidelines.	2006 IPCC Guidelines
	Degradable organic carbon (DOC), fraction of DOC disseminated (DOCf), and methane generation rate constant (k)	Default values in Table 2.4, Section 3.2.3, and Table 3.3 of Volume 5 from the 2006 IPCC Guidelines, respectively.	2006 IPCC Guidelines
	Percentage of waste sent to solid waste disposal sites (SWDS)	JICA 2009 Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands.	Research by inventory compilers on project documents from JICA

Category	Type of data	Data source	Data providers
	Description of Fiji´s SWDS	Fiji National Solid Waste Management Strategy and Plan 2011-2014.	Ministry for Local Government, Urban Development, Housing and Environment
	Percentage of waste treated at managed, unmanaged, and uncategorized SWDS	Fiji National Solid Waste Management Strategy and Plan 2011-2014.	Ministry for Local Government, Urban Development, Housing and Environment
	Methane Correction Factors (MCF)	Default values in Table 3.1 of Volume 5 from the 2006 IPCC Guidelines.	2006 IPCC Guidelines
4B Biological Treatment of Solid Waste	Percentage of MSW sent to large-scale composting sites	JICA 2009 Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands.	Research by inventory compilers on project documents from JICA
4C1 Waste Incineration	Annual quantity of clinical waste incinerated in Fiji´s three Divisional Hospitals	Incineration Records for Divisional Hospitals between 2010 and 2018.	Central Board of Health
	Incineration technologies used in Fiji´s three Divisional Hospitals	Baseline Study for the Pacific Hazardous Waste Management Project - Healthcare Waste (Fiji)	Research by inventory compilers
	Imports of goods and services in Fiji	Imports of goods and services (current US$) - Fiji	World Bank Data
	Annual quantity of quarantined waste incinerated	Data Collection Form for the Waste Sector	Biosecurity Authority of Fiji
	Composition of quarantined waste incinerated	Data Collection Form for the Waste Sector	Biosecurity Authority of Fiji
	Technologies used in the incineration of quarantine waste	Data Collection Form for the Waste Sector	Biosecurity Authority of Fiji
	Dry matter content (dm), carbon fraction in dry matter (CF), and fossil carbon fraction in total carbon (FCF) in clinical and quarantined waste	Default values in Table 5.2 and Table 2.4 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
	Waste incineration emission factors	Default values in Tables 5.2, 5.3, and 5.6 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
4C2 Open Burning of Waste	Percentage of population conducting open burning (Pfrac)	Default values in Section 5.3.2 of Volume 5 from the 2066 IPCC Guidelines	2006 IPCC Guidelines
	Fraction of the waste amount that is burned relative to the total amount of waste treated (Bfrac)	Default value in Section 5.3 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines

Category	Type of data	Data source	Data providers
	Dry matter content (dm), carbon fraction in dry matter (CF), and fossil carbon fraction in total carbon (FCF) in clinical and quarantined waste	Default values in Table 2.4 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
	Waste incineration emission factors	Default values in Table 5.2, Table 5.6, and Section 5.4.2 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
4D1 Domestic Wastewater Treatment and Discharge	Description of Fiji´s wastewater treatment plants (WWTP)	Fiji – Sewerage Coverage and Applied Method of Treatment	Water Authority of Fiji (WAF)
	Quantity of wastewater treated at each WWTP	Data Collection Form for the Waste Sector	Water Authority of Fiji (WAF)
	Number of people connected at each WWTP in the year 2007	Fiji National Liquid Waste Management Strategy and Action Plan	Ministry of Waterways and Environment
	Percent of population using septic tank systems and direct disposal of wastewater	Fiji National Liquid Waste Management Strategy and Action Plan	Ministry of Waterways and Environment
	Biochemical oxygen demand (BOD)	Default value for Oceania in Table 6.4 of Volume 5 from the 2006 IPCC Guidelines // cross-checked with Data Collection Form for the Waste Sector	2006 IPCC Guidelines // Water Authority of Fiji (WAF)
	Correction factor for additional industrial BOD discharged into sewers (I)	Default value in Equation 6.3 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
	Methane Correction Factors for eat type of WWTP, septic tank systems, and direct disposal of wastewater	Default values from Table 6.3 of Volume 5 from the 2006 IPCC Guidelines	2006 IPCC Guidelines
	Methane recovery and flaring rates at Kinoya Wastewater Treatment Plant	CDM Monitoring Report for Project 4552: Kinoya Sewerage Treatment Plant GHG Emission Reduction Project: Version 6	Water Authority of Fiji
	Per capita annual dietary protein consumption	Food Balance Sheets	Food and Agriculture Organization of the United Nations (FAO)
4D2 Industrial Wastewater Treatment and Discharge	Emissions included in Category 4D1 due to the lack of data on on-site industrial wastewater treatment practices in Fiji. It was thus assumed all industrial wastewater is discharged into the domestic sewer system through the default correction factor from the 2006 IPCC Guidelines for additional industrial BOD discharged into sewers (I).		

Emissions originating from the Waste Sector were estimated as per Tier 1 and Tier 2 Methodologies from the 2006 IPCC Guidelines. A summary description of methods used to estimate emissions from the Waste Sector by source categories is provided in the following tables, while a more detailed description is available in Sections 6.3 through 6.6 of this Chapter.

Table 135. Methodological Tiers Adopted for the Waste Sector

Category	Tier	Activity Data	Emission Factors and Other Parameters
4A Solid Waste Disposal	Tier 1	Country-specific data	2006 IPCC default values
4B Biological Treatment of Solid Waste	Tier 1	Country-specific data	2006 IPCC default values
4C1 Waste Incineration	Tier 1 & Tier 2a	Country-specific data	2006 IPCC default values
4C2 Open Burning of Waste	Tier 1	Country-specific data and default assumptions	2006 IPCC default values
4D1 Domestic Wastewater Treatment and Discharge	Tier 1	Country-specific data and default data	2006 IPCC default values
4D2 Industrial Wastewater Treatment and Discharge	IE	Emissions included in Category 4D1.	

Table 136. Main Methodologies and Assumptions Adopted for the Waste Sector.

Category	Methodology	Assumptions
4A Solid Waste Disposal	The IPCC First Order Decay (FOD) Waste Model was implemented using the standardized spreadsheet available through the IPCC website and conducting the "waste composition option". Following the Tier 1 method, all default parameters embedded in the spreadsheet for the Oceania region and Fiji country were selected. Country-specific activity data were introduced unto the spreadsheet, including the population, the waste-generation rates, waste composition, percentage of waste sent to SWDS, as well as the percentage of waste sent to managed, unmanaged shallow, unmanaged deep, and uncategorized SWDS.	It was assumed that the MSW composition and generation rates remain constant throughout time.
4B Biological Treatment of Solid Waste	Equations 4.1 and 4.2 of Volume 5 from the 2006 IPCC Guidelines was used to estimate CH_4 and N_2O emissions from the composting of organic wastes, respectively. The Tier 1 method was adopted, utilizing the default emission factors for composting in Table 4.1 of Volume 5 and using country-specific data on the percentage of waste that is sent to large-scale composting facilities.	Only large-scale composting occurring in centralized facilities after the year 2012 was taken into account in the emission estimates. Although it is known some household-level composting is done informally among the rural population and among urban populations without access to waste collection services, due to a lack of data, it was assumed that all population without waste collection services conduct open burning.
4C1 Waste Incineration	Equation 5.1 of Volume 5 from the 2006 IPCC Guidelines was used to estimate the CO_2 emissions from waste	In order to complete the time series on the activity data for clinical waste incineration rates, available incineration

Category	Methodology	Assumptions
	incineration. The Tier 2a method was adopted, using of country-specific activity data on the waste composition and quantities and default values for parameters on dry matter content, fossil carbon fractions, and oxidation factor. Equations 5.4 and 5.5 of Volume 5 from the 2006 IPCC Guidelines were used to estimate the CH_4 and N_2O emissions from waste incineration, respectively. The Tier 1 method was adopted, using country-specific data on waste quantities and incineration technology, with default CH_4 and N_2O emission factors obtained from Tables 5.3 and 5.6, respectively.	records for the year 2014 were extrapolated assuming a direct correlation with the annual population growth rate in Fiji. To complete the time series of the activity data for quarantined waste incineration rates, available incineration records for the year 2019 were extrapolated assuming a direct correlation with the annual quantities of imports of goods and services in Fiji. Given that no default CH_4 and N_2O emission factors are provided in the 2006 IPCC Guidelines for clinical wastes, these emissions were not estimated. CH_4 and N_2O emissions from waste incineration were only estimated for quarantined waste, which has a composition most similar to MSW.
4C2 Open Burning of Waste	Equation 5.1 of Volume 5 from the 2006 IPCC Guidelines was used to estimate the CO_2 emissions from open burning of waste. The Tier 2a method was adopted, using of country-specific activity data on the waste composition and total amount of MSW open-burned, combined with default values for parameters on dry matter content, fossil carbon fractions, and oxidation factor. Equations 5.4 and 5.5 of Volume 5 from the 2006 IPCC Guidelines were used to estimate the CH_4 and N_2O emissions from open burning, respectively. The Tier 1 method was adopted, using country-specific data on the quantity of MSW open burned, with default CH_4 and N_2O emission factors obtained from Section 5.4.2 and Table 5.6, respectively. Equation 5.7 of Volume 5 from the 2006 IPCC Guidelines was used to estimate to total amount of MSW open-burned.	Due to a lack of data on open burning, it was assumed that all the rural population in Fiji, as well as the urban population without access to waste collection services (including peripheral informal and squatter settlements) conduct open burning. It is also assumed that all unmanaged and uncategorized SWDS in Fiji undergo open burning of waste. These assumptions are in accordance with the those provided in Section 5.3.2 of Volume 5 of the 2006 IPCC Guidelines for the estimation of the fraction of population burning waste in developing countries.
4D1 Domestic Wastewater Treatment and Discharge	Equations 6.7 and 6.8 of Volume 5 from the 2006 IPCC Guidelines were used to estimate the indirect N_2O emissions from nitrogen in effluent, implementing the default N_2O emission factor and default fraction of nitrogen in protein as stated in Sections 6.3.1.2 and 6.3.1.3 of Volume 5 of the guidelines, respectively. Equations 6.1, 6.2, and 6.3 of Volume 5 from the 2006 IPCC Guidelines were used to estimate emissions from Fiji´s WWTP, septic systems, and the direct disposal of wastewater into the	Data on per capita dietary protein consumption from the FAO food balance sheets is only available up to the year 2007. It is assumed that the dietary protein consumption of Fiji remains constant after the year 2007. The number of people connected to each WWTP was derived by correlating the volume of wastewater treated at each plant every year with the number of people connected in the year 2007, assuming a direct correlation, given that no detailed records on sewerage connections exist in the country.

Category	Methodology	Assumptions
	environment without treatment. The Tier 1 method was adopted, using the default maximum CH_4 producing capacity and Methane correction factors (Tables 6.2 and 6.3), as well as the default BOD value for the Oceania Region (Table 6.4). Country-specific data was used on the quantity of population using each type of wastewater treatment/discharge method in Fiji. Associated emissions from industrial wastewater are included under Category 4D1 through the use of the correction factor for additional industrial BOD discharged into sewers, in accordance with Equation 6.3 of Volume 5 of the 2006 IPCC Guidelines. A correction factor of 1.25 was selected for all WWTP, while a correction factor of 1.00 was selected for direct disposal and septic tank systems, in accordance with Equation 6.3.	As per 2006 IPCC Guidelines, it was assumed no sludge recovery takes place at WWTPs, as no information is available on this matter. Due to lack of data on in-situ industrial wastewater treatment, it was assumed that all industrial facilities in Fiji either discharge their wastewater into the domestic sewage systems or dispose their wastewater directly into the environment without treatment.
4D2 Industrial Wastewater Treatment and Discharge	This category was not included in the present 2013-2019 edition of the IPCC Guidelines due to the lack of data on in-situ industrial wastewater treatment facilities. Instead, associated emissions from industrial wastewater are included under Category 4D1 through the use of the correction factor for additional industrial BOD discharged into sewers, in accordance with Equation 6.3 of Volume 5 of the 2006 IPCC Guidelines. A correction factor of 1.25 was selected for all WWTP, while a correction factor of 1.00 was selected for direct disposal and septic tank systems, in accordance with Equation 6.3.	It was assumed that all industrial facilities in Fiji either discharge their wastewater into the domestic sewage systems or dispose their wastewater directly into the environment without treatment.

Several challenges were encountered throughout the data collection, treatment, and selection process, leading to the adoption of several assumptions to overcome these challenges, described as follows:

- **Limited national data on MSW generation rates:** Of Fiji´s eight solid waste disposal sites currently under operation, only the Naboro Landfill and the Vunato Dump at Lautoka feature operational weighbridges, for which it is not possible to derive updated waste generation rates. Currently, statistics on waste generation rates exist for Lautoka and Nadi, values derived from a study conducted in 2009 by JICA for the Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands. Although this study provides the differentiated waste generation rates for rural and urban populations, the values are outdated and reflect a single year, for which it is not possible to derive a timeline evolution of waste generation rates in the country. For the preparation of the inventory, the average rural and urban waste generation rates from the JICA 2009 Study were adopted and assumed constant for all the country and throughout the entire time series.

- **Limited national data on MSW composition:** Since the year 2000, several municipal and town councils have begun to conduct waste characterization campaigns and maintain waste composition records. However, these composition records implement varying waste composition categories, inconsistent between the different councils and inconsistent with the IPCC waste composition categories, for which these values could not be used for the inventory preparation. Since its opening in 2005, the H.G. Leach (Fiji) Pte. Limited at the Naboro Landfill maintains detailed waste composition records. However, such records do not specify details on the different fractions of organic waste treated at the site, which is the main source of methane emissions at SWDS. Currently, waste composition statistics exist for Lautoka and Nadi as part of the 2009 JICA study conducted for the Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands, although these values are outdated and reflect only a single year, for which it is not possible to derive a timeline evolution of waste composition in the country. For the preparation of the inventory, the average waste compositions from the JICA 2009 Study were adopted and assumed constant for all the country and throughout the entire time series.
- **Limited information on waste management practices among Fiji´s rural population and informal urban settlements:** A study conducted in 2007 on the Economics of rural waste management in the Rewa Province[20] reveals that rural waste management practices include a combination of open burning, reuse, burial, composting, littering, and feeding of pigs, with the most common practice being open burning. Nevertheless, very limited quantifiable and updated data exists on rural waste management practices in Fiji. As a result, it has been assumed that 100% of the rural population of Fiji and 100% of the population without access to waste collection services (including peripheral informal settlements) conducts open burning, in line with the default 2006 IPCC assumption on open burning practices in developing countries.
- **Limited national data on oxidation rates in soil covers at managed SWDS:** The default value of zero for CH_4 oxidation was assumed due to the non-availability of country-specific data. While soil cover used at Naboro landfill could provide oxidation loss typically in the range of 10%[21], this is not accounted for in the calculation but is very well within the uncertainty limit.
- **Limited national data on composting rates:** Waste composting records are being maintained since the initiation of centralized large-scale composting initiatives in 2012 across several city councils and municipal markets throughout Fiji. Given that there are no statistics on informal composting activities conducted at a household level, the present GHG inventory therefore only considers emissions from large-scale composting at centralized facilities. However, these records are inconsistent, as

[20] Economics of rural waste management in the Rewa Province and development of a rural solid waste management policy for Fiji. Padma Lal, Margaret Tabunakawai and Sandeep K. Singh. IWP-Pacific Technical Report (International Waters Project) no. 57. ISBN 978-982-04-0381-9. (2007)

[21] Pre-feasibility study for methane recovery at Naboro Landfill, Suva, Fiji Islands: Final Report on projects funded by PACE-Net Plus seed funding grants 2015. Dr. Francis Mani. The University of the South Pacific. (2016).

some measure the quantity of organic waste collected, other measure the quantity of compost sold, while other records track the profits from compost sales. Consequently, this data could not be used in the preparation of the inventory. Instead, the percentage of MSW sent to large-scale composting sites was obtained from the 2009 JICA Study under the Waste Minimisation and Recycling Promotion Project in the Republic of the Fiji Islands, and assumed constant from 2012 to 2019.

- **Inconsistent and incomplete clinical waste incineration records:** While monthly clinical waste incineration records have become available for Fiji´s three Divisional Hospitals since the year 2012, important data gaps can be observed attributed to both inconsistent reporting and temporary incinerator malfunction. Given that no clear distinction is available in the hospital records between data gaps and incinerator malfunction, annual values could not be directly extrapolated from the available data. Instead, records for the year 2014 (corresponding to the most complete data available) was extrapolated by assuming a direct correlation between annual clinical waste incineration rates with Fiji´s annual population growth rate.
- **Limited data on quarantined waste incineration:** Incineration records for quarantined waste is only partially available for some of Fiji´s Biosecurity Authority facilities since the year 2017. In order to incorporate this source of emissions into the inventory, the available data was extrapolated by assuming a direct correlation between annual quarantined waste incineration rates and the annual quantity of imports of goods and services in Fiji.
- **Limited data on the number of people connected to each WWTP:** Fiji does not currently have detailed annual records on the number of people connected to each sewer lines, but maintains updated records of the volume of wastewater treated at each WWTP. To obtain an accurate assessment, it was imperative to know the population that is actually connected to each WWTP. These statistics were derived by correlating the annual volume of wastewater treated at each WWTP with the number of people connected to each WWTP in the year 2007.
- **Lack of reliable biochemical oxygen demand (BOD) statistics:** Currently, data resolution on BOD measurements for most of Fiji´s wastewater treatment plants are very limited and, in some instances, there was only one BOD measurement for the entire year. High-frequency data measurements are available only for Kinoya Wastewater Treatment Plant, which agree with the default BOD value for Oceania under the 2006 IPCC Guidelines. As a result, the default 2006 IPCC default BOD value for Oceania was adopted for all wastewater treatments in Fiji.
- **Lack of data on industrial wastewater management practices:** While the majority of industrial facilities either discharge their wastewater into the domestic sewage system or directly into the environment, there is no information currently available on the existence of in-situ industrial wastewater treatment practices. As such, Category 4D2 was not encompassed by the inventory and the emissions from industrial sources were accounted for under Category 4D1 – Domestic Wastewater treatment and discharge as per 2006 IPCC Guideline Assumptions.

6.3. Solid waste disposal (4.A)

The quantity and type of solid waste generated over a given period is closely linked to population growth, urbanization, and lifestyle, with urban and higher-income populations tending to generate higher quantities of waste in comparison with rural and underdeveloped populations.

Methane (CH_4) and biogenic carbon dioxide (CO_2), with smaller quantities of nitrous oxide (N_2O) are the main greenhouse gases associated with solid waste disposal through biological decomposition of organic wastes and degradable materials at solid waste disposal sites (SWDS). In fact, the decomposition of organic materials under anaerobic conditions generates landfill gas, or biogas, consisting of approximately 50 % CH_4 and 50 % CO_2 by volume. However, this carbon dioxide results in its major part from oxidation of organic materials and are not included hence in the national GHG emission totals. Furthermore, the 2006 IPCC Guidelines do not provide a methodology for estimating N_2O emissions from solid waste disposal, for which these emissions have not been estimated. As such, Category 4A consists of the CH_4 emissions arising from the decomposition of municipal solid waste (MSW) in Fiji´s eight (8) operational SWDS and one (1) decommissioned SWDS, which primarily cater to Fiji´s urban population with access to waste collection services.

Different factors affect the generation of CH_4:

- Waste generation rates: Greater quantities of waste lead to greater quantities of emissions.
- Waste composition: Greater quantities of degradable materials is the one major element influencing increased biogas production.
- Waste disposal practices, particularly the degree of control of disposal sites: In general, controlled placement of waste favours anaerobic activity and consequently landfill gas formation, but the gas can be recovered and be either flared or used for energy purposes.
- Physical factors: Factors such as moisture content and temperature influence the survival of microbes that decompose waste and generate CH_4 under favourable anaerobic conditions.

Depending on the common management practice at each SWDS, emissions from solid waste disposal are grouped into: i) managed waste disposal sites (Category 4A1), ii) unmanaged waste disposal sites (Category 4A2), and iii) uncategorized waste disposal sites (Category 4A3). Of all of Fiji´s SWDS, one is categorized as a managed anaerobic site (Naboro Landfill), one is categorized as a managed semi-aerobic site (Vunatu Site since 2009), two are categorized as unmanaged shallow (Vunato Dump until 2009 and Labasa Dump), one is categorized as unmanaged deep (Lami Dump), and the remaining five have remained are uncategorized (Sigatoka Dump, Savudavu Dump, Levuka Dump, Ba Dump, and Rakiraki Dump). Except for the Naboro Landfill and the Vunatu Site, all SWDS in Fiji are considered open dumps.

Decomposition of organic waste does not occur instantaneously after disposal at SWDS, but rather, after a default delay period of approximately six months. CH_4 is emitted over a long period of time at a diminishing rate following a logarithmic curve, even after a SWDS is decommissioned.

Methane emissions have been calculated on the basis of the First Order Decay (FOD) Method, following the guidance from the 2006 IPCC Guidelines and applying the Tier 1 IPCC Waste Model spreadsheet with the "waste composition option".

The use of the FOD method requires building a data time series for several decades in the past concerning country-specific waste quantities, composition, and disposal practices. According to 2006 IPCC Guidelines, historical data has been estimated as far back as 1950 to account for the slow-decomposition nature of waste. The urban waste generation rate (1.5 kg/person/day) and composition have been obtained from the 2006 JICA study under the Waste Minimisation and Recycling Promotion Project and assumed constant throughout the 1950-2019 time series constructed. The waste composition considered in the estimations are as follows: food (33.6%), wood (39.6%), paper/cardboard (11.4%), plastics (6.7%), textiles (1.0%), and inerts (7.7%). Due to a lack of data on sludge recovery from wastewater treatment, it is assumed no sludge is deposited at SWDS as per 2006 IPCC Guidelines.

The urban population within the 1950-2019 time period was estimated based on total population statistics obtained from the Fiji Bureau of Statistics and urban percentage of population obtained from the World Bank Data (See the following table).

Table 137. Total and Urban Population of Fiji 1950-2019.

Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)
1950	294 078	24.6%	**1968**	498 995	34.0%	**1986**	715 375	38.7%	**2004**	820 309	49.5%
1951	302 688	25.1%	**1969**	510 129	34.4%	**1987**	721 345	39.3%	**2005**	825 963	49.9%
1952	311 297	25.5%	**1970**	521 263	34.8%	**1988**	727 315	40.1%	**2006**	831 617	50.3%
1953	319 907	26.0%	**1971**	532 398	35.2%	**1989**	733 286	40.8%	**2007**	837 271	50.7%
1954	328 517	26.4%	**1972**	543 532	35.5%	**1990**	739 256	41.6%	**2008**	842 033	51.2%
1955	337 127	26.9%	**1973**	554 666	35.9%	**1991**	745 226	42.4%	**2009**	846 794	51.7%
1956	345 737	27.3%	**1974**	565 800	36.3%	**1992**	751 196	43.2%	**2010**	851 556	52.2%
1957	358 836	27.8%	**1975**	576 934	36.7%	**1993**	757 166	43.9%	**2011**	856 317	52.7%
1958	371 935	28.2%	**1976**	588 068	37.1%	**1994**	763 137	44.7%	**2012**	861 079	53.2%
1959	385 034	28.7%	**1977**	600 799	37.3%	**1995**	769 107	45.5%	**2013**	865 841	53.7%
1960	398 133	29.7%	**1978**	613 529	37.5%	**1996**	775 077	46.3%	**2014**	870 602	54.2%
1961	411 232	30.3%	**1979**	626 260	37.6%	**1997**	780 731	46.7%	**2015**	875 364	54.7%
1962	424 331	30.8%	**1980**	638 991	37.8%	**1998**	786 385	47.1%	**2016**	880 125	55.2%
1963	437 430	31.4%	**1981**	651 722	37.9%	**1999**	792 039	47.5%	**2017**	884 887	55.7%

Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)	Year	Total (capita)	Urban (%)
1964	450 529	32.0%	**1982**	664 452	38.1%	**2000**	797 693	47.9%	**2018**	889 649	56.3%
1965	463 628	32.6%	**1983**	677 183	38.2%	**2001**	803 347	48.3%	**2019**	894 410	56.8%
1966	476 727	33.2%	**1984**	689 914	38.4%	**2002**	809 001	48.7%	-	-	-
1967	487 861	33.6%	**1985**	702 644	38.5%	**2003**	814 655	49.1%	-	-	-

Concerning the waste disposal practices, the afore-mentioned JICA study has been used to determine the quantity of MSW that is collected and sent to SWDS in urban areas, whereas the percent of the collected waste decomposing at managed, unmanaged, and uncategorized SWDS were obtained from the Fiji National Solid Waste Management Strategy and Plan 2011-2014. It was assumed that approximately 60% of all waste sent to open dumps undergoes open burning and the remaining 40% is left unburned and undergoes decomposition. This assumption in in line with the underlying IPCC assumption regarding B_{frac}.[22]

Refer to Figures 71 through 74 for the waste streams considered to determine the annual quantity of waste that undergoes decomposition at each type of SWDS from 1950 to 2019. The time series of the national waste disposal practices reflects the closure of the Lami Dump in 2005 and its replacement by the Naboro Landfill that same year. Emissions from the Lami Dump between 2005 and 2019 are accounted for in the inventory, since its contained waste continues to degrade, even after it has been decommissioned. The time series accounts for the upgrade of the Vunatu Site in 2009 through the implementation of managed aerobic methods under the JICA project. It also accounts for the introduction of large-scale recycling and composting programmes in Fiji starting in 2012 as part the JICA Waste Minimisation and Recycling Promotion Project, which diverted wastes away from disposal sites.

Default methane correction factors (MCF) were used to describe the extent of anaerobic conditions at each type of SWDS as follows:

- Managed anaerobic SWDS: MCF = 1
- Managed semi-aerobic SWDS: MCF = 0.5
- Unmanaged Shallow SWDS: MCF = 0.4
- Unmanaged Deep SWDS: MCF = 0.8
- Uncategorized SWDS: MCF = 0.6

No methane recovery or flaring occurs in Fiji. As per 2006 IPCC defaults, it is assumed that the fraction of methane in the biogas generated is 50% and no oxidation takes place in SWDS soil covers.

The FOD model is built on an exponential factor that describes the fraction of degradable material which each year that is degraded into CH_4 and CO_2. One key input in the model is

[22] See Section 5.3.2 from Volume 5 of the 2006 IPCC Guidelines for further details.

the amount of degradable organic matter (DOCm) in waste disposed into SWDS. This is based on default IPCC parameters corresponding to the "Oceania Region" and "Moist and Wet Tropical" climate, including the degradable organic carbon (DOC), the fraction of DOC disseminated (DOCf), the methane generation rate constant (k).

The following table presents the uncertainties of the main data inputs to estimate CH_4 emissions from this category.

Table 138. Uncertainties for Estimating CH_4 Emissions from Solid Waste Disposal

Parameter	Uncertainty
Total quantity of MSW generated	-30%,+30%
Fraction of MSW sent to SWDS	-30%,+30%
Waste composition	-30%,+30%
Degradable organic carbon	-20%,+20%
Fraction of DOC dissimilated	-20%,+20%
Methane generation rate constant – average value based on uncertainties for each waste fraction	-27%,+27%
Delay time	-33%, +33%
Fraction of methane in developed gas	-20%,+20%
Oxidation factor	0%
Methane correction factor - managed	.10%-0%
Methane correction factor - unmanaged deep	-20%,+20%
Methane correction factor - unmanaged shallow	-30%,+30%
Methane correction factor - uncategorized	-50%,+60%

The following table and figure below present the emission results for Category 4A. Solid waste disposal (Category 4A) has been identified as a key category both in terms of total national GHG emission levels and trends, being the main contributor of methane emissions within the Waste Sector. In fact, in 2019, solid waste disposal represented 61.67% of the total sectoral emissions and 65.39% of the sectoral CH_4 emissions.

Table 139. Summary of GHG Emissions from Solid Waste Disposal.

Gas	Type of SWDS	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
CH_4	Managed sites (Category 4A1)	136.33	147.18	157.51	167.43	177.03	186.36	195.46	76%
	Unmanaged sites (Category A42)	42.06	40.00	38.16	36.48	34.95	33.52	32.18	81%
	Uncategorized sites (Category A43)	12.38	12.58	12.79	13.00	13.22	13.44	13.67	94%
	Total solid waste disposal (Category 4A)	190.77	199.76	208.45	216.92	225.20	233.32	241.32	77%

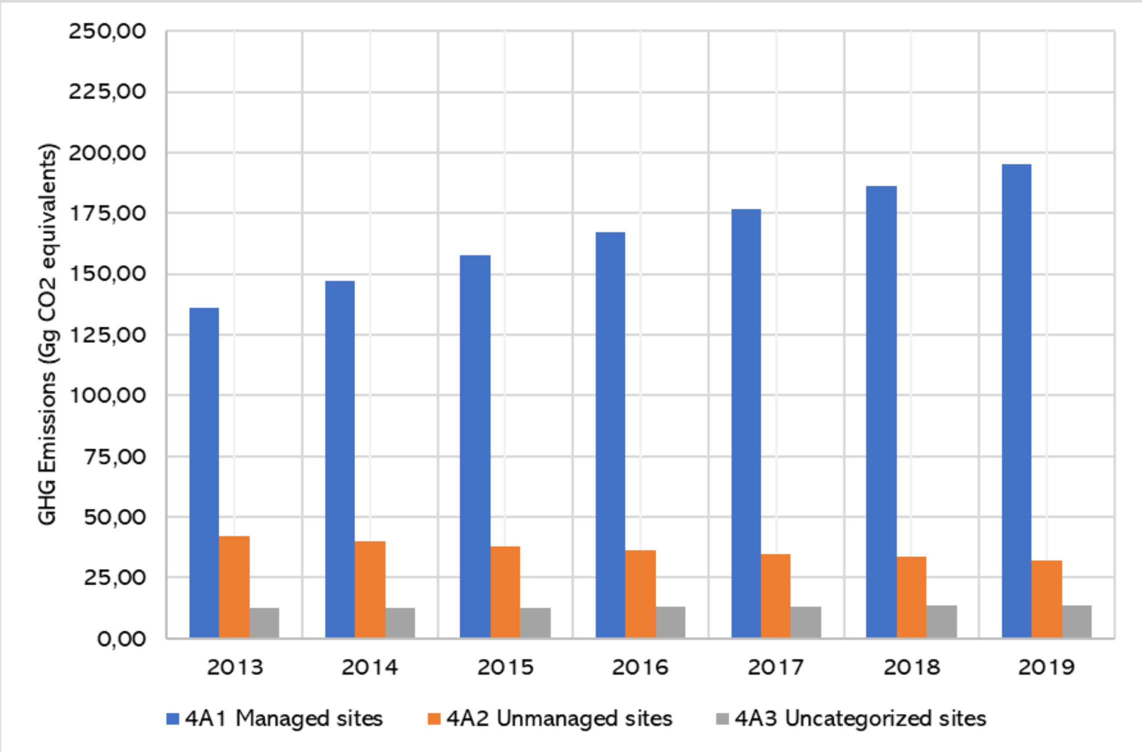


Figure 83: CH4 Emissions by Type of Solid Waste Disposal Site.

Within solid waste disposal, the main source of CH_4 emissions is Category 4A1 (managed solid waste disposal), which corresponds to Fiji's only engineered sanitary landfill, namely the Naboro Landfill, as well as the managed aerobic Vunatu Sire, which together generated 80% of methane emissions from all solid waste disposal in Fiji in 2019. Such elevated contribution is attributed to the highly anaerobic conditions at the Naboro Landfill which promote methanogenic microbial activity during waste decomposition processes. The remaining 13% of emissions were generated by unmanaged sites such as Labasa, and Lami Dumps (Category 4A2) and the remaining 7% by uncategorized sites (Category 4A3) including the Sigatoka, Savudavu, Levuka, Ba, and Rakiraki Dumps. It should be noted that the opening of the Naboro Landfill has marked a pivotal milestone in Fiji´s path towards sustainable development by implementing efficient and engineered techniques that prevent waste from being exposed to the natural elements, being washed out and contaminating the natural environment, or being ignited with the subsequent release of toxic fumes, all of which are a hazard both to human and the environmental health. However, the burial of waste under anaerobic conditions lead to higher CH_4 emissions. Pre-feasibility studies for methane recovery at the Naboro Landfill have been done as a possible mitigation strategy for the future.

A growth of 26.50% is observed between emissions from solid waste disposal in 2013 to 2019, surmounting to 190.77 Gg CO_{2eq} and 241.32 Gg CO_{2eq}, respectively. There are two main drivers for this increasing trend:

- **Population growth and urbanization:** As the population of Fiji continues to grow and move towards urban centres with greater access to waste collection services, the total quantity of waste generated in the country is increasing accordingly. The quantity of waste generated is increasing not only because there are more people generating waste, but also because the overall rate of waste generation is augmenting through the demographic shift away from rural communities towards urban centres, given that urban centres have a per capita MSW generation rate approximately 3.75 times higher than rural communities.
- **Relatively recent opening of the Naboro Landfill in 2005:** As previous mentioned, waste decomposition occurs over a long period of time in a logarithmic curve. After a delay period of approximately six months, waste begins to decompose at an increasing rate until it stabilizes with time. During the 2013-2019 period, the Naboro landfill is just coming to the end of this increasing rate of decomposition stage, contributing significantly to the growth in emissions within the given time period.

The combined uncertainty of emissions from Category 4A has been estimated at 77%. Inherent modelling uncertainties are introduced by the FOD model, as well as the default parameters/emission factors embedded within the IPCC FOD model spreadsheet used to represent the logarithmic decay of organic waste material and subsequent CH_4 emissions released from solid waste disposal sites. Additional uncertainty is introduced through the waste generation rates, waste composition, and percentage of waste deposited ant each type of SWDS, given that these values were obtained from a single study performed in 2009. To improve the estimates of the sector it is recommended to collect data on solid waste generation annually and undertake studies on waste management practices and waste composition in the country regularly (at least every 5 years). It is particularly important that the national GHG emission inventory ensures that the emissions from all waste management practices that take place in the country are accounted for. This is usually performed by waste stream analysis by waste type, as illustrated by box 2.1. chapter 2, volume 5 of IPCC 2006 Guidelines.

6.4. Biological treatment (4.B)

Biological treatment of solid waste refers to the treatment of organic fractions (such as food and garden waste, for example) by means of composting or anaerobic digestion. Composting is an aerobic process whereby a large fraction of the degradable organic carbon in the waste material is converted into biogenic carbon dioxide (CO_2). Limited quantities of methane (CH_4) are formed in anaerobic sections of the compost and some nitrous oxide (N_2O) is also generated and emitted.

Up to this date, there are no anaerobic digestion facilities for organic waste in the country. Composting is a common, yet informal, method of waste management practiced on a small scale by individual households in rural areas of Fiji[23] and among the urban population without access to waste collection services (including informal and squatter settlements).

Home composting is promoted under national Home Compost Subsidy Programme whereby citizens are encouraged to purchase compost bin at subsidized rate of $30.00. For example, 501 households in Lautoka city are practicing home composting whereby estimated 97.83 tons of household organic waste is composted per year. Other councils are implementing same initiative. However sufficiently comprehensive data on household-based compositing rates before 2019 is currently lacking.

Several large-scale formal composting initiatives have begun in urban areas in the year 2012 as part of the JICA Waste Minimisation and Recycling Promotion Project. Currently, there are five major organic waste composting programs in the following municipal areas: Ba, Lautoka, Nadi, Sigatoka and Suva[24]. Centralized composting facilities are currently in operation at the Lautoka and Suva City to recycle market organic wastes generated from Suva and Lautoka Markets respectively. In the case of the Lautoka City Council, a total of 121 tons of compost have been sold and a total of 2208 tons of market organic waste has been recycled since 2011.

This category plays a small part of the total GHG emissions arising from Fiji´s Waste Sector and has been included for the first time in the present 2013-2019 edition of the National GHG Inventory of Fiji, since composting only became sufficiently prominent following the year 2012.

Given the lack of data on informal household-level waste management practices, it has been assumed that all rural population, as well as the urban population without access to waste collection services conduct open burning of waste, as per the default assumption in Section 5.3.2 of Volume 5 from the 2006 IPCC Guidelines. As such, Category 4B only encompasses the CH_4 and N_2O emissions large-scale composting conducted in urban centralized facilities after the year 2012.

[23] Economics of rural waste management in the Rewa Province and development of a rural solid waste management policy for Fiji. Padma Lal, Margaret Tabunakawai and Sandeep K. Singh. ISBN 978-982-04-0381-9.
[24] Cleaner Pacific 2025-Pacific Regional Waste and Pollution Management Strategy 2016-2025. ISBN 978-982-04-0571-4.

Emissions have been estimated using the 2006 IPCC Tier 1 methodology through a multiplication of the annual organic waste composted in Fiji by the corresponding default CH_4 and N_2O emission factors.

The main data inputs needed is thus the total quantities of organic waste that is composted each year. This value has been derived from the urban population of Fiji, the urban MSW generation rate, and the percent of MSW that is collected and sent to composting facilities. The total population and the urban proportion have been obtained from the Fiji Bureau of Statistics and World Bank Data, respectively, while the urban MSW generation and composting rates have been obtained from the 2009 JICA study under the Waste Minimization and Recycling Promotion Project.

The following table presents the principal information used to calculate emissions from the biological treatment of solid waste in Fiji between 2013 and 2019.

Table 140. Data Used to Estimate GHG Emissions from Biological Treatment of Solid Waste.

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Total population of Fiji (capita)	865 841	870 602	875 364	880 125	884 887	889 649	894 410	-5%, +5%
Urban population (%)	53.71%	54.22%	54.73%	55.23%	55.74%	56.25%	56.75%	
Urban MSW generation rate (kg/person/day)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	-
Proportion of waste composted with respect to total waste generated by urban population (%)	8.28%	8.28%	8.28%	8.28%	8.28%	8.28%	8.28%	-
Annual mass of organic waste treated through composting (tonnes, wet basis)	21 068	21 385	21 704	22 021	22 345	22 671	22 995	-30%, +30%
CH_4 Emission factor for composting (g CH_4 /kg waste wet basis)	4	4	4	4	4	4	4	-99%, +100%
N_2O Emission factor for composting (g N_2O /kg waste wet basis)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	-75%, +150%

The following table and figure summarise the GHG emissions and trends of biological treatment of solid waste by gas. The total GHG emissions for Category 4B were 4.04 Gg

CO_{2e} in 2019 and 3.70 Gg CO_{2e} in 2013, representing an increase of 9.19%. This emissions trend corresponds to the urban population growth rate, which serves as the main driver for the amount of wate composted in Fiji and the subsequent GHG emissions. In 2019, Category 4B represented approximately 1.03% total GHG emissions from Fiji´s Waste Sector, accounting for only 0.70% of the sectoral CH_4 emissions and 9.58% of the sectoral N_2O emissions.

The combined uncertainty for CH_4 and N_2O emissions are 104% and 116%, respectively. While uncertainty is introduced through the estimation of the annual mass of organic waste treated through composting, the main source of uncertainty is attributed to the selection of the emissions factors. The representativeness of the selected emission factors greatly depends on the type of waste composted, as well as the amount and type of supporting material, the temperature, moisture content, and the aeration rates implemented during the composting process. As such, the selected default 2006 IPCC emission factors introduce a great level of uncertainty to the emissions estimates for composting.

Table 141. Summary of GHG Emissions from Biological Treatment of Solid Waste.

Category	Gas	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
4B Biological treatment of solid waste	CO_2	-	-	-	-	-	-	-	-
	CH_4	2.36	2.40	2.43	2.47	2.50	2.54	2.58	104%
	N_2O	1.34	1.36	1.38	1.40	1.42	1.44	1.46	116%
	Total	3.70	3.76	3.81	3.87	3.92	3.98	4.04	-

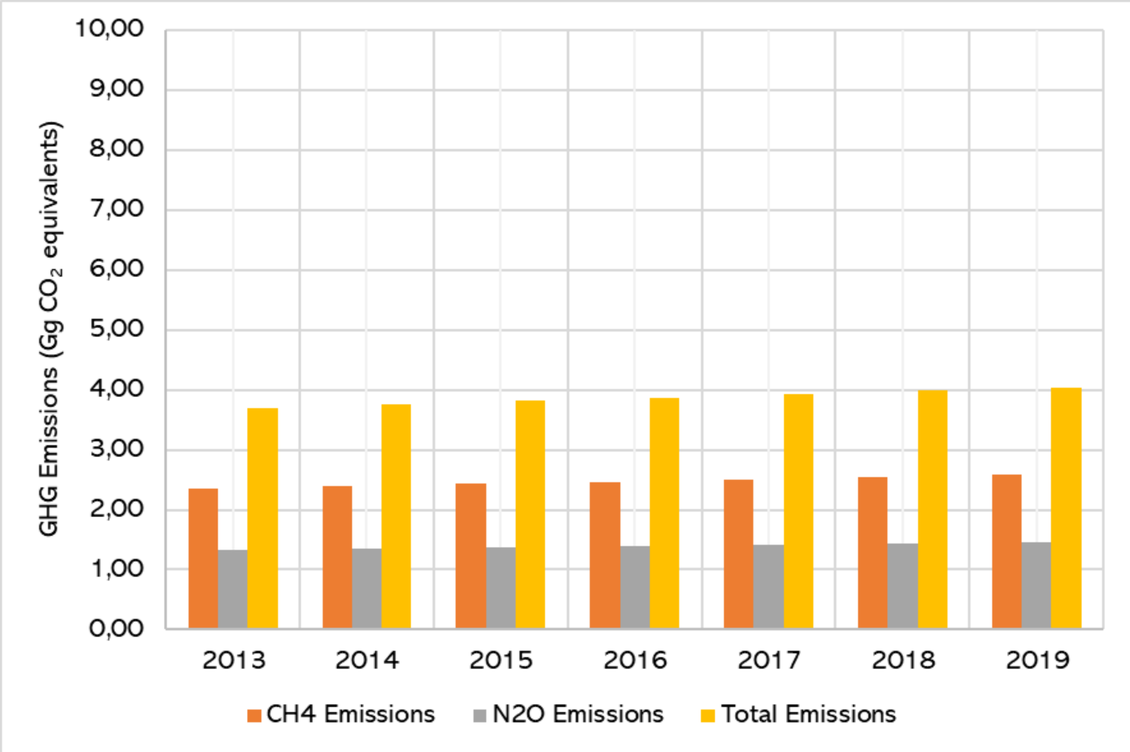


Figure 84: GHG Emissions from Biological Treatment of Solid Waste.

6.5. Incineration and open burning (4.C)

Category 4C has been included for the first time in the present 2013-2019 edition of the National GHG Inventory of Fiji, marking an important milestone in the improvement of the level of completeness of the inventory. It is divided into incineration (Category 4C1) and open burning (Category 4C2). Waste incineration refers to the deliberate, controlled combustion of waste in specialized facilities, whereas open burning consists of the intentional or unintentional combustion of waste in nature or open dumps where smoke is released directly into the air.

Disposal of solid waste through incineration and open burning generates carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions. Consistent with the 2006 IPCC Guidelines, only CO_2 emissions resulting from the oxidation of carbon of fossil origin contained in the waste are considered and included in the national net GHG emissions estimates. Fossil carbon in waste includes that in contained plastics, synthetic textiles, rubber, liquid solvents, and waste oil. On the contrary, CO_2 emissions resulting from the oxidation of carbon contained in biomass waste materials such as paper, food, and wood waste are classified as biogenic and not included in the national net GHG emissions estimates.

CO_2 emissions have been estimated using the 2006 IPCC Tier 2a methodology. The Tier 2a approach requires the use of country-specific activity data on the quantity and composition of waste incinerated/open burned, in conjunction with default parameters regarding the dry matter content, carbon fraction, fossil carbon fraction, and oxidation factor of the waste. Given that CO_2 emissions are dependent to a large extent on the amount of fossil carbon in the waste combusted, it therefore of critical importance to dispose of reliable data on the composition of the waste that is combusted in the country, either through open burning or incineration.

The calculation of CH_4 and N_2O emissions are based on the 2006 IPCC Tier 1 approach, which employs country-specific activity data on the total quantity of waste incinerated/open burned, in conjunction with appropriate default emission factors corresponding to the type of waste combusted (clinical waste or MSW), and the type of combustion method used (incineration or open-burning).

Category 4C1. Waste incineration

Incineration of clinical waste occurs at three Divisional Hospitals in Fiji, namely the Colonial War Memorial (CWM) Hospital in Suva, the Lautoka Divisional Hospital, and the Labasa Divisional Hospital. All three hospitals implement batch-type stroker technology and have begun to upkeep monthly incineration records since the year 2011. Due to significant data gaps in the incineration records provided by the Central Board of Health, the annual quantity of clinical waste incinerated in 2014 was extrapolated using the national population growth rate obtained from the Fiji Bureau of Statistics, assuming a direct correlation between clinical waste incineration and population growth. No energy recovery takes place at these incinerators.

The following table presents the principal information used to calculate CO_2 emissions from the incineration of clinical waste in Fiji between 2013 and 2019. Default IPCC values for parameters such as dry matter content, carbon fraction, fossil carbon fraction, and oxidation factor were used. It is important to note that no default emission factors are provided in the 2006 IPCC Guidelines for estimating nitrous oxide and methane emissions from the incineration of clinical waste, and thus, these emissions were not estimated.

Table 142. Data Used to Estimate GHG Emissions from the Incineration of Clinical Waste.

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Total population of Fiji (capita)	865 841	870 602	875 364	880 125	884 887	889 649	894 410	-5%, +5%
Annual amount of clinical waste incinerated (kg)	280 657	282 200	283 743	285 287	286 830	288 374	289 917	-100%, +100%
Dry matter content, dm (fraction)	1	1	1	1	1	1	1	-40%, +40%
Carbon fraction in dry matter, CF (fraction)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Fossil carbon fraction in total carbon, FCF (fraction)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Oxidation factor of carbon input, OF (fraction)	1	1	1	1	1	1	1	
Conversion factor from C to CO_2	44/12	44/12	44/12	44/12	44/12	44/12	44/12	

Incineration of quarantined waste is conducted under the Biosecurity Authority of Fiji which has provided quarantine waste incineration rates starting in 2017. Partial data is available for the Biosecurity Authority of Fiji and for the King´s and Queen´s Wharfs, which implement continuous fluidized bed and batch-type stroker technologies, respectively. The total quantity of quarantined waste incinerated in 2019 was extrapolated to complete the time series, assuming a direct correlation with the annual quantities of imports of goods and services in Fiji obtained from the World Bank Data. No energy recovery takes place at these incinerators.

The following table presents the principal information used to calculate CO_2, CH_4, and N_2O emissions from the incineration of quarantined waste in Fiji between 2013 and 2019. The composition of the quarantined waste provided by the Biosecurity Authority of Fiji considered in the calculations is as follows: food (49.3%), garden (11.7%), wood (11.7%), paper/cardboard (10.0%), textiles (8.3%), and inerts (9.0%). All other parameters and emission factors consist of default values from the 2006 IPCC Guidelines.

Table 143. Data to Estimate GHG Emissions from the Incineration of Quarantined Waste.

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Imports of goods and services (millions current USD)	2 911	2 840	2 451	2 491	2 727	3 099	3 031	-
Annual amount of quarantined waste incinerated by continuous fluidized bed (kg)	1 825	1 780	1 537	1 562	1 710	1 943	1 900	-100%, +100%
Annual amount of quarantined waste incinerated by batch-type stroker (kg)	36 592	35 702	30 814	31 313	34 282	38 954	38 099	-100%, +100%
Dry matter content, dm (fraction)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	-40%, +40%
Carbon fraction in dry matter, CF (fraction)	0.39	0.39	0.39	0.39	0.39	0.39	0.39	
Fossil carbon fraction in total carbon, FCF (fraction)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	
Oxidation factor of carbon input, OF (fraction)	1	1	1	1	1	1	1	
Conversion factor from C to CO_2	44/12	44/12	44/12	44/12	44/12	44/12	44/12	
N_2O Emission factor for continuous fluidized bed (kg N_2O/kg waste, wet basis)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	-100%, +100%
CH_4 Emission factor for continuous fluidized bed (kg CH_4/kg waste, wet basis)	0	0	0	0	0	0	0	-100%, +100%
N_2O Emission factor for batch-type stroker (kg N_2O/kg waste, wet basis)	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	-100%, +100%
CH_4 Emission factor for batch-type stroker (kg CH_4/kg waste, wet basis)	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	-100%, +100%

The following table and figure summarise the GHG emissions and trends of waste incineration by gas. The total GHG emissions for Category 4C1 were 0.26 Gg CO_{2e} in 2019 and 0.25 Gg CO_{2e} in 2013, representing a steady increase of 4%. In 2019, Category 4C1 represented less than 0.07% of the total GHG emissions from Fiji´s Waste Sector. While CO_2 emissions from waste incineration account for 3.71% of the sectoral CO_2 emissions, the contribution of Category 4C1 to sectoral CH_4 and N_2O emissions are considered negligible.[25]

Table 144. Summary of GHG Emissions from Waste Incineration.

Category	Gas	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
4C1 Waste incineration	CO_2	0.25	0.25	0.25	0.25	0.26	0.26	0.26	108%
	CH_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	141%
	N_2O	0.001	0.001	0.001	0.001	0.001	0.001	0.001	141%
	Total	0.25	0.25	0.25	0.25	0.26	0.26	0.26	-

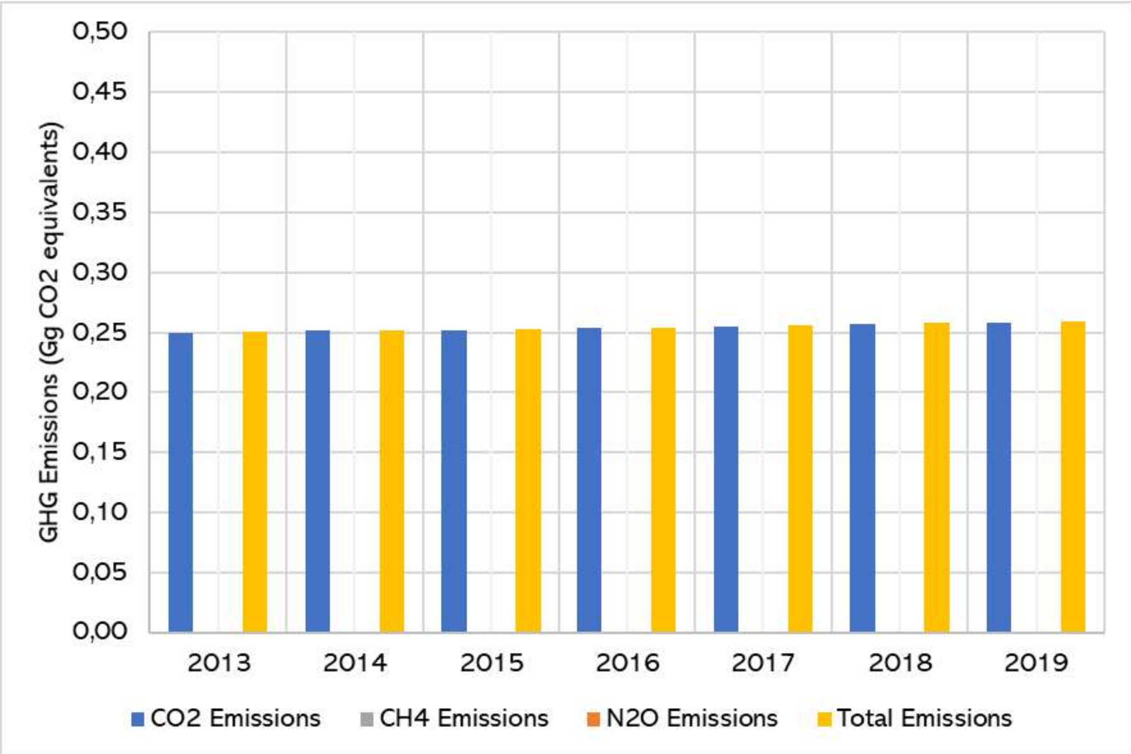


Figure 85: GHG Emissions from Waste Incineration.

[25] Provision 32 of Decision 18/CMA.1 - Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement states that "Those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead consider emissions insignificant if the likely level of emissions is below 0.1 per cent of the national total GHG emissions, excluding FOLU, or 1,000 kt CO_{2eq}, whichever is lower."

The combined uncertainty for CO_2, CH_4, and N_2O emissions are 108%, 141%, and 141%, respectively. The main sources of uncertainty arise due to the data gaps in the incineration records of Fiji´s divisional Hospitals and its Biosecurity Authority, for which extrapolation was required. The major uncertainty associated with the CO_2 emissions estimate is related to the estimation of the fossil carbon fraction in the waste, which arises from limited data on waste composition. Although Category 4C1 is a minor contributor to national GHG emissions, for future inventory improvement, detailed waste incineration records should be upkept with updated data on the quantity and composition of waste incinerated at each facility, explicitly indicating any incinerator downtimes.

Category 4C2. Open burning of waste

Rural communities as well as informal or squatter settlements in Fiji have very limited (if any) access to waste collection services. Although littering and the open burning of waste are illegal under Open Fires by-laws and the 2010 amended Littering Decree, illegal dumping and burning of waste are still very common among these population groups due to inadequate enforcement. Other informal waste management techniques include household-level reuse, burial, composting, and feeding to pigs, but no quantifiable statistics exist on this matter. It is also known that open burning is a common sight throughout all of Fiji´s SWDS, except for the Naboro Landfill, which is the only managed engineered sanitary landfill.

As per 2006 IPCC Guidelines, in developing countries such as Fiji, although it is preferable to apply country- and region-specific data on waste-handling practices, the fraction of the population burning waste (Pfrac) can be roughly estimated as the sum of i) the population in urban areas whose waste is not collected by collection structures, ii) the population in urban areas whose waste is collected and disposed in open dumps (unmanaged and uncategorized SWDS), and iii) all the rural population. The 2006 IPCC Guidelines also adopt the assumption that approximately 60% of the waste exposed to open burning actually burns (Bfac = 0.60).

To estimate the emissions from Category 4C2, the afore-mentioned assumptions were adopted, in combination with the rural and urban MSW generation rates obtained from the 2009 JICA study under the Waste Minimization and Recycling Promotion Project. The composition of the MSW considered in the calculations was also obtained from the 2009 JICA study as follows: food (33.6%), wood (39.6%), paper/cardboard (11.4%), plastics (6.7%), textiles (1.0%), and inerts (7.7%).

The following table presents the principal information used to calculate CO_2, CH_4, and N_2O emissions from the open burning of waste in Fiji between 2013 and 2019. Data on the total population of Fiji and the rural/urban proportions were obtained from the Fiji Bureau of Statistics and World Bank Data, respectively. All other parameters (including dry matter content, carbon fraction, fossil carbon fraction, oxidation factor, CH_4 emission factor, and N_2O emission factor) were selected among the default values provided by the 2006 IPCC Guidelines.

Table 145. Data Used to Estimate GHG Emissions from Open Burning.

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Total population of Fiji (capita)	865 841	870 602	875 364	880 125	884 887	889 649	894 410	-
Urban population (%)	53.71%	54.22%	54.73%	55.23%	55.74%	56.25%	56.75%	-
Urban waste generation rate, (kg/person/day)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	-
Proportion of urban population open burning waste, Pfrac (%)	40.26%	40.26%	40.26%	40.26%	40.26%	40.26%	40.26%	-
Rural population (%)	46.29%	45.78%	45.27%	44.77%	44.26%	43.75%	43.25%	-
Rural waste generation rate, (kg/person/day)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-
Proportion of rural population open burning waste, Pfrac (%)	100%	100%	100%	100%	100%	100%	100%	-
Total annual quantity of MSW open-burned (tonnes, wet basis)	96 621	97 351	98 082	98 813	99 549	100 287	101 024	-30%, +30%
Dry matter content, dm (fraction)	0.72	0.72	0.72	0.72	0.72	0.72	0.72	-40%, +40%
Carbon fraction in dry matter, CF (fraction)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	
Fossil carbon fraction in total carbon, FCF (fraction)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
Oxidation factor of carbon input, OF (fraction)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	
Conversion factor from C to CO_2	44/12	44/12	44/12	44/12	44/12	44/12	44/12	
CH_4 emission factor (kg CH_4/ kg MSW wet basis)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	-100%, +100%
N_2O emission factor (kg N_2O/ kg MSW dry basis)	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	-100%, +100%

The following table and figure summarise the GHG emissions and trends of open burning by gas. The total GHG emissions for Category 4C2 were 21.24 Gg CO_{2e} in 2019 and 20.72 Gg CO_{2e} in 2013, representing a steady increase of 2.5%. Such growth could be attributed to the increase in the overall population in Fiji, resulting in greater quantities of waste generated, but a decreasing rural population, resulting in greater access to waste collection services and thus smaller quantities of open burning.

In 2019, Open burning of waste represented approximately 5.42% of the total GHG emissions from Fiji´s Waste Sector, being the main source of CO_2 emissions for the Waste Sector, accounting for 96.29% of the sectoral CO_2 emissions. On the other hand, this Category 4C2 accounted for 3.40% of the sectoral CH_4 emissions and 12.93% of the sectoral N_2O emissions.

Table 146. Summary of GHG Emissions from Open Burning.

Category	Gas	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
4C2 Open burning of waste	CO_2	6.57	6.60	6.63	6.66	6.69	6.71	6.74	50%
	CH_4	12.23	12.28	12.33	12.38	12.43	12.49	12.54	104%
	N_2O	1.92	1.93	1.93	1.94	1.95	1.96	1.97	116%
	Total	20.72	20.81	20.89	20.98	21.07	21.16	21.24	-

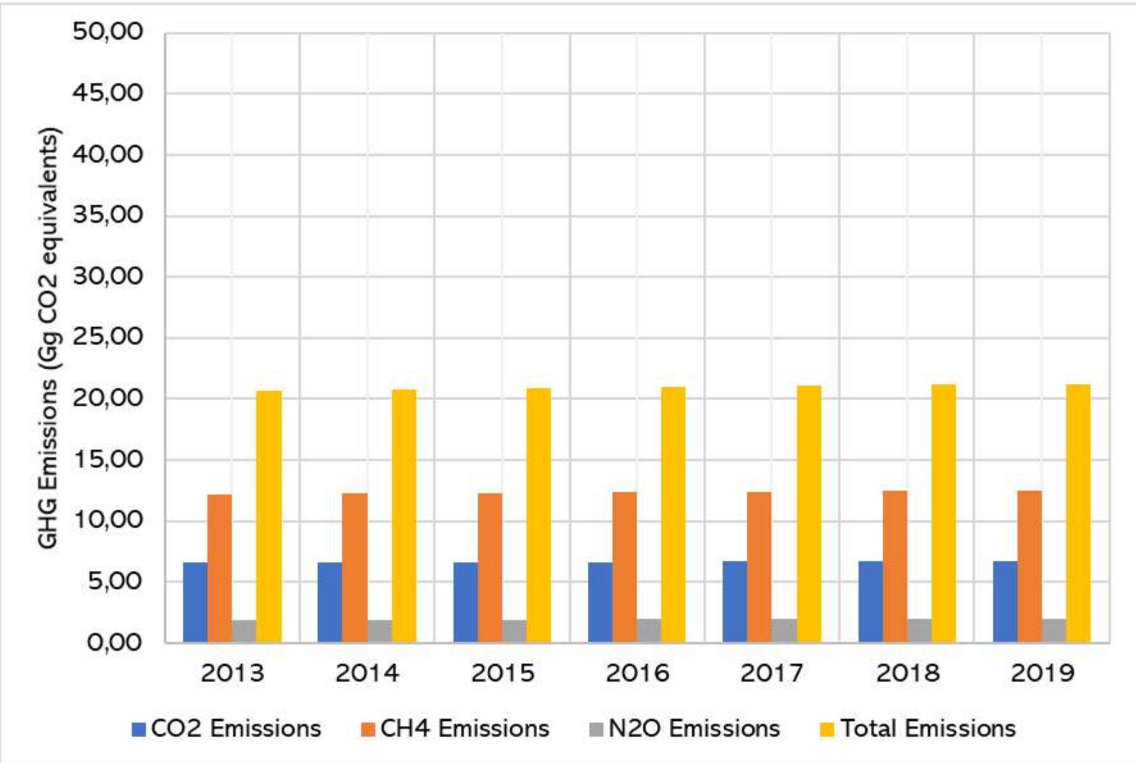


Figure 86: GHG Emissions from Open Burning.

The combined uncertainty for CO_2, CH_4, and N_2O emissions are 50%, 104%, and 116%, respectively. Default emission factors for N_2O and CH_4 emissions from open burning of waste have a relatively high level of uncertainty, accounting for the greater combined uncertainty of these to gases in comparison with CO_2 emissions. The major uncertainty associated with the CO_2 emissions estimate is related to the estimation of the fossil carbon fraction in the waste. Future estimates could be improved by conducting further waste characterization campaigns, given that the values used from the 2009 JICA study require updating. Furthermore, studies on rural waste management practices could be conducted to improve the estimation of the fraction of the population in Fiji that conducts open burning.

6.6. Wastewater treatment and discharge (4.D)

Wastewater treatment and discharge processes can be a source of methane (CH_4), as well as direct and indirect nitrous oxide (N_2O) emissions. Methane is generated as a result of the anaerobic decomposition of degradable matter in wastewater. Indirect N_2O emissions occur from the decomposition of nitrogen contained in wastewater after disposal of effluent into waterways. Direct N_2O emissions are a minor source arising from controlled nitrification and denitrification processes at advanced wastewater treatment plants (WWTPs). As per the 2006 IPCC Guidelines, direct N_2O emissions are only of interest to countries that predominantly have advanced centralized WWTPs with nitrification and denitrification steps, which is not the case of Fiji. Therefore, the 2013-2019 edition of the National GHG Inventory of Fiji only considers indirect N_2O emissions from human sewage. Carbon dioxide (CO_2) emissions from wastewater are not considered as these are of biogenic origin and thus should not be included in the national total emissions.

It is important to note that wastewater treatment systems are not final disposal points or sites. They are usually considered as intermediary treatment facility since they ultimately end up in the sea or river but not in its raw state.

Domestic wastewater includes human sewage, while industrial wastewater results as a by-product of industrial processes. Domestic wastewater may be collected by the public sewage system, treated in de-centralized latrines, septic tanks or lagoon, or released directly into the environment without treatment. On the other hand, industrial wastewater may be treated on-site, discharged into the public sewer system, or released directly into the environment without treatment.

Category 4D is dived into two sub-categories: domestic (Category 4D1) and industrial (Category 4D2) wastewater treatment and discharge. Category 4D1 concerns the treatment and discharge of all domestic wastewater. Category 4D2 only concerns the on-site treatment of industrial wastewater by industries. According to the 2006 IPCC Guidelines, if industries dispose their wastewater into the public sewer lines, then their associated emissions are accounted for under the domestic wastewater treatment and discharge. Given that most industries in Fiji are either connected to the public sewage system or discharge their wastewater directly into the environment and given a lack of data on the existence of any in-situ industrial wastewater treatment processes, Category 4D2 is not included in the present 2013-2019 edition of the National GHG Inventory of Fiji. Instead, industrial wastewater emissions have been included within Category 4D1 using the correction factor for additional industrial matter discharged into domestic sewers.

The estimation of CH_4 emissions from wastewater treatment and discharge in Fiji are conducted are based on the 2006 IPCC Tier 1 approach, which requires country-specific knowledge on the quantity of wastewater generated, the biological oxygen demand (BOD) of the wastewater, and the type of wastewater management practices employed. The estimation of indirect N_2O emissions from effluent through the 2006 Tier 1 approach requires country-specific data on the per capita protein intake and the total population.

In Fiji, data on total wastewater generation and characteristics is limited. The containment of wastewater is challenging, with approximately 35% of all wastewater generated currently being discharged into the sea (referred to as "marine treatment"). Local enterprises have also recognized some of the potential benefits from liquid waste recovery, and there are ongoing efforts to reuse or recycle liquid waste by converting it to biodiesel, animal feed and soap products.

Category 4D1. Domestic wastewater treatment and discharge

To estimate CH_4 emissions from domestic wastewater treatment and discharge under the 2006 IPCC Tier 1 approach, the main data requirements are:

- Types of wastewater treatment/discharge streams and their emission factors.
- Quantity of population using each treatment and discharge stream (degree of utilization of each stream).
- Per capita biochemical oxygen demand (BOD).
- Annual quantity of sludge recovery (if any).
- Annual quantity of methane recovery and flaring (if any).

There are a total of 11 wastewater treatment plants in Fiji, providing a coverage of 26-28% of Fiji´s population, 98% of which employs anaerobic treatment processes and the remaining 2% employ aerobic treatment processes. The remaining 74-72% of Fiji´s population either use septic systems (52%) or discharge wastewater directly without treatment (48%).

The Water Authority of Fiji does not currently possess detailed records of the number of people connected to each WWTP, but rather, the annual volume of wastewater treated at each facility. However, the National Liquid Waste Management Strategy does specify the number of connections at each WWTP for the year 2007. The number of connections at each WWTP was thus derived by correlating the volume of wastewater treated at each facility in 2007 with the number of people connected that same year. The proportion of the population using septic systems and direct disposal were obtained from the National Liquid Waste Management Strategy, assumed constant throughout the time series.

Currently, the Water Authority of Fiji only has high-resolution BOD measurements available for the Kinoya WWTP, with an average value of 60 g/person/day, consistent with the 2006 IPCC default value for Oceania. To account for the additional industrial BOD discharged into sewers, the default correction factor of 1.25 was applied to the BOD values used to estimate emissions from aerobic and anaerobic WWTPs, whereas the default correction factor of 1.00 was applied for septic systems and direct disposal, as per 2006 IPCC Guidelines. The default IPCC maximum CH_4 producing capacity of 60 kg CH_4/kg BOD was adopted, and default methane correction factors (MCF) were obtained from the 2006 IPCC Guidelines as follows:

- Anaerobic wastewater treatment plants: MCF = 0.8
- Aerobic wastewater treatment plants: MCF = 0.3
- Septic systems: MCF = 0.5
- Direct disposal: MCF = 0.1

No data is currently available on sludge recovery, for which it was assumed that no sludge recovery occurs in Fiji, as per default 2006 IPCC assumption. Starting in 2014, the Kinoya WWTP began methane recovery and flaring through a CDM project financed by the Asian Development Bank. No energy recovery takes place in these processes. Information on annual methane recovery and flaring rates were thus obtained from CDM project records.

The following table presents the principal information used to calculate CH_4 emissions from domestic wastewater treatment and discharge in Fiji between 2013 and 2019.

Table 147. Data Used to Estimate CH_4 Emissions from Domestic Wastewater Treatment and Discharge.

Stream	Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Cross-cutting data	Total population of Fiji (capita)	865 841	870 602	875 364	880 125	884 887	889 649	894 410	-5%, +5%
	BOD (g/person/day)	60	60	60	60	60	60	60	-30%, +30%
	Maximum CH_4 producing capacity, Bo (kg CH_4/kg BOD)	0.60	0.60	0.60	0.60	0.60	0.60	0.60	-30%, +30%
Aerobic WWTP	Degree of utilization (%)	6.66%	6.75%	6.83%	6.92%	7.01%	7.10%	7.20%	-50%, +50%
	Correction factor for additional industrial BOD discharged into sewers	1.25	1.25	1.25	1.25	1.25	1.25	1.25	-20%, +20%
	Methane correction factor (MCF)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-30%, +30%
	Organic component removed as sludge (kg)	0	0	0	0	0	0	0	-
	Annual methane recovery and flaring (kg CH_4)	0	0	0	0	0	0	0	-
Anaerobic WWTP	Degree of utilization (%)	19.02%	19.37%	19.72%	20.09%	20.45%	20.83%	21.21%	-50%, +50%
	Correction factor for additional industrial BOD discharged into sewers	1.25	1.25	1.25	1.25	1.25	1.25	1.25	-20%, +20%
	Methane correction factor (MCF)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	-30%, +30%
	Organic component removed as sludge (kg)	0	0	0	0	0	0	0	-
	Annual methane recovery and flaring (tonnes CH_4)	0	46	437	707	1,346	1,378	1,378	-10%, +10%

Direct disposal	Degree of utilization (%)	35.71%	35.50%	35.29%	35.07%	34.85%	34.63%	34.40%	-50%, +50%
	Correction factor for additional industrial BOD discharged into sewers	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-20%, +20%
	Methane correction factor (MCF)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-50%, +50%
	Organic component removed as sludge (kg)	0	0	0	0	0	0	0	-
	Annual methane recovery and flaring (kg CH_4)	0	0	0	0	0	0	0	-
Septic systems	Degree of utilization (%)	38.61%	38.38%	38.15%	37.92%	37.68%	37.44%	37.19%	-50%, +50%
	Correction factor for additional industrial BOD discharged into sewers	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-20%, +20%
	Methane correction factor (MCF)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-50%, +50%
	Organic component removed as sludge (kg)	0	0	0	0	0	0	0	-
	Annual methane recovery and flaring (tonnes CH_4)	0	0	0	0	0	0	0	-

The estimation of nitrous oxide emissions from human sewage effluent was based on the per capita dietary protein consumption of Fiji obtained from FAO statistics, and the total population of the country obtained from the Fiji Bureau of Statistics. Given that FAO only provides the necessary data up to the year 2007, it was assumed that the per-capita dietary protein consumption of Fiji remained constant after 2007 at a value of 79 g/person/day. The necessary parameters and emission factors were obtained from the 2006 IPCC Guidelines, assuming no sludge removal occurs.

The following table presents the principal information used to calculate indirect N_2O emissions from human sewage in Fiji between 2013 and 2019.

Table 148. Data Used to Estimate Indirect N_2O Emissions from Human Sewage.

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Total population of Fiji (capita)	865 841	870 602	875 364	880 125	884 887	889 649	894 410	-5%, +5%

Data	2013	2014	2015	2016	2017	2018	2019	Uncertainty
Dietary protein consumption, (kg/person/yr)	29	29	29	29	29	29	29	-10%, +10%
Nitrogen removed with sludge (kg N/yr)	0	0	0	0	0	0	0	-
Fraction of nitrogen in protein (kg N/kg protein)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	-6%, +6%
Factor for non-consumed protein added to the wastewater	1.1	1.1	1.1	1.1	1.1	1.1	1.1	-9%, +36%
Factor for industrial and commercial co-discharged protein	1.25	1.25	1.25	1.25	1.25	1.25	1.25	-20%, +20%
EF effluent (kg N_2O-N/kg N)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	-90%, +4900%

The following table and set of figures summarise the GHG emissions and trends of wastewater treatment and discharge by wastewater treatment and discharge stream. Category 4D is a key category both in terms of level and trend assessments. In 2019, emissions from domestic wastewater treatment and discharge represented approximately 32.63% of the total GHG emissions from Fiji´s Waste Sector, accounting for 31.73% of the sectoral CH_4 emissions. The decomposition of nitrogen content in human sewage is the main source of N_2O emissions for the Waste Sector, accounting for 73.08% of the sectoral N_2O emissions.

Table 149. Summary of GHG Emissions from Domestic Wastewater Treatment and Discharge

Gas	Wastewater Stream	GHG emissions in Gg CO_{2eq}							Uncertainty
		2013	2014	2015	2016	2017	2018	2019	
CH_4	Aerobic WWTP	7.96	8.10	8.25	8.41	8.56	8.72	8.88	75%
	Anaerobic WWTP	60.60	60.77	51.28	45.25	28.90	29.60	31.22	76%
	Direct disposal	11.38	11.37	11.37	11.36	11.35	11.33	11.32	83%
	Septic tank	61.49	61.47	61.44	61.39	61.34	61.27	61.19	83%
	Total	141.42	141.71	132.34	126.40	110.15	110.92	112.62	80%
N_2O	Total	11.44	11.50	11.56	11.63	11.69	11.75	11.81	501%
Total		152.86	153.21	143.90	138.03	121.83	122.67	124.43	-

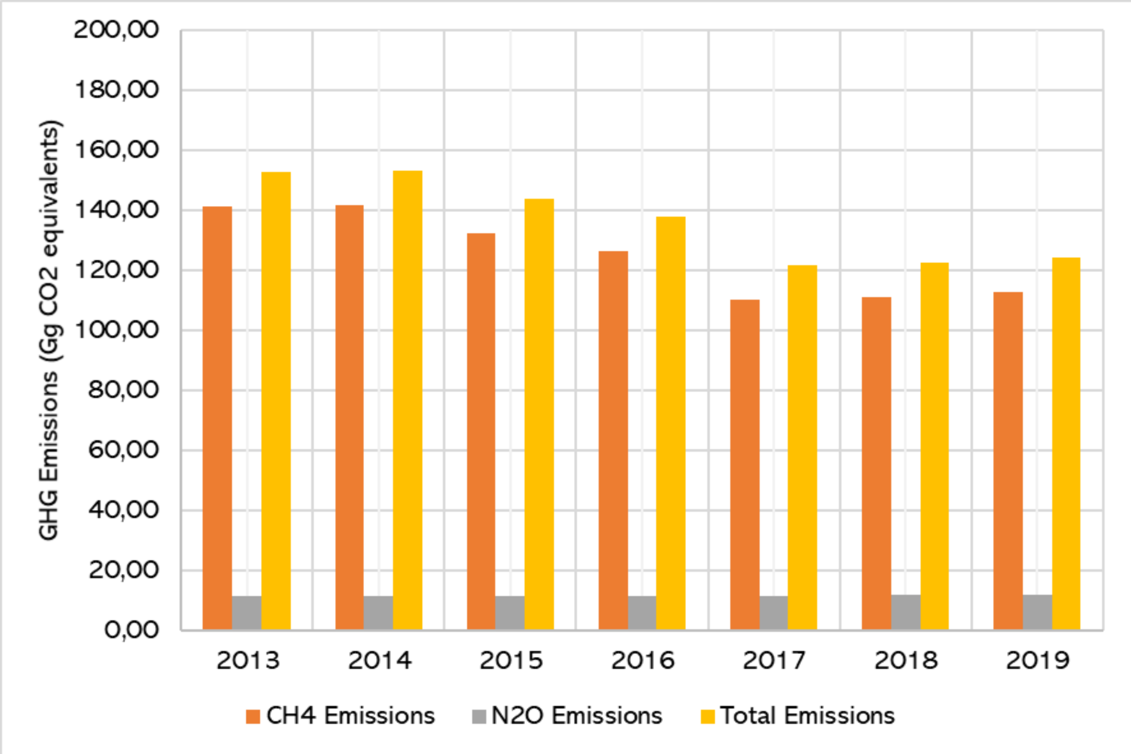


Figure 87. Total GHG Emissions from Domestic Wastewater Treatment and Discharge.

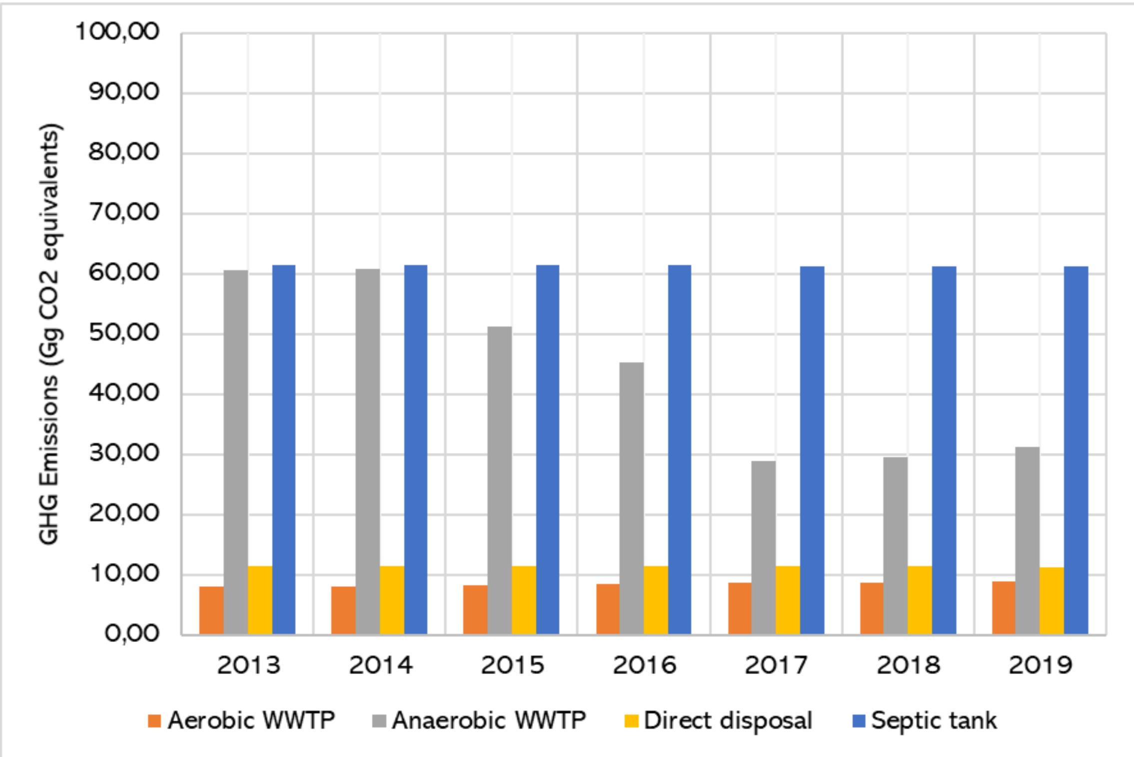


Figure 88. CH4 Emissions from by Type of Wastewater Treatment and Discharge Stream.

A decrease of 22.85% is observed in the total GHG emissions for Category 4D between the years 2013 and 2019, with total emissions surmounting to 152.86 Gg CO_{2e} in 2013 and 124.43 Gg CO_{2e} in 2019. This trend can be attributed to the introduction of methane recovery and flaring at the Kinoya WWTP, given that an increase of 3.23% in N_2O emissions from human sewage is observed, driven by the increase in the total population of Fiji during the 2013-2019 time period.

Upon analysing the CH_4 emissions generated by each type of wastewater treatment/discharge stream, it can be observed that emissions from anaerobic WWTPs and septic systems are the two most important sources of emissions within this category. In 2013, emissions from anaerobic WWTPs and septic tanks represented 42.85% and 43.48% of all methane emission from domestic wastewater treatment and discharge. While emissions from aerobic WWTPs, direct disposal, and septic systems remained relatively constant throughout the 2013-2019 time period, emission from anaerobic WWTPs have decreased by almost 50% thanks to the introduction of methane recovery and flaring at the Kinoya WWTP. By 2019, the contribution of anaerobic WWTPs decreased to 27.72%.

The combined uncertainty for CH_4 and N_2O emissions are 80% and 501%, respectively. As asserted by the 2006 IPCC Guidelines, large uncertainties are associated with the IPCC default emission factors for N_2O from effluent, and there is currently insufficient field data exist to improve this factor. The main source of uncertainty in methane emissions are both the BOD values and the degree of utilization of each type of wastewater treatment/discharge stream. The accuracy of the inventory could be greatly improved through the incorporation of high-resolution and frequent BOD measurements at each WWTP in Fiji, and well as the establishment of detailed records on the quantity of people connected to each WWTP.

Category 4D2. Industrial wastewater treatment and discharge

This category has not been included in the 2013-2019 edition of the National GHG Inventory of Fiji. Most industrial wastewater is discharged either into the domestic sewage system or directly into the environment without pre-treatment, for which corresponding emissions are accounted for under Category 4D1 through the use of the appropriate correction factor for additional industrial BOD discharged into sewers, as per 2006 IPCC Guidelines. No activity data is currently available on industrial wastewater characteristics, generation rates or in-situ treatment processes (if any).

6.7. Planned improvements

During the inventory compilation, certain areas were identified for future improvements to ensure building greater confidence in the inventory estimate by reducing uncertainties to the extent possible. Fiji is already underway in increasing data quality and availability. Efforts should be prioritized to enhance country-specific activity data collection systems that will greatly increase the accuracy of the inventory, focused primarily on the key categories of solid waste disposal (4A) and wastewater treatment and discharge (4D).

Category 4A:

Emission results depend on the quantity of degradable manner that is deposited at solid waste disposal sites each year and the extent of anaerobic conditions of these sites. As such, it is of fundamental importance to have detailed records of the waste generation rates and the composition of waste generated in the country, which is currently lacking in Fiji.

To estimate results, both data needs were obtained from the 2009 JICA study under the Waste Minimization and Recycling Promotion Project and assumed constant throughout time. Regular waste characterization campaigns should be taken at least every 5 years to reflect the temporal evolution of waste generation practices. Currently, Ba, Labasa, Lami, Lautoka, Levuka, Sigatoka, and Tavua Councils maintain sporadic waste characterization campaigns. However, the waste categories used different from those of the IPCC Guidelines and differ between the different councils. The establishment of standardized national waste composition categories and tables of maintaining waste composition categories is a cost-effective way to increase the quality of waste composition data in the short-term. While H.G. Leach (Fiji) Pte. Limited maintains detailed waste composition records for the Naboro Landfill, updated on a monthly basis, the waste categories used do not specify the quantity of organic materials in the waste, which is one of the main drivers dictating the quantity of CH_4 emissions generated.

Regarding waste generation, a bottom-up approach that sums the annual quantity of waste deposited at each SWDS annually would greatly increase the quality of the data. For this, it would be highly beneficial to have weighbridges installed at each SWDS. Since its opening, the Naboro Landfill features a weighbridge and a new one was installed at the Vanuatu Dump as part of the 2009 JICA-funded project. In the future, weighbridges in all solid waste disposal sites, starting in the biggest-used sites should be installed. Nevertheless, it is recommended to collect data on solid waste generation annually through accounting for the number of waste disposal trucks delivering waste to each site on a daily basis.

It is also worth mentioning that Fiji has undertaken several initiatives to divert plastics from solid waste disposal sites, but little data is available on the quantities of such waste that is diverted. A future recommendation would be to partner with the key recycling agencies to establish annual records of the type and quantity of waste that is recycled.

The GHG inventory currently accounts for the rural population through the IPCC assumption that all rural communities in developing countries conduct open burning. In the long-term, rural waste generation and management studies should be undertaken in partnership with research institutions.

Furthermore, there is a lack of data on industrial waste generation rates, composition and treatment methods used in the country. As a result, this type of waste was not accounted for in the present edition of the GHG emission inventory. With the aim of enhancing completeness, future research and data collection on industrial waste generation and handling should be conducted in Fiji in order to adequately account for the associated emissions.

These actions should be led by the Fiji Waste Management Authority.

Category 4B:

This Category has become of relevance in Fiji starting in 2012 through the commencement of large-scale composting in several town councils and municipal markets. Given that the main data input for estimating emissions under this category corresponds to the mass of waste that is composting each year, it is of high importance for Fiji to maintain updated records of this data. Annual records are already being maintained since 2012 by each composting facilities, but are currently inconsistent, as some measure the quantity of compost sold or the revenues of composting sales. Ideally, the mass of organic waste that is sent to each composting facility should be monitored and recorded. Given that each facility already has data-collection process, a low-cost and short-term solution would be for the Fiji Waste Management Authority to create standardized data collection templates and instruct all composting facilities to maintain comparable records using the standardized forms.

Category 4C1:

One of the main data inputs for estimating emissions from waste incineration is the annual quantity of waste that is incinerated by waste type.

The three Divisional Hospitals in Fiji that undertake incineration of clinical waste already have established monthly incineration records. However, the records could be improved by ensuring that all months are accounted for and clearly indicating when the incinerators are down to eliminate data gaps, which have introduced additional uncertainty in the emissions estimates of the current 2013-2019 edition of the National Inventory of Fiji. It is therefore recommended as a short-term and cost-effective action that the Central Board of Health ensures the three divisional hospitals adequately upkeep their established waste incineration records and accounting systems.

Very limited data is available on quarantined waste incineration rates and composition, and the types of monitoring systems led by the Biosecurity Authority of Fiji on quarantined waste incineration is unknown. It is therefore recommended to begin establishing annual records of this information. Given that the emissions from Category 4C1 represent less than 0.07% of the total GHG emission of the Waste Sector in 2019, with CH_4 and N_2O emissions from quarantined waste incineration considered negligible, this recommendation is of low priority and can be implemented as a long-term action.

Category 4C2:

One of the main data inputs for estimating emissions from open burning is the total quantity of waste that is open burned each year. It is known that open burning is a common practice among the rural population, squatter, and informal settlements, as well as open dumps. As such, the IPCC default assumption for estimating the proportion of the population of Fiji that undergoes open burning can be applied. In order to improve the accuracy of this assumption and better reflect the national context, future studies on informal waste management practices in Fiji could be undertaken by the Waste Management Authority of Fiji, in partnership with research institutions. However, such studies are resource-intensive and could be considered as a long-term action considering that Category 4C2 only accounted for 8.17% of emissions from the Waste Sector.

Category 4D:

The main data inputs for estimating emissions from wastewater treatment and discharge is the per capita BOD and the number of people utilizing each type of wastewater treatment/discharge stream. Given that high-resolution BOD measurements are only available for the Kinoya WWTP, it would be of high priority to initiate regular BOD monitoring processes and each of the other wastewater treatment plants in Fiji, using standardized measurement techniques that should be verified by the Water Authority of Fiji. Detailed records on the number of people connected to each treatment/discharge system are not maintained, which introduce a significant degree of uncertainty in the emissions estimates. Both these actions would immediately improve the quality of the inventory and should therefore be implemented with high priority, considering that Category 4D is a key category.

In the Future, Category 4D2 – Industrial Wastewater Treatment and Discharge could be included in subsequent versions of the 2013-2019 National GHG Emissions Inventory of Fiji if studies are conducted on in-situ wastewater treatment processes, which are currently lacking in Fiji. Considering that most industrial facilities in Fiji discharge their sewage either into the public sewerage system or directly into the environment, this recommendation could be considered for the potential adoption in the long-term.

The following table summarises the improvement areas, institutions responsible, and proposed period of implementation for the Waste Sector.

Table 150. Improvement Areas for the Waste Sector.

Waste Sector – Solid Waste Generation and Treatment			
Identified fields of improvement			
There is currently a lack of standardized, country-specific, updated information of municipal solid waste composition and generation rates.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Create standardized waste composition categories aligned with IPCC values to be used among all city/town councils waste characterization studies.	2023	Ministry of Local Government and Housing/Department of Environment/Fiji Waste Management Authority
Medium-term Actions		Proposed period of implementation	Institution responsible
2	Align the waste composition categories used in the records of the Naboro Landfill with the IPCC categories for municipal solid waste compositions.	2024	HG Leach/Department of Environment
3	Install weighbridges in all solid waste disposal sites, starting in the biggest-used sites.	2024-2030	Ministry of Local Government
4	Initiate close monitoring and standard records of open fires and Fiji´s dumpsites in order to apply country-specific values regarding open burning at dumpsites, rather than the IPCC Assumption	2024-2030	HG Leach/Department of Environment
Long-term Actions		Proposed period of implementation	Institution responsible
4	Launch studies on rural waste generation and management practices.	2025-2030	Department of Environment/Ministry of Rural and Maritime/Fiji Waste Management Authority
5	Launch studies and data collection on industrial waste generation rates, composition and management practices.	2025-2030	Department of Environment/Ministry of Rural and Maritime/Fiji Waste Management Authority
Identified fields of improvement			
Incineration records of clinical waste at the Divisional Hospitals, as well as the incineration records of quarantined waste in Fiji´s Ports and Biosecurity facilities require standardized and comprehensive implementation.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Ensure hospital incineration records are adequately updated every month using standardized templates.	2023	Central Board of Health
Long-term Actions		Proposed period of implementation	Institution responsible
2	Establish standardized and regularly updated quarantine waste incineration records.	2025-2030	Fiji Ports Limited/Biosecurity Authority of Fiji
Identified fields of improvement			
Records of large-scale composting and recycling initiatives are inconsistent.			
Short-term Actions		Proposed period of implementation	Institution responsible

1	Begin collecting data on composting facilities using standardized templates.	2023-2025	Fiji Waste Management Authority
Medium-term Actions			
2	Collect data on recycling using standardized templates.	2023-2025	Fiji Waste Management Authority
Waste Sector – Wastewater Treatment and Discharge			
Identified fields of improvement			
There is currently a lack of high-quality information on the number of people connected to each wastewater treatment plant in Fiji, as well as the biological oxygen demand (BOD) of wastewater treated.			
Short-term Actions		Proposed period of implementation	Institution responsible
1	Maintain updated annual records of the number of people connected to each wastewater treatment plant.	2023	Water Authority of Fiji
2	Establish a system for frequent, mandatory, and standardized BOD measurements and record-keeping in all wastewater treatment plants by formally requiring the monitoring of BOD under the Draft Water and Sanitation Policy.	2023	Water Authority of Fiji
Identified fields of improvement			
No information is available on the generation and treatment of industrial wastewater in Fiji.			
Long-term Actions		Proposed period of implementation	Institution responsible
1	Begin collecting data on industrial facilities with on-site wastewater treatment plants.	2025-2030	Water Authority of Fiji

ANNEXES

This Annex includes the reporting tables (Table A and Table B).