

DISCLAIMER

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, photocopying, recording or otherwise, for commercial purposes without prior permission of Vanuatu. Otherwise, material in this publication may be used, shared, copied, reproduced, printed and/or stored, provided that appropriate acknowledgement is given to Vanuatu and ICAT as the source. In all cases the material may not be altered or otherwise modified without the express permission of Vanuatu.

PREPARED UNDER

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



Supported by:



on the basis of a decision
by the German Bundestag



 **Federal Ministry**
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

The ICAT Secretariat is managed and supported by the United Nations Office for Project Services (UNOPS)



WASTE

Two subsectors within the Waste sector that will be taken into account for estimating GHG emissions are Solid Waste Disposal and Wastewater Treatment and Discharge.

Solid Waste Disposal

Solid waste disposal in Vanuatu faces major challenges due to economic conditions and inadequate planning. The waste primarily consists of organic materials, plastics, metals, glass, and paper, with organic waste often exceeding 50% of the total composition.

The country lacks a comprehensive waste collection system; while residents in urban areas have their waste collected, those in rural regions do not. According to the 2020 Vanuatu census, 45% of households burn their waste, 23.9% have access to authorized waste collection services, 11.9% transport their waste to central disposal sites, 6.2% use composting systems, and 9.5% bury their waste. The remaining households (3.5%) resort to dumping in lagoons, rivers, or the sea¹.

The breakdown of solid waste primarily produces Methane (CH₄) through anaerobic decomposition of organic matter. Carbon Dioxide (CO₂) is generated from both aerobic and anaerobic processes, but it is less harmful than methane due to its lower Global Warming Potential (GWP). Non-methane volatile organic compounds (VOCs) also arise from materials like plastics and paints in the waste, however, their reporting under the MPGs is not mandatory. For this inventory, the focus will be on assessing Methane emissions.

When evaluating emissions from solid waste disposal in Vanuatu, it's important to note that not all waste is sent to landfills. Therefore, the emissions estimated in this inventory will only include waste that has been collected and deposited at the waste site.

The main gas of concern in solid waste disposal (SWD) is methane. Between 1990 and 2021, SWD emissions increased by 7.5774 Gg CO₂ equivalent, as shown in Figure 1. This emission data only reflects the 23% of the population whose waste is managed by authorized services. Table 1 summarizes emissions from SWD, calculated using Tier 1 methodology, utilizing calculations based on the Tier 1 method outlined in the Vanuatu Waste Sector Inventory Manual.

Vanuatu's population has been increasing at an approximate rate of 5,391 individuals each year from 1990 to 2021, as illustrated in Figure 2. As the population and urbanization levels rise, there is a corresponding significant increase in the amount of organic waste produced. This escalation results in larger volumes of waste being sent to landfills, which consequently leads to heightened methane emissions due to the decomposition of organic materials.

Moreover, Vanuatu encounters substantial difficulties regarding its waste management systems and practices. Many existing landfills are not equipped to effectively capture and reduce methane emissions. Additionally, there is a deficiency in knowledge regarding proper landfill

¹ <https://purl.org/spc/digilib/doc/xieet>

management techniques, such as covering waste with soil or implementing gas collection systems. This lack of expertise contributes to methane escaping into the atmosphere instead of being harnessed for energy production.

Figure 1: Solid waste

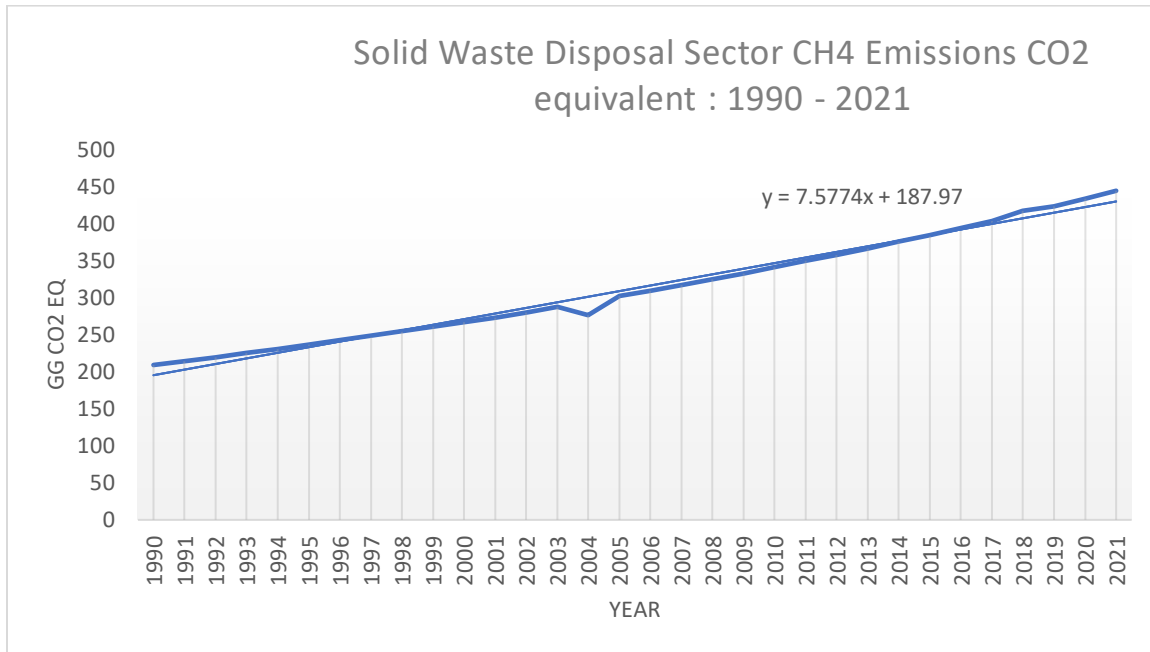


Figure 1: illustrates an estimate of the annual increase in emissions at a rate of 7.5774 Gg of CO2 equivalent. The estimates for waste disposal pertain solely to the waste that is deposited at the landfill site.

Figure 2: Vanuatu Population: 1990 - 2021

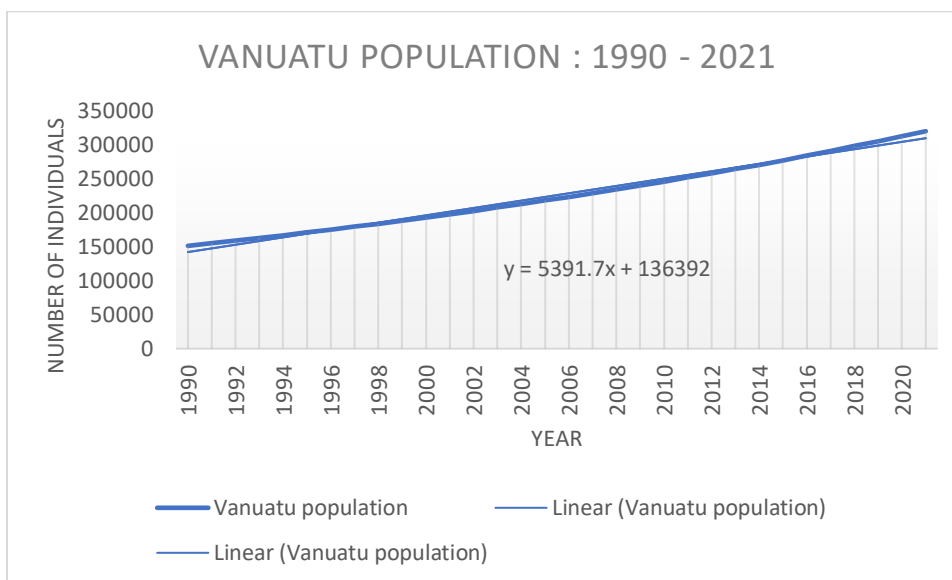


Figure 2: illustrates the population growth at a rate of 5,391 individuals per year from 1990 to 2021. This growth is directly related to the increase in Gg CO₂ equivalent emissions resulting from methane released by 23% of the waste collected in Vanuatu.

Table 1.1: SWD Gg CH₄(g): 1990 – 2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Vanuatu Population	150882	154678	158577	162548	166560	170612	174714	178871	183088	187432	192074
Total Gg CH ₄ (g) emissions	81.6586	83.6635	85.7422	87.89	90.0978	92.3543	94.6514	96.9857	99.3557	101.7613	104.2148
Total CH ₄ Emissions CO ₂ eq	209.3429	214.4828	219.8119	225.3269	230.9781	236.7628	242.6518	248.6361	254.7114	260.879	267.1687

Table 1.2 SWD Gg CH₄(g); 2001 – 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Vanuatu Population	197034	202125	207258	212422	217632	222923	228345	233952	239689	245453
Total Gg CH ₄ (g) emissions	106.7552	109.4128	112.1741	115.0139	117.9132	120.8621	123.8601	126.9161	130.1459	133.2501
Total CH ₄ Emissions CO ₂ eq	273.6816	280.4947	287.5736	276.8538	302.2907	309.8465	317.5322	325.3668	333.3904	341.6048

Table 1.3: SWD Gg CH₄(g): 2011 – 2021

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Vanuatu Population	251294	257313	263534	269927	276438	283218	290239	297298	304404	311685	319137
Total Gg CH ₄ (g) emissions	136.5105	139.8239	143.2065	146.6736	150.2301	153.8695	157.615	161.4771	165.4261	169.4437	173.5408
Total CH ₄ Emissions CO ₂ eq	349.9633	358.4576	367.1294	376.0178	385.1353	394.4655	404.0676	417.9685	424.0923	434.392	444.8955

(Note: The arrangement of tables has been separated for space considerations.)

Domestic Waste Water Treatment

Domestic Waste Water treatment involves the process whereby contaminants are removed from water, before it can be released back into the environment or reused.

In Vanuatu, treated wastewater is typically released into coastal waters or used for irrigation. Urban areas have more organized discharge systems, while rural communities often lack infrastructure, leading to the release of untreated wastewater into the environment. This practice results in pollution of local water bodies, negatively impacting marine ecosystems and human health.

The two primary greenhouse gases (GHGs) associated with wastewater treatment are Methane (CH_4) and Nitrous Oxide (N_2O). Methane is generated during the decomposition of organic matter in wastewater. In contrast, Nitrous Oxide is produced through nitrification and denitrification processes during advanced treatment methods. Methane (CH_4) is produced mainly during anaerobic digestion, a process where microorganisms break down organic matter in the absence of oxygen. This process is common in many wastewater treatment facilities. Throughout the years of 1990 to 2021 Methane emissions have increased at a rate of 1.2398 Gg CH_4 per year, as shown in figure 3.

Figure 3: Total Domestic Wastewater Treatment Gg (CH_4) Emissions

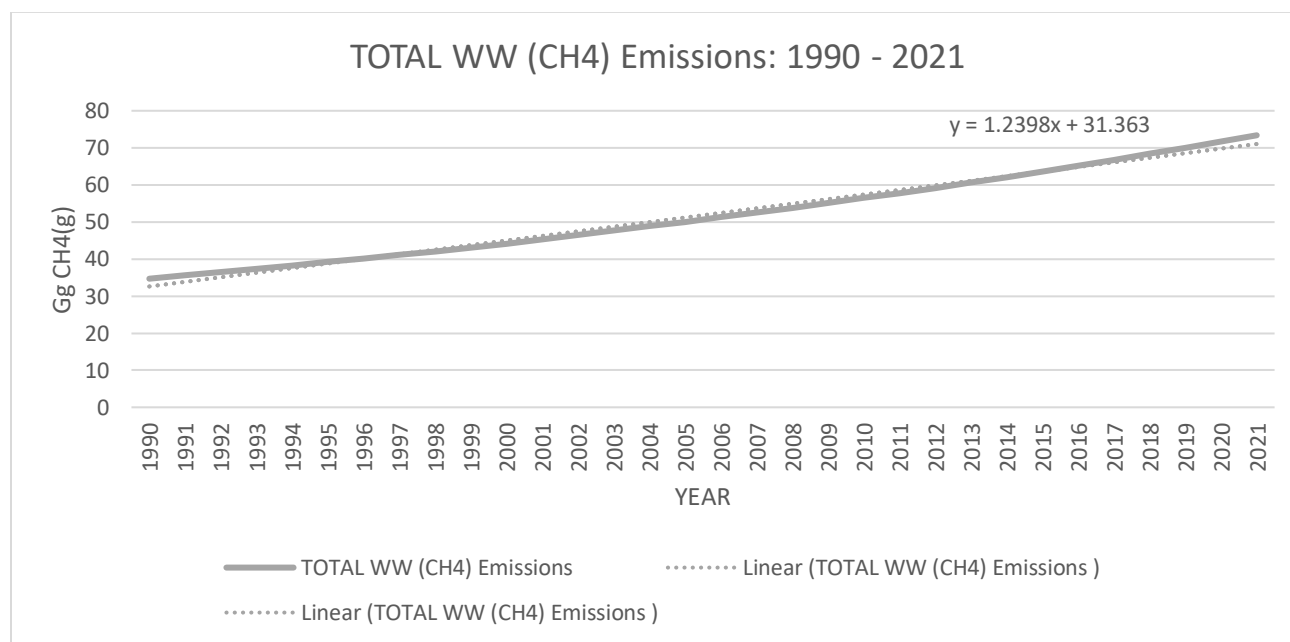


Figure 3 shows an annual increase of approximately 1.2398 Gg of CH_4 emissions from 1990 to 2021.

Nitrous oxide (N_2O) is mainly produced during nitrification and denitrification in wastewater treatment nitrogen removal processes. Compared to methane, N_2O emissions are lower, as illustrated in Figure 5.

Figure 4: Total Domestic Waste Water $\text{N}_2\text{O}(\text{g})$ Emissions: 1990 - 2021

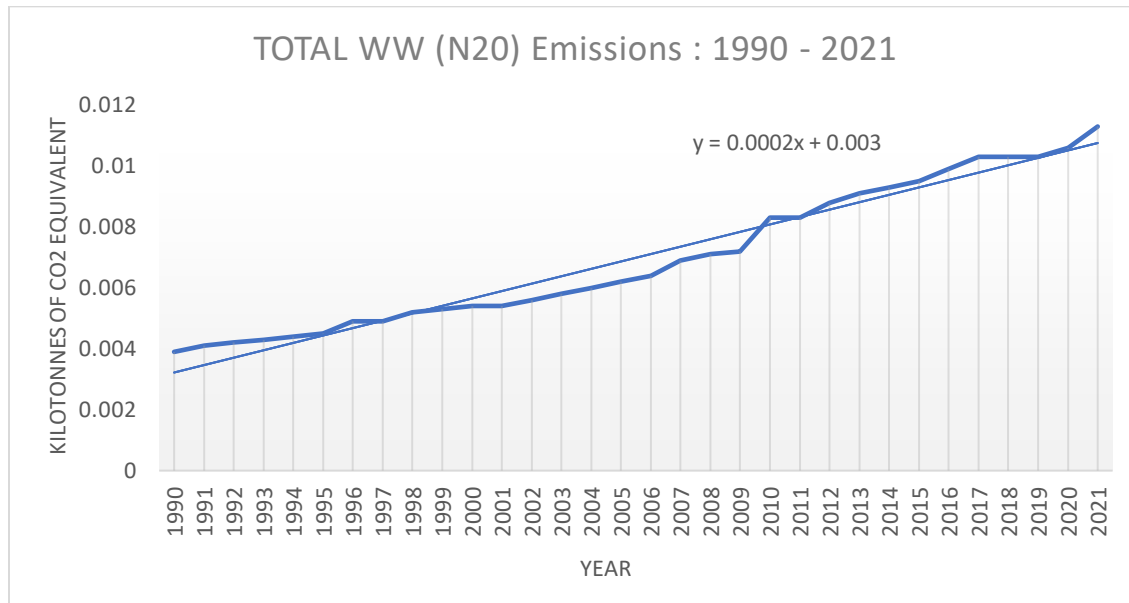
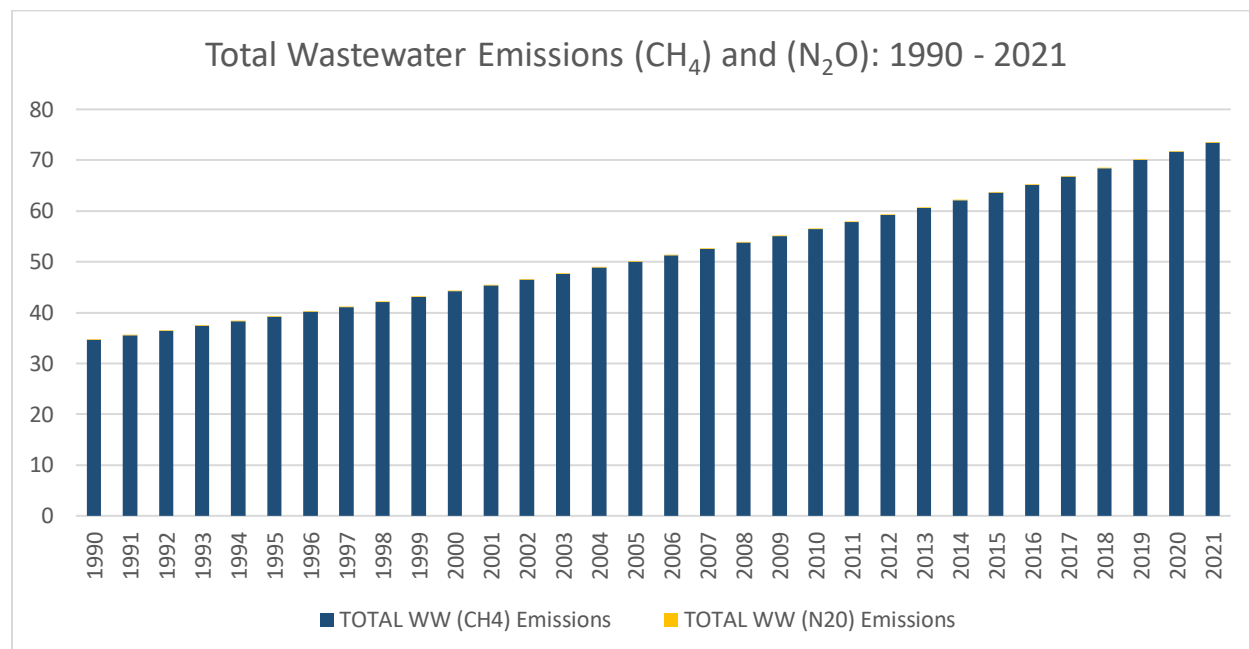


Figure 4 depicts the increase in N_2O emissions at an estimated rate of 0.0002 Gg of Methane emitted per year.

Figure 5: Total Wastewater Emissions (CH_4) and (N_2O): 1990 - 2021



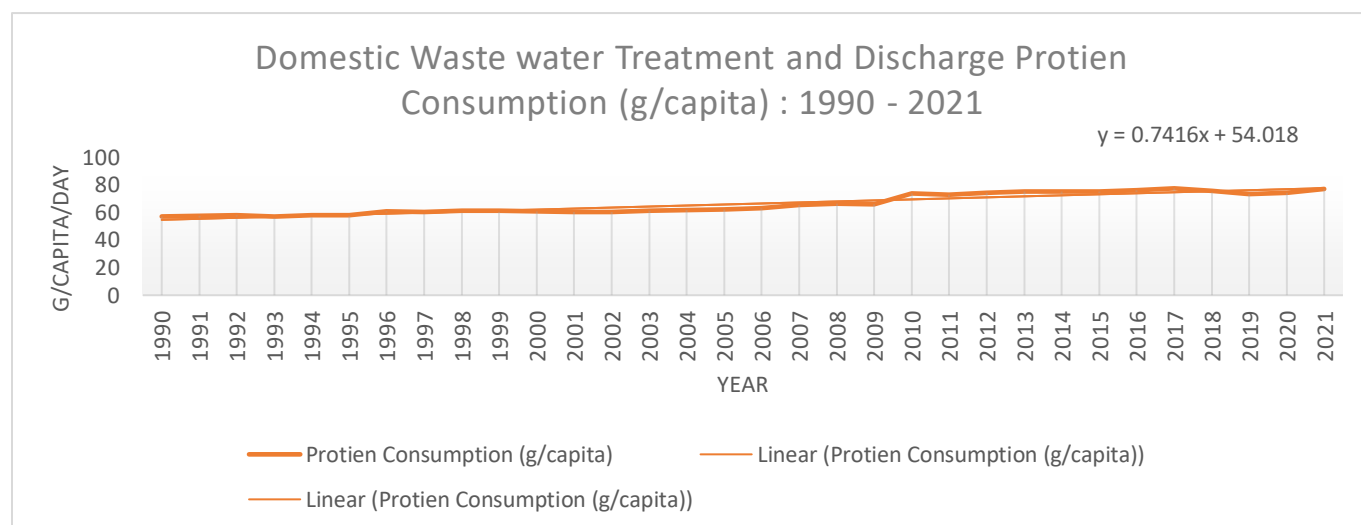
The graph shows that methane (CH_4) emissions are significantly higher than those of nitrous oxide (N_2O) on an annual basis.

Several factors contribute to the rise in methane (CH_4) emissions in Vanuatu. The country's tropical wet climate promotes anaerobic digestion, which is a significant source of methane production. Additionally, from 1990 to 2021, Vanuatu has seen a steady increase in population. This growth leads to higher levels of biodegradable organic material, further escalating annual methane emissions during this period.

Dietary habits significantly influence nitrogen levels in wastewater. Increased protein intake raises nitrogen content in sewage, which can lead to higher N_2O emissions during nitrification and denitrification processes. From 1990 to 2021, the rise in protein consumption has been a primary factor driving N_2O emissions, as illustrated in Figure 6 below. This increase has averaged only 0.7416 g/capita per year, which explains why annual N_2O emissions remain relatively low.

Another contributing factor to rising emissions is the lack of adequate infrastructure for capturing gases for energy conversion. Consequently, these gases are released directly into the atmosphere, further exacerbating annual emission increases. Table 2.1 – 2.3 is provided below containing the Annual Emissions produced from the waste water treatment and discharge.

Figure 6: Domestic Waste Water Treatment and Discharge: Vanuatu Protein Consumption: 1990 - 2021



The graph shows that annual protein consumption has risen by 0.7416 g per capita, which corresponds with an increase in annual N₂O emissions.

Table 2.1 Wastewater Treatment and Discharge Emissions: 1990 - 2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Vanuatu Population	150882	154678	158577	162548	166560	170612	174714	178871	183088	187432	192074
Total Gg CH ₄ (g) Emissions (WW)	34.6953	35.5682	36.4648	37.3779	38.3005	39.2322	40.1755	41.1314	42.1011	43.1	44.1674
Total CH ₄ Emissions (Gg CO ₂ eq) (WW)	34.6953	35.5682	36.4648	37.3779	38.3005	39.2322	40.1755	41.1314	42.1011	43.1	44.1674
Protein Consumption (g/capita/day)	57.28032	57.69849	58.02494	57.13442	58.04081	58.15207	61.00352	60.42073	61.54592	61.2957	60.98383
Total Gg N ₂ O(g) Emissions (WW)	0.0039	0.0041	0.0042	0.0043	0.0044	0.0045	0.0049	0.0049	0.0052	0.0053	0.0054
Total N ₂ O(g) Emissions (CO ₂ eq) (WW)	0.004	0.0041	0.0042	0.0043	0.0044	0.0045	0.0049	0.005	0.0052	0.0053	0.0054
Total Emissions CO ₂ eq (Wastewater treatment and Discharge)	34.6993	35.5723	36.469	37.3822	38.3049	39.2367	40.1804	41.1364	42.1063	43.1053	44.1728

Table 2.2: Wastewater Treatment and Discharge Emissions: 2001 - 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Vanuatu Population	197034	202125	207258	212422	217632	222923	228345	233952	239689	245453
Total Gg CH ₄ (g) Emissions (WW)	45.308	46.4786	47.659	48.8464	50.0445	51.2611	52.5079	53.7973	55.1165	56.4419
Total CH ₄ Emissions (Gg CO ₂ eq) (WW)	45.308	46.4786	47.659	48.8464	50.0445	51.2611	52.5079	53.7973	55.1165	56.4419
Protein Consumption (g/capita/day)	60.27497	60.43396	61.36843	61.61361	62.12133	63.08213	65.7421	66.25935	65.85957	73.79579
Total Gg N ₂ O(g) Emissions (WW)	0.0054	0.0056	0.0058	0.006	0.0062	0.0064	0.0069	0.0071	0.0072	0.0083
Total N ₂ O(g) Emissions (CO ₂ eq) (WW)	0.0054	0.0056	0.0058	0.006	0.0062	0.0064	0.0069	0.0071	0.0072	0.0083
Total Emissions CO ₂ eq (Wastewater treatment and Discharge)	45.3134	46.4842	47.6648	48.8524	50.0507	51.2675	52.5148	53.8044	55.1237	56.4502

In total, the municipal solid waste sector accounts for 70% of emissions from the sector, while wastewater treatment and discharge contribute 30%, as illustrated in Figure 7. The excessive emissions from the waste sector are detailed in the summary table below and in Figure 8. Without improvements to the waste management system, such as installing effective gas trapping systems, emissions are projected to rise annually due to ongoing population growth and urbanization in Vanuatu.

Figure 7: WASTE SECTOTOR TOTAL GHG EMISSIONS (Gg CO₂ EQUIVALENT): 1990 - 2021

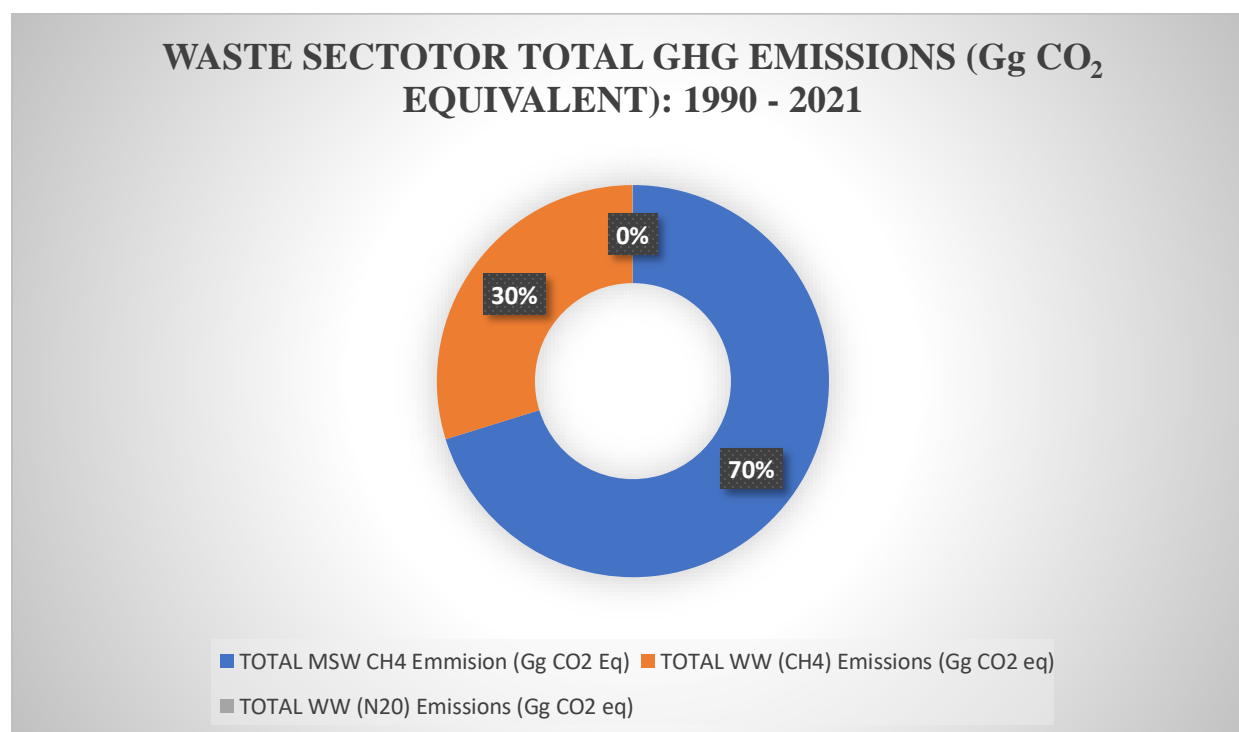


Figure 7 shows the total greenhouse gas emissions in CO₂ equivalent from two subsectors: Municipal Solid Waste and Wastewater Treatment and Discharge, between 1990 and 2021. It indicates that municipal solid waste is the primary source of emissions, accounting for 70%, while wastewater contributes 30%.

Figure 8: Estimated total GHG Emissions (CO₂ equivalent): 1990 - 2021

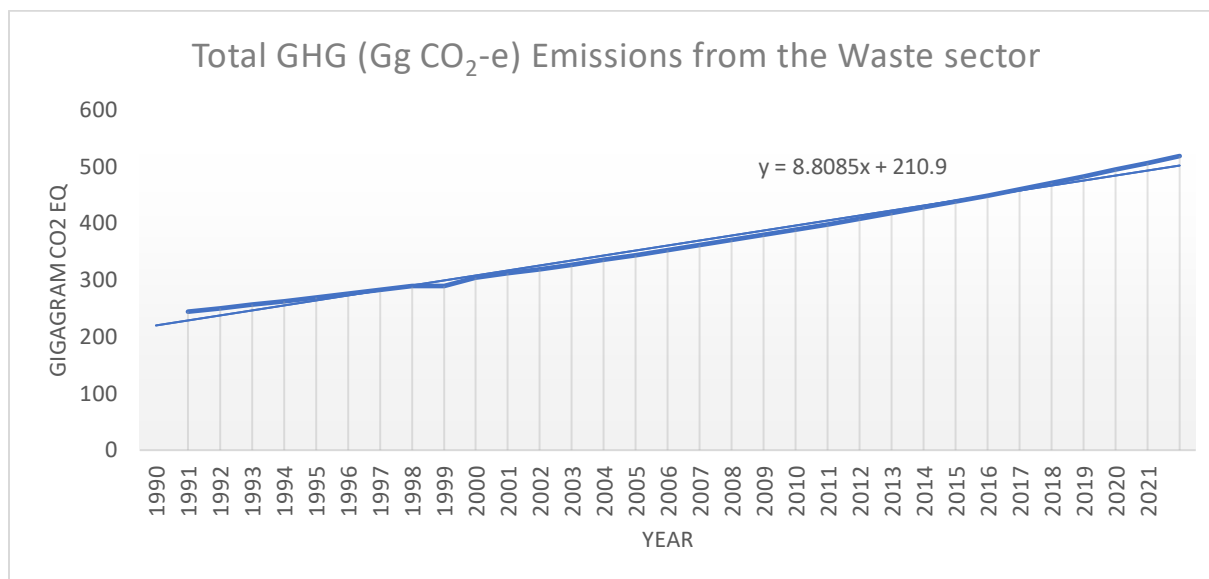


Figure 8: Depicts an increasing Emissions (Gg CO₂ equivalent) by the year approximately at a rate of 8.8085 Gg per year. Without proper Waste management systems practiced or installed for capturing gas emitted, the Emissions will continue to increase.

SUMMARY TABLES

Summary table 3.1 Waste Sector: 1990 – 2000 ²

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Vanuatu Population	150882	154678	158577	162548	166560	170612	174714	178871	183088	187432	192074
Total CH ₄ Emissions (SWD)	81.6586	83.6635	85.7422	87.89	90.0978	92.3543	94.6514	96.9857	99.3557	101.7613	104.2148
Total Gg CH ₄ (g) Emissions (Gg CO ₂ eq) (SWD)	209.3429	214.4828	219.8119	225.3269	230.9781	236.7628	242.6518	248.6361	254.7114	260.879	267.1687
Total Gg CH ₄ (g) Emissions (WW)	34.6953	35.5682	36.4648	37.3779	38.3005	39.2322	40.1755	41.1314	42.1011	43.1	44.1674
Total CH ₄ Emissions (Gg CO ₂ eq) (WW)	34.6953	35.5682	36.4648	37.3779	38.3005	39.2322	40.1755	41.1314	42.1011	43.1	44.1674
Protein Consumption (g/capita/day)	57.28032	57.69849	58.02494	57.13442	58.04081	58.15207	61.00352	60.42073	61.54592	61.2957	60.98383
Total Gg N ₂ O(g) Emissions (WW)	0.0039	0.0041	0.0042	0.0043	0.0044	0.0045	0.0049	0.0049	0.0052	0.0053	0.0054
Total N ₂ O(g) Emissions (CO ₂ eq) (WW)	0.004	0.0041	0.0042	0.0043	0.0044	0.0045	0.0049	0.005	0.0052	0.0053	0.0054
Total CO ₂ eq Waste Sector	244.042	250.055	256.2809	262.7001	269.2829	275.9995	282.8322	289.7723	289.8182	303.9844	311.3416

Summary Table 3.2: Waste sector: 2001 - 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Vanuatu Population	197034	202125	207258	212422	217632	222923	228345	233952	239689	245453
Total CH ₄ Emissions (SWD)	106.7552	109.4128	112.1741	115.0139	117.9132	120.8621	123.8601	126.9161	130.1459	133.2501
Total Gg CH ₄ (g) Emissions (Gg CO ₂ eq) (SWD)	273.6816	280.4947	287.5736	276.8538	302.2907	309.8465	317.5322	325.3668	333.3904	341.6048
Total Gg CH ₄ (g) Emissions (WW)	45.308	46.4786	47.659	48.8464	50.0445	51.2611	52.5079	53.7973	55.1165	56.4419
Total CH ₄ Emissions (Gg CO ₂ eq) (WW)	45.308	46.4786	47.659	48.8464	50.0445	51.2611	52.5079	53.7973	55.1165	56.4419
Protein Consumption (g/capita/day)	60.27497	60.43396	61.36843	61.61361	62.12133	63.08213	65.7421	66.25935	65.85957	73.79579
Total Gg N ₂ O(g) Emissions (WW)	0.0054	0.0056	0.0058	0.006	0.0062	0.0064	0.0069	0.0071	0.0072	0.0083
Total N ₂ O(g) Emissions (CO ₂ eq) (WW)	0.0054	0.0056	0.0058	0.006	0.0062	0.0064	0.0069	0.0071	0.0072	0.0083
Total CO ₂ eq Waste Sector	318.9949	326.979	335.2384	343.7062	352.3381	361.1139	370.0471	379.1711	388.5141	398.055

² Vanuatu 2020 National Population and Housing Census: basic Tables Report - Volume 1. Noumea, New Caledonia: Pacific Community. 351 p. <https://purl.org/spc/digilib/doc/xieet>

Summary Table 3.3 Waste Sector: 2011 - 2021

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Vanuatu Population	251294	257313	263534	269927	276438	283218	290239	297298	304404	311685	319137
Total CH ₄ Emissions (SWD)	136.5105	139.8239	143.2065	146.6736	150.2301	153.8695	157.615	161.4771	165.4261	169.4437	173.5408
Total Gg CH ₄ (g) Emissions (Gg CO ₂ eq) (SWD)	349.9633	358.4576	367.1294	376.0178	385.1353	394.4655	404.0676	417.9685	424.0923	434.392	444.8955
Total Gg CH ₄ (g) Emissions (WW)	57.7851	59.1691	60.5996	62.0697	63.5669	65.126	66.7405	68.3637	69.9977	71.672	73.3856
Total CH ₄ Emissions (Gg CO ₂ eq) (WW)	57.7851	59.1691	60.5996	62.0697	63.5669	65.126	66.7405	68.3637	69.9977	71.672	73.3853
Protein Consumption (g/capita/day)	72.99448	74.3345	75.28514	75.31665	75.42727	76.1049	77.59732	75.86821	73.63661	74.15905	77.26855
Total Gg N ₂ O(g) Emissions (WW)	0.0083	0.0088	0.0091	0.0093	0.0095	0.0099	0.0103	0.0103	0.0103	0.0106	0.0113
Total N ₂ O(g) Emissions (CO ₂ eq) (WW)	0.0084	0.0088	0.0091	0.0093	0.0096	0.0099	0.0103	0.0103	0.0103	0.0106	0.0113
Total CO ₂ eq Waste Sector	407.7566	417.6355	427.7381	438.0967	448.7117	459.6014	470.8183	482.3425	494.1003	506.0746	518.28213