INITIATIVE FOR CLIMATE ACTION TRANSPARENCY (ICAT)

PHASE II

FIJI

SOLID WASTE SECTOR EMISSIONS CALCULATION

PREPARED UNDER

The Initiative for Climate Action Transparency (ICAT) is supported by Austria, Canada, Germany, Italy, the Children's Investment Fund Foundation, and the Climate Works Foundation.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS).

Contents

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 Background

The waste sector is a significant contributor to Fiji's greenhouse gas (GHG) emissions, accounting for 9.7% [1]of the country's total GHG emissions. Historical data shows substantial growth, increasing from 65 Gg CO2 eq in 2011[2] to 241.32 Gg CO2 eq in 2019[1]. This sector has experienced a notable average annual growth rate of 47.97%[3] in solid waste emissions between 2006-2019, correlating strongly with urbanisation patterns and changing consumption habits.

Fiji's waste management landscape presents unique challenges shaped by its geographical, climatic, and institutional characteristics. As a tropical island nation, the country's high temperatures and rainfall accelerate waste decomposition rates, particularly affecting methane generation in disposal sites. The Naboro Landfill, Fiji's primary engineered facility, exemplifies these challenges, having experienced a substantial increase in waste volumes from 60,000 tonnes in 2006 to approximately 94,000 tonnes in 2023[4].

The institutional framework operates under multiple agencies, with the Department of Environment serving as the primary regulatory authority under the Environment Management Act 2005. Municipal councils manage waste collection and disposal within their jurisdictions, while the Ministry of Health oversees public health aspects. Private sector involvement has grown significantly, with companies like H.G. Leach Fiji Limited operating the Naboro Landfill through public-private partnerships alongside other operators such as Waste Recyclers Fiji and South Pacific Waste Recyclers.

1.2 Purpose

This emissions report has been prepared using the Guidance Document on Solid Waste Disposal Emissions Calculations. The primary purpose of this GHG emissions assessment for Fiji's solid waste disposal sector is outlined in the table below:

Table 1: Purpose of GHG emissions Assessment

Support National Reporting Requirements	Inform Policy Development	Establish Baseline Emissions
▪ Fulfill Fiji's obligations under the Enhanced Transparency	▪ Provide evidence-based data for waste management policy formulation.	▪ Develop a comprehensive baseline of GHG

[1] Government of Fiji (2023). National Inventory Report (NIR) of Fiji. Government of Fiji, Suva, Fiji.
[2] Government of Fiji (2020). Third National Communication to the United Nations Framework Convention on Climate Change. Ministry of Economy, Suva, Fiji.
[3] Calculations performed by the waste expert.
[4] Information from data provided by Department of Environment

Support National Reporting Requirements	Inform Policy Development	Establish Baseline Emissions
Framework of the Paris Agreement ▪ Contribute to Fiji's Fourth National Communication and Biennial Transparency Report to the UNFCCC ▪ Support the updating of Fiji's National Determined Contributions (NDCs)	▪ Support the implementation of Fiji's National Development Plan (2025-2029) and NDCs. ▪ Guide the development of the National Solid Waste Management Strategy. ▪ Contribute to Fiji's Low Emission Development Strategy 2018-2050.	emissions from the solid waste sector. ▪ Create a foundation for measuring progress against national climate targets . ▪ Enable accurate tracking of emission reduction achievements. ▪ Enable Monitoring, Reporting and Verification (MRV) of mitigation actions for SWD in Fiji.

1.3 Policy and Regulatory Framework Analysis - Fiji's Waste Sector

The policy and regulatory landscape governing Fiji's waste sector has evolved significantly over the past two decades, establishing a comprehensive framework that addresses both waste management practices and associated GHG emissions. This analysis examines the key policy instruments, legislative framework, and international commitments shaping Fiji's waste management and emissions control approach.

1.3.1 National Policy Framework

Legislative Evolution

The foundation of Fiji's waste management policy framework was established through the National Solid Waste Management Strategy 2011-2014, which introduced fundamental principles such as the waste hierarchy and the "polluter pays" principle. While this strategy would need to be updated with the latest available data, its core principles continue to inform current practices and subsequent policies.

Key Legislative Instruments

Several crucial pieces of legislation anchor the regulatory framework.

Table 2: Core Legislative Framework

Legislative Instrument	Year	Key Provisions
Environment Management Act	2005	▪ Waste management and pollution control (Part 5) ▪ Environmental impact assessment requirements ▪ Operational standards for waste facilities
Environment Management Regulations	2007	▪ Specific guidelines for waste disposal operations ▪ Emissions monitoring requirements
Climate Change Act	2021	▪ GHG Inventory establishment (Section 29) ▪ Sector-based data collection (Section 30) ▪ National Inventory reporting (Section 33)
Public Health Act [Cap.111]	-	▪ Local enforcement and waste management
Litter Act	2008	▪ Waste collection and disposal regulations
Local Government Act [Cap.125]	-	▪ Municipal council empowerment

1.3.2 Strategic Planning Framework

Several key planning documents guide the waste sector's strategic direction:

- NDC Implementation Roadmap 2017-2030
- Fiji Low Emission Development Strategy (LEDs) 2018-2050
- National Adaptation Plan (NAP) 2018
- National Development Plan 2025-2029 and Vision 2050

These documents collectively establish:

- Connection between waste management and climate resilience
- Specific infrastructure improvement targets
- Integration of waste management into broader climate action strategies

1.3.3 International Commitments and Regional Cooperation

Fiji's international obligations and regional partnerships significantly influence its waste management practices.

Table 3: International and Regional Commitments

Framework/ Initiatives	Requirements/ Key Objectives
International Frameworks	United Nations Framework Convention on Climate Change (UNFCCC) ▪ Regular National Communications

Framework/ Initiatives	Requirements/ Key Objectives
	▪ Biennial Update Reports, now Biennial Transparency Reports ▪ Emissions accounting requirements
Regional Initiatives	▪ Cleaner Pacific 2025 ▪ Pacific Regional Waste and Pollution Management Strategy

1.3.4 Implementation and Enforcement Structure

The implementation and enforcement structure for climate change and environmental management represents a comprehensive, multi-tiered approach that ensures coordinated action across different governance levels. This hierarchical framework creates a robust accountability system, policy execution, and environmental governance.

The implementation framework operates at multiple levels, as shown in the table below.

Table 4: Implementation Hierarchy

Level	Responsible Entity	Key Responsibilities
Local	Municipal Councils	▪ Waste collection and management ▪ Local-level environmental initiatives ▪ implementation of environmental regulations
National	Department of Environment	▪ Developing national environmental policies ▪ Monitoring national environmental compliance
	Climate Change Division	▪ National-level climate change policy oversight ▪ Coordinating climate change mitigation and adaptation strategies ▪ Ensuring national compliance with environmental commitments ▪ Nationally Determined Contributions (NDC) Tracking ▪ Policy oversight compliance at the national level
International	UNFCCC, Regional Bodies	▪ Compliance monitoring ▪ Review of Biennial Transparency Reports, including the Monitoring, Reporting, and Verification (MRV) of emissions

1.4 Data Limitations and Assumptions

In certain areas of the emissions assessment, the use of assumptions has been necessary to address data gaps, particularly in regions where consistent or detailed waste management data is unavailable. These assumptions ensure the inclusion of emissions sources that might otherwise be omitted, but they also introduce inherent uncertainties.

The assessment of Fiji's waste sector emissions faces several critical data and operational constraints that influence the accuracy and comprehensiveness of emissions calculations:

1.4.1 Data Availability and Quality

The primary challenge lies in limited data availability, particularly from rural and remote areas. While urban centres maintain relatively consistent records, data from outlying regions and the maritime regions remains sparse. Waste composition studies conducted from 2018-2021 indicate that organic waste constitutes 45-50% of the total waste stream, followed by paper and cardboard (12-15%) and plastics (10-12%)[5]. However, these figures primarily represent urban areas with formal waste collection systems.

1.4.2 Operational Constraints

The geographical dispersion of Fiji's population across multiple islands creates significant challenges in waste collection, transportation, and monitoring. Rural and remote island communities often rely on informal disposal methods, including burning, burying, or dumping, making accurate emissions assessment difficult. The presence of numerous unmanaged dump sites without monitoring systems further complicates data collection and analysis.

1.4.3 Technical and Resource Limitations

Limited technical capacity for regular emission monitoring and reporting, combined with financial constraints, affects proper waste management infrastructure development and maintenance. These limitations necessitate certain assumptions in emissions calculations, particularly for areas without formal waste management systems.

1.4.4 Methodological Assumptions

Given these constraints, the following key assumptions underpin the emissions assessment:

- **Rural and Informal Settlements:** Data from these areas remain sparse due to challenges in accessing remote communities and the lack of formalised waste collection systems. Consequently, emissions estimates rely on extrapolated figures derived from urban data. Adjustments were made to account for socioeconomic factors, such as lower waste generation rates and different waste composition patterns. However, the extrapolation process and its limitations warrant further elaboration to ensure transparency.

[5] JICA (2018). Data Collection Survey on Waste Management in the Pacific Region

- Methane generation potential is calculated using IPCC default values for tropical wet conditions where site-specific data is unavailable.
- Emissions from informal disposal practices are estimated using conservative factors to avoid potential underreporting.

These limitations and assumptions are being progressively addressed through various initiatives, including waste audit programs supported by the Pacific Regional Infrastructure Facility (PRIF), technical assistance from the Japan International Cooperation Agency (JICA), and capacity building through the Pacific-European Union Waste Management Programme (PacWaste Plus).

2.0 METHODOLOGY

2.1 Scope

This inventory only focuses on Category 4A: Solid Waste Disposal per the IPCC guideline outlined in the Guidance Document on Solid Waste Disposal Emissions Calculations. The assessment encompasses the elements represented in the table below:

Table 5: Scope category

Scope category	Elements
Temporal Scope	Historical data analysis: 1994-2023
Geographic Coverage	▪ All administrative divisions of Fiji: ✓ Central Division ✓ Western Division ✓ Northern Division ✓ Eastern Division ▪ Special focus on main population centres.
Technical Scope	1. Emission Sources Covered ✓ Managed landfill sites ✓ Unmanaged disposal sites ✓ Dump sites
	2. Waste Categories ✓ Municipal solid waste ✓ Commercial and industrial waste ✓ Green waste
	3. Greenhouse Gases ▪ Methane (CH_4) ▪ Carbon dioxide (CO_2)
Methodological Boundaries	▪ Application of IPCC 2006 Guidelines and 2019 Refinements ▪ First Order Decay (FOD) model implementation ▪ Tier 1 approach for categories with limited data
Exclusions	• Wastewater treatment • Industrial wastewater • Composting facilities • Waste-to-energy facilities • Recycling operations • Transportation of waste
Assessment Components	• Direct Emissions: Methane from waste decomposition
Data Collection Scope	1. Activity Data • Waste generation rates • Waste composition studies • Population statistics

Scope category	Elements
	• Tourist numbers
	2. Technical Parameters • Waste degradation rates • Methane generation potential • Oxidation factors • Recovery efficiency
Reporting Scope	• Emissions inventory • Uncertainty analysis • Quality assurance procedures • Verification Protocols • Documentation of methodologies • Data management systems

2.2 Assessment Framework

The assessment employs the IPCC 2006 Guidelines, utilising:

- First Order Decay (FOD) model for methane generation
- Tier 2 approach for managed disposal sites
- Tier 1 approach for unmanaged and uncategorised sites

The assessment framework employs a comprehensive three-component approach to ensure accurate GHG emissions calculations from Fiji's waste sector. At its foundation, the methodology adheres to the IPCC 2006 Guidelines, tailored explicitly for municipal solid waste disposal emissions calculations, and seamlessly integrated with GHG inventory requirements.

The data collection strategy combines multiple sources, incorporating historical and current data through a systematic review of existing waste composition studies, continuous weighbridge data from operational facilities, and parallel household and landfill site information analysis from 2000 to 2024. The technical parameters are carefully structured to align with IPCC guidelines, incorporating detailed waste categorisation that is specific to Fiji, region-specific generation rates, and precise calculations of methane generation potential while accounting for site-specific oxidation factors that affect emissions rates. This methodological approach ensures consistency with international standards while accommodating Fiji's unique waste management context.

Table 6: Assessment framework components

Component	Element	Details
IPCC Guidelines Application	• 2006 IPCC Guideline • Emissions Focus • Inventory Integration	• Specific focus on municipal solid waste disposal emissions • Integration with national GHG inventory requirements

Component	Element	Details
Data Collection Methods	• Studies Review • Operational Data • Historical Analysis • Multi-source Data	• Review of existing waste composition studies and audits • Integration of weighbridge data from facilities • Analysis of trends from 2000-2024 • Combined household and landfill site data collection
Technical Parameters	• Waste Categories • Generation Metrics • Emissions Calculations • Environmental Factors	• IPCC-aligned waste composition categories • Regional and point-specific generation rates • Methane generation potential calculations • Site-specific oxidation factors

Furthermore, the template developed and used for the NIR was also used for this assignment. All the default values and most of the assumptions were maintained. However, the following information was altered:

(i) <u>Population growth</u>
The template included the 1945 census data to calculate population growth. The annual growth rate calculation was used to project the future population, considering that population growth is typically exponential.

(ii) <u>Waste generation rate</u>
The 2024 calculation used the 0.46kg/person/day waste generation rate, compared to 1.5 kg/person/day used under the NIR emissions calculation. The 0.46kg/person/day was derived from the ICAT Phase II project research.

(iii) <u>Waste composition</u>
The initial waste composition of 33.6% food waste, 11.4% paper waste, 39.6% wood waste, 1.0% textile, and 14.4% plastics inert waste (%) used in NIR was maintained until 2019 for emission calculation. However, for the emission calculation from 2020 to 2024, the new waste composition of 35.8% food waste, 29.6% garden waste, 13.9% paper waste, 5% wood, 2.5% textiles, Nappies 5.3%, and 7.9% plastics, inert waste was used.

(iv) <u>Emission calculation</u>
The emission was recalculated from 1994 using the new waste generation rate and the calculated population numbers.

2.3 Key Parameters and Justification

2.3.1 Activity data parameter

Country-specific parameters were calculated and utilised in the 2024 calculations to improve the accuracy of greenhouse gas emissions estimates. Fiji's unique climatic conditions, such as high temperatures and rainfall typical of tropical environments, significantly influence waste decomposition and methane generation. Default IPCC values, while suitable for broad assessments, often fail to capture these localised effects. Therefore, adapting parameters to the local context ensures more realistic and representative emissions estimates.

Table 7: Waste composition parameters

Waste type	2020-2024 Value (%)	Previous Value (%)	Change
Food Waste	35.8	33.6	+2.2
Garden waste	29.6	Not categorised	new
Paper waste	13.9	11.4	+2.5
Wood	5.0	39.6	-43.6
Textiles	2.5	1.0	+1.5
Nappies	5.3	Not categorised	New
Plastic/ inert	7.9	14.4	-6.5

Table 8: Technical Parameters and Uncertainty

Parameter type	Category	Value	Uncertainty Range	Justification
Waste generation	Daily rate	0.46 kg/person/day	±52%	ICAT Phase II research
MFC Value	Managed sites	1.0	±5%	Engineered systems
	Unmanaged sites	0.8	±20%	Partial anaerobic conditions
	Unmanaged shallow	0.4	±30%	Higher aerobic decomposition
	Uncategorised	0.6	±55%	Unknown conditions
Decay rate	Tropical wet	0.17 yr^{-1}	±25%	IPCC guidelines for MAP >1000mm
Uncertainty	Activity data	-	±52%	Data collection challenges
	Emission factors	-	±56-78%	Varies by site type

Parameter type	Category	Value	Uncertainty Range	Justification
	Combined	-	±77	Error propagation calculation

Table 9: Monitoring and verification

Aspect	Method	Frequency
Data Collection	Weighbridge Records	Daily
	Waste Composition Studies	Annual
	Site Inspections	Quarterly
Quality Control	Cross-Validation	Monthly
	Expert Review	Annual
	Expert Review	Quarterly

2.3.2 Methodology for Deriving Parameters

- **Waste Composition Studies**: Recent audits, including those conducted under the ICAT Phase II project, identified substantial changes in Fiji's waste composition, such as increased organic waste and reduced wood content, which directly affect methane generation potential.
- **Waste Generation Rates**: The updated rate of 0.46 kg/person/day is based on a comprehensive review of municipal records, rural waste surveys, and population growth trends. This contrasts with the previously used figure of 1.5 kg/person/day, which was derived from assumptions more applicable to urban, high-income regions .
- **Methane Correction Factors**: Fiji-specific values for managed and unmanaged disposal sites were adjusted using regional studies and site-specific measurements to reflect actual landfill conditions.

Impact of Country-Specific Parameters: By applying country-specific parameters:

1. **Methane Generation Potential (Lo)**: Revised to reflect higher organic waste content, consistent with regional waste audits.
2. **Degradable Organic Carbon (DOC)**: Adjusted based on updated waste composition categories, including nappies and garden waste.
3. **Emission Accuracy**: The updated parameters reduced overestimation associated with default values and more accurately reflected actual emissions trends.

3.0 WASTE SECTOR OVERVIEW

3.1 Current Status

Fiji's current waste management system operates through a combination of municipal and private services, covering 62.7% of urban areas. This coverage is split between municipal council services, which handle 39.7% of collections, and private contractors, who manage the remaining 23%. The major waste facilities process a substantial volume of waste, with average disposal rates ranging between 80-100 tonnes per day. At the household level, waste generation averages 0.46 kilograms per person per day. These figures reflect the growing challenges of waste management in Fiji's urban areas and highlight the significant role of both public and private sectors in maintaining effective waste collection services.[6]

Municipal councils do not collect waste generated by informal and squatter settlements on the outskirts of cities and towns, as these areas typically do not pay town rates. Informal practices such as household-level recycling, composting, open burning, and illegal dumping for uncollected waste is common among the urban informal settlement population. Skip bins have been made available to informal settlements for a number of years. However, the bins are picked up according to the schedule rather than when they were filled; hence, at certain times, overflow. Thus, the effectiveness of this initiative needs to be researched. In the case of Lautoka city council, the council collected the waste from informal settlements, and the government reimbursed the cost.

3.2 Waste Generation and Composition

Lecture reviews are usually conducted to obtain the parameters for activity data. According to the research conducted under the ICAT Phase II project[7], emissions calculations for waste in Fiji rely heavily on understanding the composition and characteristics of different waste types, as different materials decompose and release GHGs at varying rates.

According to the JICA 2009 study cited in Fiji's NIR, municipal solid waste is categorised into several key components: kitchen waste (33.6%), yard waste like grass and leaves (39.6%), paper (11.4%), plastics (films 5.1% and PET 1.7%), glass/ceramics (3.7%), metals (1.4%), textiles (1.1%), and other materials (2.4%).

The research also uncovered that organic waste, particularly kitchen and yard waste, forms the largest component of Fiji's waste stream. This is significant for emissions calculations since organic materials decompose anaerobically in landfills to produce methane (CH_4), a potent GHG. Recent studies, including the 2021 PRIF Report for Ba Town and Labasa, have helped refine these composition estimates. The comprehensive analysis from recent waste audits suggests variation in waste composition across different regions, with kitchen waste ranging from 29-43% and grass/leaves from 21-38% of total waste.

---

[6] Information obtained from the research conducted by Janette Mani and Riteshma Devi under the ICAT Phase II project.

[7] The research was conducted by Jeantte Mani and Riteshma Devi. The results have not been published yet.

Therefore, the waste composition percentage for Fiji using the current and previous publications is presented in the table below.

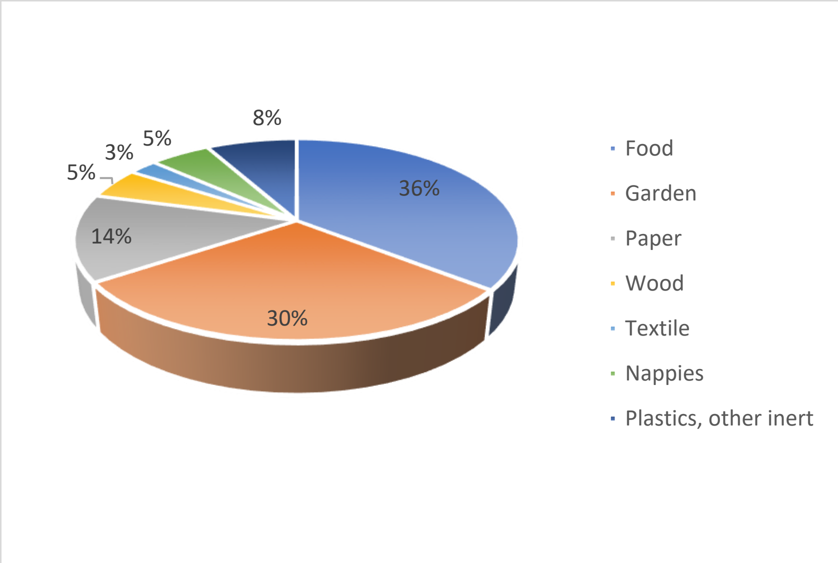

Figure 1: Waste composition for Fiji

Table 10: Waste composition comparison

Categories studied	IPCC Oceania Default (%)	JICA, Fiji, March 2009 (%)	2024 Fiji Literature Review data average (%)[8]
Glass and ceramics	3.0	3.7	4.1
Metals	5.0	1.4	4.4
Organic matter			49.2
Kitchen waste	50.0	33.5	35.8
Grass, leaves	20	39.6	29.6
Paper and cardboard	10	11.4	13.9
Plastics	10	1.7	7.9
Films		5.1	6.9
Hygiene (Nappies/ diapers)			10.2 (5.3)
e-waste			0.5

[8] Research conducted by Jeantte Mani and Riteshma Devi (2024).

Categories studied	IPCC Oceania Default (%)	JICA, Fiji, March 2009 (%)	2024 Fiji Literature Review data average (%)[8]
Rubber and Leather			0.2
single-use items			3.1
Textiles		1.1	2.5
Wood			(5.0)
medical waste			3.7
Others	2.0	2.4	4.8

The review provides a comprehensive snapshot of Fiji's waste composition using the most recent studies, thus forming a benchmark for Fiji's waste composition factor. Therefore, the above waste composition values were used as Fiji values.

Furthermore, SPREP, in collaboration with the European Union, PacWastePlus Programme and Engineers Without Borders Australia, conducted an assessment [9]of alternatives to single-use disposable diapers. The assessment stated that a baby uses 309kg/year of diapers in the Pacific. Out of which 47.6% (147 kg) goes to landfills/dumps, 45.6% (141 kg) ends up in the environment, and 8.4% (26 kg) is burnt. So nearly half of disposable diaper waste ends up in formal disposal sites (landfills/dumps), while a similar proportion is discarded directly into the environment. A small percentage is disposed of through burning, despite this not being recommended due to toxic fumes and health risks.

The report notes that disposable diapers can take approximately 500 years to break down, regardless of where they are disposed of. This creates long-term waste management challenges for Pacific communities, particularly given the significant volume generated—one baby uses an estimated 1,460 diapers per year in the Pacific region.[10]

In light of this assessment and taking into account (Table 10) the hygiene[11] waste product contributes 10.2% towards the total waste composition, it is assumed for the emission calculation purpose that 5.3% of the total hygiene waste is Nappies/ diapers.

Additionally, in the previous emission calculations (SNC, TNC & NIR), the wood used contributed 40% of the total waste composition. However, the research conducted under the ICAT phase II project did not register any wood in the waste composition. However, given that Fiji is prone to natural disasters such as floods and cyclones, the waste generated from

---

[9] Secretariat of the Pacific Regional Environment Programme (SPREP). Assessment of Alternatives to Single-Use Disposable Diapers: Volume 5: Guidance for Communities and Private Sector. SPREP, 2022

[10] Secretariat of the Pacific Regional Environment Programme (SPREP). Assessment of Alternatives to Single-Use Disposable Diapers: Volume 5: Guidance for Communities and Private Sector. SPREP, 2022.

[11] Sanitary waste encompasses a broad range, including liquid or solid waste, such as diapers, feminine hygiene products, and incontinence products. It's also about items classified as 'offensive/hygiene waste' due to their appearance and odour resulting from human activities and bodily fluids.

these natural disasters, such as the damaged trees, is disposed of in the municipal waste disposal site. This was also confirmed by a representative of the Lautoka city council in the waste sector meeting on 15-16 October 2024 in Novotel Lami. Hence, for the purpose of emission calculation, it is assumed that the total waste composition consists of 5% wood.

4.0 DATA COLLECTION

4.1 Primary Data Sources

The assessment uses three main sources of information to give a complete picture of Fiji's solid waste sector. First, it relies on four major municipal waste audits conducted between 2009 and 2023, which show how waste composition has changed over time. Second, it uses ongoing records from disposal facilities, including daily weighbridge data and collection records from municipal councils and private contractors. Third, it includes additional data like population trends, economic factors, and weather conditions that affect how waste breaks down. This combined approach helps provide a clearer and more accurate understanding of waste patterns and their GHG emissions.

Table 11: Primary data sources for solid waste sector assessment

Data Category	Source Type	Details/Examples
Municipal Waste Audits	Supplementary Data	▪ JICA 2009 Study baseline data ▪ PRIF 2021 Report ▪ Waste Amount & Composition Survey 2022 (Suva & Lautoka) ▪ SPREP National Waste Audit Analysis 2023
Operational Records	Facility Data	▪ Weighbridge data from disposal facilities ▪ Municipal council collection records ▪ Contractor reports ▪ Waste transport records
Supplementary Data	Supporting Statistics	▪ Population statistics and projections ▪ Economic indicators affecting waste generation. ▪ Meteorological data influencing decomposition rates

5.0 GHG EMISSIONS CALCULATIONS

5.1 Calculation Methodology

5.1.1 First Order Decay Model Implementation

The FOD model calculation follows the equation:

$$CH_4 \text{ Generation} = \sum [A \times k \times DOC \times DOCf \times MCF \times F \times 16/12 \times e^{(-k(t-x))}]$$

Where:

- A = Normalized waste amount
- k = Decay rate (0.17 yr^{-1})
- DOC = Degradable organic carbon
- DOCf = Fraction of DOC decomposing
- MCF = Methane correction factor
- F = Fraction of CH_4 in generated landfill gas (0.5)

5.1.2 Site-Specific Parameters

Managed Sites (Tier 2):

- MCF: 1.0 ± 5%
- DOC: Calculated from waste composition
- Oxidation factor: 0.1

Unmanaged Sites (Tier 1):

- MCF: 0.4-0.8 ± 20%
- Default DOC values
- Oxidation factor: 0

5.2 Result Summary

5.2.1 Summary of Solid Waste Sector Emission

Fiji's solid waste disposal sector has undergone significant transformation over the past three decades, with corresponding changes in methane emissions patterns. Analysis based on IPCC methodology calculations reveals a substantial increase in emissions from 1994 to 2024, reflecting growing urban development and improved urban waste collection practices.

The analysis, utilising the IPCC Waste Model with First Order Decay (FOD) Method, considers multiple factors, including population demographics, municipal solid waste generation rates, waste composition, and treatment methods. The methodology employs site-specific methane correction factors and Global Warming Potential (GWP) conversions to provide comprehensive emission estimates. Key parameters in the analysis include a municipal waste generation rate of 0.46 kg/person/day, with waste collection services primarily focused on urban populations.

The emission trends show a remarkable evolution over the study period. Total emissions have increased from 19.75 Gg CO2e/year in 1994 to 95.72 Gg CO2e/year in 2024, representing an approximately 384.66% increase over three decades. With an annual growth rate of 5.44%. By 2024, managed sites contributed the largest share at 61.05 Gg CO2e/year, followed by unmanaged sites at 8.25 Gg CO2e/year and uncategorised sites at 5.06 Gg CO2eq/year.

The period before 2005 was characterised by predominantly unmanaged and uncategorised waste disposal sites, resulting in lower overall emissions but poor environmental controls. The years 2005-2019 marked a significant transition with the introduction of managed facilities and a gradual shift away from unmanaged disposal methods. This period saw increased emission control efficiency despite rising total emissions because of enhanced intermediate cover practices at disposal sites. The most recent period (2020-2024) has been defined by the dominance of managed sites, reflecting improved waste management practices and better emission monitoring capabilities.

Several factors have contributed to these evolving emission patterns. Demographic changes have played a crucial role, with urbanisation increasing from 22% to 59.54% and the overall population growing from approximately 260,000 to 920,000[12]. The waste management sector has seen substantial development, including establishing the Naboro Landfill as a managed facility and closing unmanaged dumps such as the Lami Dump. Operational improvements have included the establishment of Naboro Landfill as a centralised managed facility for central division and the closure of unmanaged Lami dump sites.

The analysis faces certain limitations and uncertainties. Data quality varies significantly, with uncertainty levels ranging from 0% to 94% and limited historical data availability. The methodology relies on IPCC default values where local data is unavailable and employs simplified modelling of complex degradation processes. The impacts of climate variations on waste decomposition are also not fully accounted for in the current (2024 calculation) analysis.

[12] Urbanisation increased calculated using the population projections under emission calculation.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 Uncertainty Assessment

The uncertainty analysis for Fiji's waste sector emissions encompasses three main components: *activity data, emission factors, and total combined uncertainty*. The activity data uncertainty stems from several primary sources, with waste generation rates and waste composition each contributing ±30% uncertainty, while population data shows a lower uncertainty of ±5%. When these uncertainties are propagated, they result in a combined activity data uncertainty of ±52%.

Emission factor uncertainties vary significantly by site type, reflecting the different levels of monitoring and control at various disposal facilities. Managed sites demonstrate the lowest uncertainty at ±55%, benefiting from more systematic monitoring and better-controlled conditions. Unmanaged sites show higher uncertainty at ±63%, while uncategorised sites exhibit the highest uncertainty at ±78%, primarily due to limited monitoring and variable management practices.

The overall uncertainty in emissions calculations has shown improvement over time, decreasing from ±81% during the 1994-2004 period to ±77% for the 2005-2024 period. This reduction in uncertainty can be attributed to several factors, including implementing better data collection processes, involvement of technical working groups, building stakeholder capacity together with better relationships, enhanced monitoring practices, and more accurate waste characterisation studies. These improvements reflect the ongoing development of Fiji's waste management infrastructure and the increasing sophistication of its monitoring capabilities.

6.2 Quality Control Procedures

Quality control procedures for the waste sector emissions inventory encompass a comprehensive set of verification and documentation steps. The initial phase focuses on validating assumptions and criteria used in selecting activity data, emission factors, and other estimation parameters. This includes thoroughly cross-checking descriptions for all data types, ensuring proper recording and archiving of information, and verifying that all footnote references are correctly cited in the internal documentation.

Data integrity verification forms were a crucial component of the QC process. This involves checking for transcription errors in data input, reproducing emissions calculations to ensure accuracy, and validating the proper use of parameters and units throughout all calculations. Particular attention is paid to unit labelling in calculation sheets, consistency in unit conversion throughout the process, and the accuracy of conversion factors. Database integrity was maintained by confirming appropriate data processing steps and their correct representation in the IPCC Model (Excel-based).

Cross-category consistency checks are essential for maintaining data reliability. This involved identifying and verifying parameters common to multiple categories, such as activity data and constants, ensuring consistent application across all emission and removal calculations. Uncertainty estimations were validated by checking calculation methods and verifying the qualifications of experts providing judgment for uncertainty estimates. Time series consistency is maintained through careful examination of methodological changes and data modifications that result in recalculations.

The completeness of the inventory was verified by confirming comprehensive coverage of the solid waste sector. Trend analysis played a vital role in quality control, involving the comparison of current estimates with previous values and the investigation of any significant changes or unexpected trends. This includes examining implied emission factors across time series and scrutinising unusual patterns in activity data or other parameters. Particular attention is given to explaining and documenting any departures from expected trends.

Data gaps were addressed using local measured data, regional comparative data, national statistical estimates, IPCC default values, and expert judgment-based estimation.

Documentation and archiving procedures formed the final crucial element of the QC process. This involved maintaining detailed internal documentation that supports all estimates and enables the reproduction of emission, removal, and uncertainty calculations. In any case, the archiving system must ensure that all inventory data, supporting documentation, and records are properly stored and secured. Once the inventory is complete, the archive is closed and maintained in a secure location. The integrity of data archiving arrangements can also verified for any outside organisations involved in inventory preparation.

The QC checklist is attached as Annex 2.

7.0 RESULTS AND DISCUSSION

7.1 Key Findings

The analysis reveals several critical trends and driving factors contributing to emissions from waste disposal in Fiji. Firstly, emission trends indicate a consistent increase in total greenhouse gas (GHG) emissions over time. This is largely attributed to a gradual shift from unmanaged disposal sites to managed disposal facilities, which, while offering improved emission control efficiency, also account for a significant share of the overall emissions.

***Emission Trends**:*

* *Consistent increase in total emissions*
* *Shift toward managed disposal sites*
* *Improved emission control efficiency*

Key driving factors for these trends include urbanisation, with the urban population increasing from 22% to 59.54% over the studied period, necessitating more formal waste management systems. Population growth further compounds this challenge by increasing the volume of waste generated. Additionally, improved waste management practices, such as the adoption of engineered landfills, have contributed to changes in emissions patterns, reducing emissions from unmanaged sites while increasing those from managed facilities.

Driving Factors:

* *Urbanization (22% to 59.54%)*
* *Population grow*
* *Improved waste management practices*

7.2 Overall emission trend

The Figure below illustrates the emission trends from different disposal sites in Fiji, highlighting variations by site type and temporal changes.

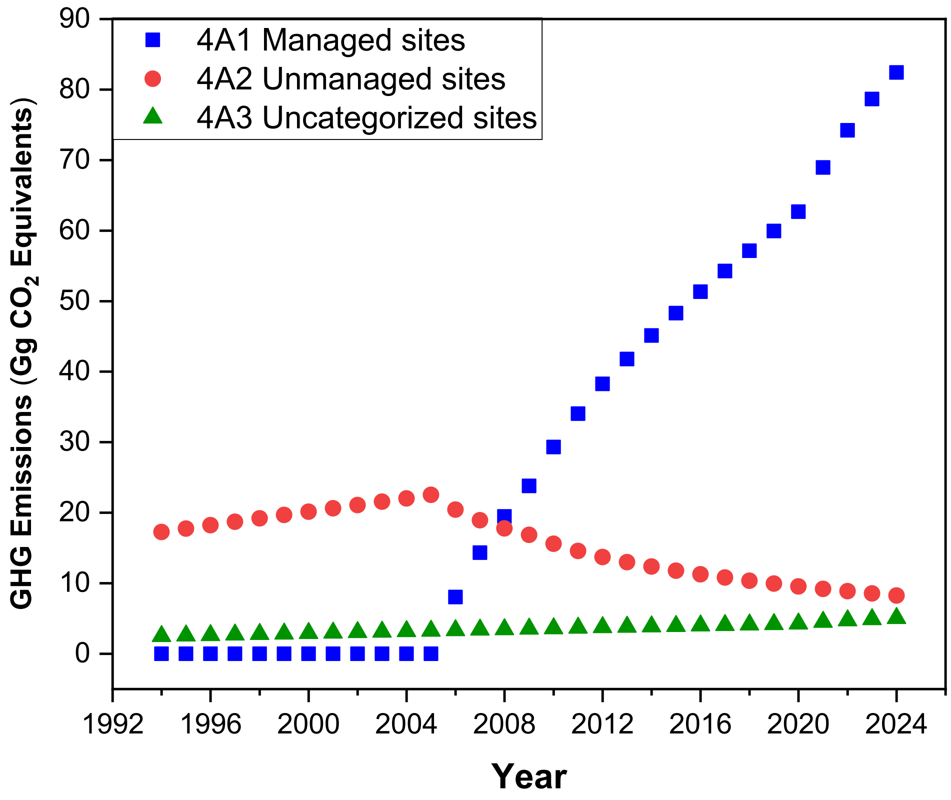

Figure 2: Emission trend from different disposal sites in Fiji

7.1.1 Emissions by Site Type (2024)

Managed Sites:

Managed sites have become the dominant source of emissions, with the first recorded emissions in 2006 (0.29 Gg CO_2e/year) rising to 61.05 Gg CO_2e/year by 2024, representing 82% of total emissions. The trend exhibited a rapid growth phase during the initial years (2006-2010), attributed to the increasing adoption of engineered landfills and centralisation of waste disposal.

Unmanaged Sites:

Emissions from unmanaged sites started at 17.25 Gg CO_2e/year in 1994 and have since declined to 8.25 Gg CO_2e/year in 2024, now accounting for only 11% of total emissions. This pattern shows an initial growth phase from 1994 to 2005, likely due to limited waste management infrastructure during that time. The steady decline post-2005 highlights a successful transition to managed facilities, reducing reliance on unmanaged disposal sites.

Uncategorised Sites:
Emissions from uncategorised sites began at 2.50 Gg CO_2e/year in 1994 and have grown slowly but consistently to 5.06 Gg CO_2e/year in 2024. These sites now account for 7% of total emissions. This steady growth with minimal variability reflects persistent informal waste disposal practices, which continue to exist despite the overall shift toward managed systems.

In summary, the transition from unmanaged to managed disposal sites has significantly altered Fiji's emission profile. Managed sites now dominate emissions, while unmanaged sites are becoming less prominent, indicating progress in waste management practices. However, the continued growth of emissions from uncategorized sites underscores the need for further intervention in informal disposal systems.

7.3 Comparative Analysis

The evolution of Fiji's waste sector emissions reporting from 1994 to 2024 shows significant variations in methodologies and results, with emissions estimates ranging from 95.72 Gg CO2-eq (2024) to 241.32 Gg CO2-eq (NIR 2023). These differences can be attributed to several key factors:

7.3.1 Methodological Evolution

Table 12: Methodological Differences Comparison between different reports

Aspect	Initial National Communication (INC)[13]	Second National Communication (SNC)[14]	Third National Communication (TNC)	Fiji's National Inventory Report (NIR)	Solid waste sector emission calculations (2024)
IPCC Guidelines Used	1996 IPCC Guidelines For the waste sector: -Used a basic IPCC Tier 1 approach with default parameters. -Assumed methane is released in the same year waste is disposed of, neglecting the gradual degradation process.	1996 IPCC Guidelines Improved Tier 1 with regional adjustments	2006 IPCC Guidelines For the waste sector: -Adopted the First Order Decay (FOD) model for methane emissions. -Temporal decomposition dynamics of solid waste were considered, enhancing accuracy compared to the INC.	2006 IPCC Guidelines For the waste sector: -Employed 2006 IPCC guidelines and FOD methodology. -Introduced higher granularity in activity data, including waste composition and methane correction factors specific to managed, unmanaged, and uncategorised sites	2006 IPCC Guidelines 2024 Assessment: Refined calculations with country-specific waste generation rates
Global Warming Potential (GWP)	Not specified	AR4 (Fourth Assessment Report)	AR5 (Fifth Assessment Report)	AR5 (Fifth Assessment Report)	AR5 (Fifth Assessment Report)

[13] Gov Fiji (2005). Fiji's First National Communication under the Framework Convention on Climate Change. Gov of Fiji, Suva.
[14] Gov Fiji (2014). Republic of Fiji Second National Communication to the United Nations Framework Convention on Climate Change. Ministry of Foreign Affairs, Suva, Fiji.

Aspect	Initial National Communication (INC)[13]	Second National Communication (SNC)[14]	Third National Communication (TNC)	Fiji's National Inventory Report (NIR)	Solid waste sector emission calculations (2024)
Scope	Limited categories and gases	Slightly expanded categories and gases	Comprehensive inclusion of gases and sectors	Comprehensive coverage	Focus only on solid waste disposal.
Key Methodological Updates	Simplified methods	Sectoral and reference approaches were added	Detailed tiered methodologies (e.g., Tier 1 & Tier 2); consistent back-calculations	REDD+ integration for FOLU sectors	Solid waste composition was improved by including country-specific information.

7.3.2 Key Differences in Parameters

The 2024 emissions estimate for Fiji's waste sector is lower than previous assessments due to methodological improvements and updated data sources. The following factors contributed significantly:

(i) *Revised Waste Generation Rates*

One of the primary reasons for the lower emissions estimate is the revision of waste generation rates. Previous calculations used a rate of 1.5 kg/person/day, which was later identified as being overly generalised and reflective of urbanised, high-income populations. Fiji, however, has a predominantly rural and peri-urban population, where waste generation patterns differ significantly. The updated rate of 0.46 kg/person/day was derived from recent municipal and household-level surveys conducted between 2020 and 2023. These surveys accounted for local consumption behaviours, economic conditions, and waste disposal practices, providing a more accurate reflection of the waste generated across Fiji.

Had the previous rate of 1.5 kg/person/day been retained, emissions estimates would have been inflated by 30-50%, as waste generation is a key driver of methane production. The adoption of the revised rate has not only improved the accuracy of the emissions inventory but also aligned the estimates with Fiji's socio-economic realities.

(ii) Updated Waste Composition

The updated emissions estimate also incorporates significant changes to waste composition data. Recent studies revealed that garden waste and nappies now constitute 29.6% and 5.3% of total waste, respectively. These additions reflect the evolving waste disposal habits in Fiji. Concurrently, wood content in the waste stream dropped from 39.6% to 5%, further altering methane generation potential.

Organic waste, which plays a critical role in methane production, is now better quantified, with the proportion increasing to 35.8%. These adjustments ensure that the emissions calculations are grounded in real-world observations, reducing the likelihood of overestimations and improving the reliability of the results.

(iii) Improved Waste Management Practices

Another major factor influencing the lower emissions estimate is the substantial improvement in waste management practices over recent years. Managed disposal sites, such as the Naboro Landfill, now account for 82% of total emissions due to better monitoring. The closure of unmanaged sites, like the Lami Dump, has also reduced emissions from uncontrolled waste decomposition. These shifts highlight Fiji's progress in modernising its waste infrastructure, contributing to lower overall emissions.

(iv) Refinement in Methodology

The transition to a Tier 2 approach for managed sites has significantly enhanced the accuracy of emissions modelling. This methodological refinement involved site-specific methane correction factors, which better account for the conditions unique to Fiji's waste disposal sites. Additionally, adjustments to the First Order Decay (FOD) model have captured temporal variations in waste decomposition rates more precisely. These refinements underscore the role of improved modelling techniques in producing more reliable emissions estimates.

(v) Uncertainty Considerations

While the 2024 emissions estimate is lower, it is important to acknowledge residual uncertainties in the calculations. Data from rural and informal settlements remain limited, requiring continued efforts in data collection through audits and surveys. Furthermore, differences between Tier 1 and Tier 2 methodologies may create apparent discrepancies in emissions trends. However, these variations reflect methodological advancements rather than actual reductions in emissions, underscoring the importance of refining future assessments to maintain consistency and accuracy.

Table 13: Summary of key parameter differences

Parameter	Previous calculation	2024 calculation	Reason for change
Waste Generation Rate (kg/person/day)	1.5	0.46	Reflects recent data from household and municipal audits.
Organic Waste (% of total)	33.6	35.8	Increased organic content was identified in recent audits.
Wood Content (% of total)	39.6	5	Reduced due to changes in disposal practices and audits.
Methane Correction Factor (Managed Sites)	1.0	1.0	There was no change.

Table 14: The waste sector emission results comparison

Category	INC (1994)	SNC (2004)	TNC (2006)[15]	NIR 2023	Solid waste sector emission calculations (2024)
Solid Waste (Gg CO2-eq)	95.2[16]	87.36[17]	84[18]	241.32[19]	95.72
Explanation of Variations	▪ Overestimated due to immediate methane release assumption. ▪ Didn't account for temporal decomposition dynamics. ▪ Limited waste	▪ Reflects open dumping conditions; no methane recovery	▪ Significant increase due to the use of the FOD model and improved data	▪ Higher waste generation rate assumption ▪ Inclusion of previously uncounted waste streams	▪ Based on country-specific waste generation rates ▪ Improved waste composition data ▪ Better understanding of local conditions

[15] Gov Fiji (2020). Republic of Fiji Third National Communication Report to the United Nations Framework Convention on Climate Change. Ministry of Economy, Suva, Fiji.
[16] The CH_4 emission from the solid waste reported in the INC was 3.4 Gg. Therefore, it has been converted to Gg CO2-eq using the CH_4 GWP of 28.
[17] The CH_4 emission from the solid waste reported in the SNC was 3.12 Gg. Therefore, it has been converted to Gg CO2-eq using the CH_4 GWP of 28.
[18] The CH_4 emission from the solid waste reported in the TNC was 3.0 Gg for 2006. Therefore, it has been converted to Gg CO2-eq using the CH_4 GWP of 28.
[19] 2019 data.

Category	INC (1994)	SNC (2004)	TNC (2006)[15]	NIR 2023	Solid waste sector emission calculations (2024)
	characterisation data			▪ More comprehensive coverage of disposal sites	

The evolution of Fiji's GHG inventory methodology—from simplistic assumptions in the INC to more sophisticated, data-rich approaches in the BUR1—has resulted in more accurate and higher emissions estimates. Key improvements in activity data, waste composition details, and the adoption of dynamic decay models have illuminated the critical role of solid waste management in Fiji's GHG profile.

7.3.3 Improvements in Assessment Quality

	Data Quality	Coverage
Earlier reports	Heavy reliance on IPCC defaults	Limited to main urban areas
Recent assessments	Increased use of country-specific data	Broader geographical coverage
Impact	More accurate representation of local conditions	More comprehensive national emissions profile

Technical Sophistication

- Evolution from basic calculations of using IPCC default to country-specific values
- Integration of climate-specific factors
- Better uncertainty quantification

7.3.4 Uncertainty Levels

The evolution of uncertainty analysis in Fiji's waste sector emissions reporting demonstrates significant methodological advancement over time. In early reports, such as the Initial National Communication (INC), uncertainty quantification could have been more present in the assessment process, limiting the reliability evaluation of the presented data. The Second National Communication (SNC) marked an improvement by introducing basic uncertainty ranges, though these were primarily based on IPCC default values rather than country-specific data. The uncertainty analysis became more sophisticated with the Third National Communication (TNC), incorporating improved statistical methods and a broader range of variables.

Recent assessments show marked improvement in uncertainty quantification. The NIR 2023 introduced a comprehensive uncertainty analysis framework, considering multiple variables and their interactions in the emissions calculations. The same applied to 2024 calculations.

8.0 INVENTORY IMPROVEMENT PLAN

8.1 Data Improvement Recommendations

The 2024 calculation uses both Tier 1 and Tier 2 approaches. To migrate fully to higher level the following data/information needs to be obtained/ studied upon.

Transition	Key Actions	Details
TIER 2	Use of Country-Specific Data	*Replace IPCC default values with country-specific emission factors (e.g., Degradable Organic Carbon (DOC), Methane Correction Factor (MCF)). *Collect data on waste composition (e.g., proportions of organic, plastic, metal).
	Develop Waste Generation Data	*Conduct surveys to determine per capita waste generation rates across urban, peri-urban, and rural areas.
	Document Waste Management Practices	*Identify fractions of waste managed via landfilling, composting, recycling, and open burning. *Characterise disposal sites (e.g., sanitary landfills, unmanaged dumpsites).
	Build Capacity	*Train personnel to collect, analyse, and manage data. Set up routine data collection systems (e.g., waste composition studies).
TIER 1	Legislative and Institutional Frameworks	*Strengthen regulatory frameworks for waste reporting. *Collaborate with municipal authorities for consistent data provision.

Figure 3: Tier 1 to Tier 2 transition requirement for Fiji

Transition	Key Actions	Details
TIER 3	High-Resolution Data Collection	*Establish continuous monitoring systems for solid waste data. *Install methane monitoring systems at key landfill sites for direct emissions measurements.
	Model Development and Calibration	*Develop country-specific models to calculate emissions (e.g., advanced decay models, landfill gas generation). *Validate methane generation potential (Lo) values for Fiji's specific waste characteristics.
	Advanced Waste Sector Studies	*Conduct in-depth studies on waste decomposition and climate-specific decay rates. *Monitor methane oxidation in landfill-cover soils.
	Integration with Other Sectors	*Link waste data with national greenhouse gas inventory systems. *Incorporate data into a National Solid Waste Database.
	Stakeholder Engagement	*Partner with academic institutions for research and validation. *Engage communities and industries to refine waste management practices.
TIER 2	Technological Investments	*Equip landfills with gas collection and flaring/utilisation systems. *Invest in remote sensing and geospatial technologies for monitoring.

Figure 4: Tier 2 to Tier 3 transition requirement for Fiji

The 2024 calculation utilised IPCC default values, including default moisture content, degradable organic carbon (DOC) content, methane correction factor (MCF), methane generation rate constant (k), fraction of DOC that decomposes (DOCf), fraction of methane in generated landfill gas, and oxidation factor. Under Tier 2, only country-specific waste generation rates and waste composition were applied.

The following actionable recommendations are proposed to enhance the robustness and reliability of reporting greenhouse gas (GHG) emissions in Fiji's solid waste sector. These are directly linked to the findings and challenges identified in the current assessment:

Category	Finding	Recommendations
Improving Data Collection Systems	Limited data availability and inconsistencies hinder accurate emissions calculations, particularly from rural and informal settlements.	• Conduct nationwide waste audits at regular intervals, focusing on rural and peri-urban areas to improve the granularity and representativeness of data. • Establish a centralised digital database for waste sector data, integrating municipal records, private contractor data, and field surveys for better data sharing and tracking. • Develop automated weighbridge systems at all major landfill sites to standardise waste input records. • Partner with academic and technical institutions to perform real-time waste characterisation studies and generate region-specific parameters for emissions calculations.
Enhancing Policy Adherence	Lack of clear enforcement mechanisms and inter-agency coordination weakens compliance with waste management policies	• Strengthen inter-agency coordination by establishing a National Waste Management Taskforce, with representation from municipal councils, private contractors, and regulatory authorities. • Develop performance-based incentives for municipalities and private operators to comply with national waste management policies. • Regularly review and update legislation, including the Environment Management Act and Litter Act, to incorporate stricter penalties for non-compliance and ensure alignment with international standards.
Addressing Data Gaps and Uncertainty	High uncertainty in emissions calculations due to reliance on default IPCC values and assumptions.	• Invest in country-specific emission factor development for key parameters like methane generation potential, degradable organic carbon content, and methane correction factors. • Develop region-specific activity data, such as waste generation rates and composition for rural and remote areas. • Adopt advanced methodologies, such as Tier 2 and Tier 3 approaches, for key waste categories to reduce uncertainty.

Category	Finding	Recommendations
Capacity Building	Limited technical capacity among stakeholders affects the quality and consistency of data collection and emissions reporting.	• Conduct training programs on IPCC methodologies and advanced waste management practices for municipal staff, private contractors, and regulatory authorities. • Create a Waste Management Training Center to provide ongoing education and professional certification for waste sector personnel. • Engage local universities and research institutions to support capacity building and provide technical expertise for emissions modelling and reporting.
Integration of Advanced Technologies	The current waste management infrastructure is inadequate for supporting sophisticated monitoring and reporting systems.	• Implement remote sensing technologies to monitor waste disposal site activities and detect illegal dumping. • Invest in smart sensors and Internet of Things (IoT) solutions for real-time monitoring of landfill gas emissions and leachate management. • Explore the feasibility of waste-to-energy technologies and pilot small-scale projects for biogas recovery and utilisation.
Strengthening Public Engagement	Public awareness and participation in waste management remain low, especially in informal settlements.	• Launch community-based education programs to promote source segregation, composting, and recycling. • Establish waste management committees at the community level to support monitoring and compliance efforts. • Introduce financial incentives for households, such as reduced waste disposal fees for segregated waste or participation in recycling programs.
Monitoring and Evaluation Frameworks	Monitoring systems lack the tools and resources to provide continuous oversight of emissions and waste management practices.	• Develop a National GHG Emissions Monitoring Platform to track progress against national climate targets. • Establish Key Performance Indicators (KPIs) for waste management programs, such as landfill diversion rates, methane capture efficiency, and recycling rates. • Conduct annual third-party audits to verify emissions data and ensure the integrity of the reporting process.

By implementing these targeted recommendations, Fiji can significantly improve the quality and reliability of its waste sector GHG emissions assessments while fostering greater compliance with policy objectives and international climate commitments.

8.2 Strategic Recommendations

8.2.1 Immediate Term (1-2 years)

In the immediate term, enhanced methane capture represents a critical priority for emissions reduction. This initiative requires the installation of comprehensive gas collection systems at managed sites, coupled with the implementation of regular methane emissions monitoring protocols. By establishing baseline capture rates for performance tracking, the system aims to achieve an estimated 15-20% reduction in methane emissions through improved capture and management practices.

The closure of unmanaged sites presents another urgent priority for waste sector improvement. This process involves accelerating the closure of remaining unmanaged sites while simultaneously developing comprehensive rehabilitation plans for closed facilities. Implementation of environmental monitoring systems will ensure proper site management during and after closure.

Waste segregation enhancement forms the third key component of immediate improvements. This initiative focuses on implementing source segregation programs across urban areas, supported by the provision of segregation bins and appropriate collection infrastructure. A comprehensive public awareness campaign will be crucial to ensure community participation and program success. Through these combined efforts, the initiative aims to achieve a 40% reduction in organic waste reaching landfills, significantly impacting overall emissions and improving waste management efficiency.

8.2.2 Medium Term (2-5 years)

The medium-term development of technological infrastructure encompasses several key initiatives, beginning with comprehensive assessments of waste-to-energy facility feasibility and the implementation of pilot small-scale anaerobic digestion projects. This technological advancement will require significant upgrading of existing landfill infrastructure, with an estimated investment requirement of FJD 15-20 million to ensure proper implementation and operational efficiency.

Recycling enhancement represents a crucial component of the medium-term strategy, focusing on developing material recovery facilities and establishing formal recycling networks throughout the region. By creating market incentives for recyclables, the program aims to achieve a 30% increase in recycling rates by 2029, significantly reducing the volume of waste reaching landfills and promoting circular economy principles.

Strengthening monitoring capabilities forms the third pillar of medium-term improvements, centred on installing automated weighbridge systems at all major sites. This technological upgrade will be supported by implementing standardised data collection protocols and developing a central data management system. Comprehensive quality control procedures will ensure data accuracy and reliability, enabling better-informed decision-making and operational optimisation across the waste management sector.

8.2.3 Long Term (5-10 years)

Long-term integrated waste management strategy focuses on the development of comprehensive regional waste treatment facilities and the implementation of advanced waste-to-energy technologies. Through the establishment of circular economy frameworks, this integrated approach aims to achieve an ambitious target of 50% reduction in landfilled waste by 2034, fundamentally transforming the way waste is managed and processed across the region.

Capacity building forms a critical component of the long-term strategy, emphasizing the establishment of dedicated waste management training centers to develop and maintain expertise in the sector. The initiative includes developing technical expertise in modern technologies and creating professional certification programs to ensure high-quality operations. With a target of achieving 100% certified staff at major facilities, this program will establish a strong foundation of professional waste management expertise.

The development of sustainable infrastructure represents the third key element of long-term planning, focusing on creating climate-resilient waste facilities equipped with renewable energy systems. This initiative includes the creation of green buffer zones around facilities to minimize environmental impact and enhance community acceptance. The comprehensive infrastructure development program requires a substantial investment of FJD 25-30 million, reflecting the scale and importance of building resilient, sustainable waste management facilities for the future.

8.3 Implementation Framework

The success of Fiji's GHG inventory improvement plan and waste management strategy relies on fostering a supportive enabling environment.

8.3.1 Institutional Arrangements

- Strengthen the existing **waste** sector technical working groups that are formed during each inventory cycle to foster collaboration and continuity.
- Develop public-private partnership frameworks to drive investment and innovation.
- Strengthen regulatory enforcement capacity to ensure compliance with waste management policies and protocols.

8.3.2 Resource Requirements

Implementing Fiji's waste management strategy requires substantial financial resources from multiple funding streams. Government budgetary allocations will serve as the foundational funding source, providing consistent support for operational costs and infrastructure development. International climate finance mechanisms must supplement these allocations, including grants and concessional loans from multilateral development banks, climate funds, and bilateral donor partnerships. Private sector investments will be increasingly crucial through public-private partnerships, particularly in technological infrastructure and recycling facilities. The introduction of structured user fees and charges will ensure operational sustainability with a tiered pricing system that considers both commercial and residential users while maintaining affordability for lower-income communities.

Technical resources represent equally critical components for successful implementation. Significant investment in equipment and technology is required, ranging from basic collection infrastructure to advanced waste processing systems and environmental monitoring equipment. Expert consultants will be essential for specialised implementation, particularly in areas such as landfill design, methane capture systems, and waste-to-energy technologies. Comprehensive training programs need to be developed and maintained to build local capacity, covering operational procedures, environmental monitoring, and safety protocols. Establishing robust monitoring systems, including physical infrastructure and data management platforms, will ensure effective progress tracking and enable evidence-based decision-making. These technical resources must be supported by ongoing maintenance and upgrade programs to ensure the long-term effectiveness and sustainability of the waste management system.

8.3.3 Monitoring, Reporting and Verification

The success of Fiji's waste management initiatives will be tracked through a comprehensive Fiji Digital Transparency Tool. The tool will help operationalise Part 7 of the CCA 2021. The Permanent Secretary is responsible for sectorial data collection, and the director of CCD coordinates the data collection from the Ministry. At its core, the Tool will establish key performance indicators that measure critical aspects of waste management operations, environmental impact, and emission reductions. These indicators will be regularly assessed through quarterly progress reviews, providing opportunities for timely identification of challenges and implementation of corrective measures. Annual emission assessments will form a crucial component of the evaluation process, offering detailed analysis of the sector's contribution to national GHG inventories and progress toward emission reduction targets. The Tool will be supported by well-developed feedback mechanisms that enable input from sectorial Ministries from the data from various stakeholders, including facility operators, local communities, and regulatory bodies, ensuring continuous improvement and adaptive management of waste sector initiatives.

8.4 Expected outcomes

Implementing Fiji's comprehensive waste management strategy will deliver significant environmental benefits over the next decade. A primary achievement will be reducing sector emissions, accompanied by substantial improvements in groundwater protection through enhanced landfill management practices. The initiatives will enhance air quality around facilities, particularly through improved methane capture and reduced waste burning. These measures, combined with better waste management practices, will significantly reduce environmental pollution across urban and rural areas.

The economic implications of these improvements are equally substantial. The sector's modernisation will create numerous green jobs across various skill levels, from technical operators to facility managers. Resource recovery initiatives will generate new value streams through recycling and reuse programs, while improved operational efficiency will reduce long-term operational costs. The potential for carbon credits through improved methane capture and waste reduction presents additional economic opportunities, contributing to the financial sustainability of the waste management system.

Social benefits will manifest through multiple channels, with improved public health being a primary outcome due to better waste management practices and reduced environmental contamination. Urban areas will benefit from enhanced aesthetics through improved waste collection and reduced littering. The comprehensive public engagement programs will foster increased environmental awareness among communities, leading to better waste management practices at the household level. These improvements will culminate in better service delivery across all areas, significantly enhancing the quality of life for Fiji's residents.

9.0 CONCLUSION

9.1 Summary of Key Findings

The analysis of Fiji's solid waste sector emissions from 1994 to 2024 reveals several significant trends and challenges.

Over the past three decades, Fiji's waste sector has experienced significant changes in emission patterns. Total emissions have seen a substantial increase, rising from 19.75 Gg CO2e/year in 1994 to 74.36 Gg CO2e/year in 2024, with an annual growth rate of 4.5%. A notable shift in waste management practices is reflected in the current dominance of managed sites, which now account for 82% of total emissions at 61.05 Gg CO2e/year. This transition has led to a corresponding decrease in emissions from unmanaged sites, which have significantly declined from 17.25 to 8.25 Gg CO2e/year, demonstrating progress in waste management infrastructure development and operational practices.

The current state of Fiji's waste management system faces several operational challenges. With a waste generation rate of 0.46 kg/person/day, the system's capacity is strained, particularly as municipal services cover only 62.7% of urban areas. Informal settlements pose significant challenges to waste collection and management, as these areas often fall outside the regular municipal service boundaries. Further compounding these issues are persistent infrastructure maintenance problems that impact operational efficiency, including equipment breakdowns and inadequate facility upkeep, which affect the system's ability to manage and process waste across all served areas effectively.

10.0 ANNEX

10.1 Annex 1: Total emissions from Category 4A - Solid waste disposal

Site/Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
4A1 Managed sites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4A2 Unmanaged sites	17.25	17.74	18.22	18.72	19.20	19.68	20.15	20.62	21.09	21.56
4A3 Uncategorized sites	2.50	2.57	2.64	2.72	2.79	2.85	2.92	2.99	3.06	3.13
4A Solid waste disposal	19.75	20.31	20.87	21.43	21.99	22.53	23.07	23.61	24.15	24.69

Site/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
4A1 Managed sites	0.00	0.00	0.29	14.34	19.48	23.81	29.30	34.05	38.26	41.79
4A2 Unmanaged sites	22.03	22.53	20.45	18.92	17.77	16.87	15.60	14.57	13.72	13.00
4A3 Uncategorized sites	3.20	3.27	3.34	3.41	3.47	3.54	3.61	3.68	3.76	3.81
4A Solid waste disposal	25.23	25.79	24.07	36.67	40.72	44.23	48.51	52.30	55.74	58.60

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
4A1 Managed sites	45.12	48.29	51.33	54.27	57.14	59.93	62.67	68.94	74.20	78.64	82.41
4A2 Unmanaged sites	12.36	11.79	11.28	10.80	10.36	9.95	9.56	9.21	8.87	8.55	8.25
4A3 Uncategorized sites	3.88	3.94	4.01	4.07	4.14	4.21	4.28	4.53	4.73	4.91	5.06

4A Solid waste disposal	61.35	64.02	66.61	69.15	71.64	74.09	76.51	82.68	87.81	92.10	95.72

10.2 Annex 2: QC Checklist

QC Activity	Procedure
Check that the assumptions and criteria for selecting 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.
Check for transcription errors in data input and footnote.	Confirm that footnote references are properly cited in the internal documentation.
Check that emissions	Reproduce a set of emissions and removal calculations.
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 conversion factors are correct.
Check the integrity of database files.	Confirm that the appropriate data processing steps are correctly represented in the database.
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.
Check that uncertainties in emissions and removals are estimated and calculated correctly.	Check that the qualifications of individuals providing expert judgment for uncertainty estimates are appropriate.
Check time series consistency.	Check methodological and data changes resulting in recalculations.
Check completeness.	Confirm that the solid waste sector is being covered.
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 the value of implied emission factors (aggregate emissions divided by activity data) across time series. Check if any unusual and unexplained trends are noticed for activity data or other parameters across the time series.

QC Activity	Procedure
Review of internal documentation and archiving.	Check that detailed internal documentation supports the estimates and enables 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 a secure place following completion of the inventory. Check the integrity of any data archiving arrangements of outside organisations involved in inventory preparation.

10.3 Annex 3: Case Study: Vunato Disposal Site (VDS) – Operated by Lautoka City Council (LCC)

The Vunato Disposal Site (VDS) serves as one of Fiji's primary waste management facilities, strategically located at the northern end of Lautoka City. Established in 1968, this 50-acre (20 ha) facility was developed in a mangrove area facing the sea, reflecting the common challenges of land availability in Pacific Island nations[20]. The site's remaining capacity of approximately 28,000m^3 suggests an operational lifespan of about 10 years at current disposal rates.[21]

VDS employs an Open Aerobic and Evaporation landfilling method, organised across six distinct disposal sections with dedicated areas for special waste handling and recycling operations. The facility processes between 80-100 tonnes of waste daily (2018-2020), with operational costs averaging $12.49 per tonne as of 2020[22].Modern infrastructure includes a computerised weighbridge system, complemented by a market waste composting facility and an innovative Collection Pillars of Recycling (CPRs) program that achieves a recycling rate of 30 tonnes per day.

The facility's service area encompasses the greater Lautoka region, extending to Nadi and Denarau Island, making it a crucial component of western Fiji's waste management infrastructure. This extensive coverage area demonstrates the site's significance in regional waste management.[23]

[20] Fiji National Waste Audit Analysis Report. SPREP, August 2023
[21] The Waste Amount & Composition Survey- Suva & Lautoka. Scope Pacific PTE Ltd, 2022
[22] Information obtained from the research conducted by Janette Mani and Riteshma Devi under the ICAT Phase II project.
[23] Fiji national waste audit analysis report. SPREP, August 2023

Environmental Considerations

Site-Specific Challenges:

The coastal location of major waste disposal sites in Fiji, particularly the Vunato Disposal Site in Lautoka, presents significant environmental challenges. The high water table in these areas, typically less than 2 meters below ground level, creates persistent drainage issues and increases the risk of leachate contamination.[24] At the Vunato site, which was developed in a mangrove area, the proximity to the sea compounds these challenges, making conventional landfill management techniques less effective.[25].

Fiji's tropical climate, characterised by high temperatures and rainfall exceeding 2000mm annually, significantly accelerates waste decomposition rates. According to the Pacific Regional Infrastructure Facility (PRIF) Report (2021), this rapid decomposition leads to increased methane generation and creates challenges for waste compaction and site stability. The climate also affects the longevity of cover materials and infrastructure, requiring more frequent maintenance and replacement.

Land availability remains a critical constraint for waste management in Fiji, reflecting a common challenge across Pacific Island nations. The JICA Waste Minimization and Recycling Promotion Project (2009) highlighted that suitable land for waste disposal is increasingly scarce, particularly given the competing demands for coastal land use and the need to protect sensitive environmental areas.

Infrastructure Management Issues:

Infrastructure maintenance presents ongoing operational difficulties at Fiji's disposal sites. The Department of Energy's Resource Assessment Study (2014) documented that high humidity and salt exposure in coastal locations accelerate equipment deterioration, increasing maintenance costs and reducing operational efficiency. At the Vunato Disposal Site, maintenance costs reached $12.49 per tonne in 2020, significantly impacting the LCC operational budgets.[26]

Equipment breakdown frequency poses a significant operational challenge. According to recent assessments, major equipment such as bulldozers at the Vunato site have experienced extended periods of inoperability, sometimes lasting up to a year. This impacts waste spreading and compaction operations, reducing the site's effective capacity utilisation[27].

Disaster waste management remains a critical concern, particularly given Fiji's vulnerability to tropical cyclones. The impact of Tropical Cyclone Winston in 2016 demonstrated the scale of this challenge, generating approximately 5,955 tonnes of waste within three hours –

[24] Fiji National Waste Audit Analysis Report. SPREP, August 2023

[25] The Waste Amount & Composition Survey- Suva & Lautoka. Scope Pacific PTE Ltd, 2022

[26] Information obtained from the research conducted by Janette Mani and Riteshma Devi under the ICAT Phase II project.

[27] Enhancing Solid Waste Management in Fiji: A Comprehensive Approach with LCA, GIS, and Waste Treatment Strategies. Matagi, L., et al.2024

equivalent to two months' normal waste generation.[28] This event highlighted the need for robust disaster waste management protocols and adequate emergency response capacity.

Fire incidents at disposal sites present both environmental and safety hazards. The Fiji National Waste Audit Analysis Report (2023) documented multiple fire occurrences at various sites, attributed to factors including:

- Spontaneous combustion in inadequately compacted waste
- Methane gas accumulation
- Unauthorised waste burning
- Hot weather conditions combined with inadequate cover material

Drainage challenges persist across most sites, particularly during Fiji's wet season. The SPREP waste audit (2023) identified that inadequate drainage systems, combined with high rainfall and elevated water tables, create:

- Difficulties in waste placement and compaction
- Increased leachate generation
- Access problems for collection vehicles
- Enhanced risk of slope instability

These environmental and management challenges require integrated solutions that consider both technical and financial constraints while addressing the unique conditions of Pacific Island waste management operations.

Data Collection Systems

Overview of Recording Methods

The Vunato Disposal Site (VDS) exemplifies modern data collection practices in Fiji's waste management sector through its fully computerised weighbridge system. The system enables transparent, accountable, and fair operations while maintaining detailed records that can be retrieved in both Excel and PDF formats for reporting purposes.

Weighbridge Operations

The weighbridge facility at VDS operates by:

- Recording initial and final vehicle weights
- Calculating net waste weight automatically
- Generating computerised receipts
- Maintaining digital records of all transactions
- Enabling commercial weighing services

Volume Monitoring System

Daily waste monitoring includes:

- Average disposal tracking (80-100 tonnes/day as of 2018-2020)
- Separate recording of recyclables (30 tonnes/month)

[28] Information stated by representative for Lautoka City Council during the waste sector meeting from 15-16 October 2024.

- Market organic waste weighing for composting
- Special waste category tracking

Documentation and Record Keeping

Primary Documentation

Each waste delivery is documented with:

Data Type	Details
Temporal Data	○ Date of disposal ○ Time of entry and exit ○ Duration of disposal operation
Vehicle Information	○ Registration number ○ Vehicle type and capacity ○ Regular or occasional user status
Waste Classification	○ Source categorisation (residential/commercial/industrial) ○ Type of waste ○ Special handling requirements if applicable

Fee Assessment Structure

The fee system incorporates:

- Different rates for different waste categories
- Origin-based pricing
- Special rates for commercial weighing services
- Implementation of disposal fees based on tonnage (since January 2010)

Data Management and Reporting

Report Generation

The system enables:

- Daily reports of total waste received
- Monthly summaries of waste volumes
- Annual waste disposal statistics
- Trend analysis of waste flows
- Recycling rate monitoring

Data Usage

The collected data supports LCC:

- Operational planning and management
- Environmental compliance reporting
- Resource allocation decisions
- Long-term capacity planning
- Fee structure reviews

Integration with National Systems

The data collection system at VDS integrates with:

- Bureau of Statistics reporting requirements
- Environmental monitoring programs
- National waste management planning
- Regional waste management initiatives

This comprehensive data collection and documentation system represents a significant advancement in Fiji's waste management capabilities, providing essential information for both operational management and strategic planning. The system's implementation at VDS demonstrates the potential for modern waste management practices in Pacific Island nations, though challenges remain in maintaining consistent data quality and system reliability.