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AECOM

Masterton District Emissions Inventory 2021/22

19-Jun-2023

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Masterton District Emissions Inventory 2021/22

Client: Greater Wellington Regional Council

Co No.: N/A

Prepared by

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Assumptions and Data Sources A

Executive Summary

Greenhouse Gas (GHG) emissions for the Masterton Territorial Area (that is covered by the Masterton District Council) have been measured using the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC) methodology. This approach includes emissions from Stationary Energy, Transport, Waste, Industrial Processes and Product Use (IPPU), Agriculture and Forestry sectors. This document reports greenhouse gas emissions produced in or resulting from activity or consumption within the geographic boundaries of the Masterton Territorial Area for the 2021/22 financial reporting year and examines greenhouse gas emissions produced from 2018/19 to 2021/22.

The Masterton Territorial Area is referred to hereafter as Masterton for ease. Greenhouse gas emissions are generally reported in this document in units of carbon dioxide equivalents (CO_2e) and are referred to as 'emissions'.

Major findings of the project include:

2021/22 Emissions Inventory

- In the 2021/22 reporting year (1st July 2021 to 30th June 2022), **Total Gross Emissions** in Masterton were 785,873 tCO_2e.
- **Agriculture** is by far the largest emitting sector in Masterton, representing 80.9% of total gross emissions.
- **Transport** (e.g. emissions from road and air travel) is the second-highest emitting sector in Masterton, representing 12.4% of total gross emissions, with on-road petrol and diesel use accounting for 9.1% of Masterton's total gross emissions.
- **Stationary Energy** (e.g. emissions relating to electricity and natural gas consumption) produced 3.6% of Masterton's total gross emissions. **Waste** and **Industrial Processes and Product Use (IPPU)** (e.g. refrigerant use) represented 2.1% and 1.0% respectively.
- **Net Forestry** emissions were -811,512 tCO_2e in 2021/22 as carbon sequestration (carbon captured and stored in plants or soil by forests) was higher than emissions from forest harvesting (e.g., the release of carbon from timber, roots and organic matter following harvesting). Net Forestry emissions are not included in total gross emissions but in total net emissions.
- **Total Net Emissions** in Masterton were -25,639 tCO_2e. Total net emissions includes sequestration and emissions release from forestry and can fluctuate depending on forestry activity.

Changes in Annual Emissions, 2018/19 to 2021/22

- Between 2018/19 and 2021/22, **Total Gross Emissions** in Masterton decreased from 839,263 tCO_2e to 785,783 tCO_2e, a decrease of 6% (53,389 tCO_2e), largely due to a reduction in agriculture and transport emissions.
- Over this time the population of Masterton increased by 7.7%, resulting in **Per Capita Gross Emissions** in Masterton decreasing by 13% between 2018/19 and 2021/22, from 31.5 to 27.4 tCO_2e per person per year.
- Emissions from **Transport** decreased by 17%, between 2018/19 and 2021/22 (20,372 tCO_2e), driven by a reduction in air travel emissions and on-road petrol and diesel consumption.
- Emissions from **Agriculture** decreased by 4% between 2018/19 and 2021/22 (29,451 tCO_2e), due to a 10% reduction in the number of sheep (780,485 to 702,239).
- Emissions from **Waste** decreased by 12% between 2019/20 and 2021/22 (2,245 tCO_2e), due to an increase in landfill gas capture efficiency. Emissions from **Stationary Energy** increased by 5% between 2018/19 and 2021/22 (1,626 tCO_2e) primarily due to decreased use of fossil fuel electricity generation in the national grid.
- **Total Net Emissions** decreased by 109% (319,450 tCO_2e) between 2018/19 and 2021/22. This was caused by the 53,389 tCO_2e reduction in total gross emissions combined with a 185,933 tCO_2e decrease in emissions released by forest harvesting in these years.

Masterton Emissions Inventory for 2021/22

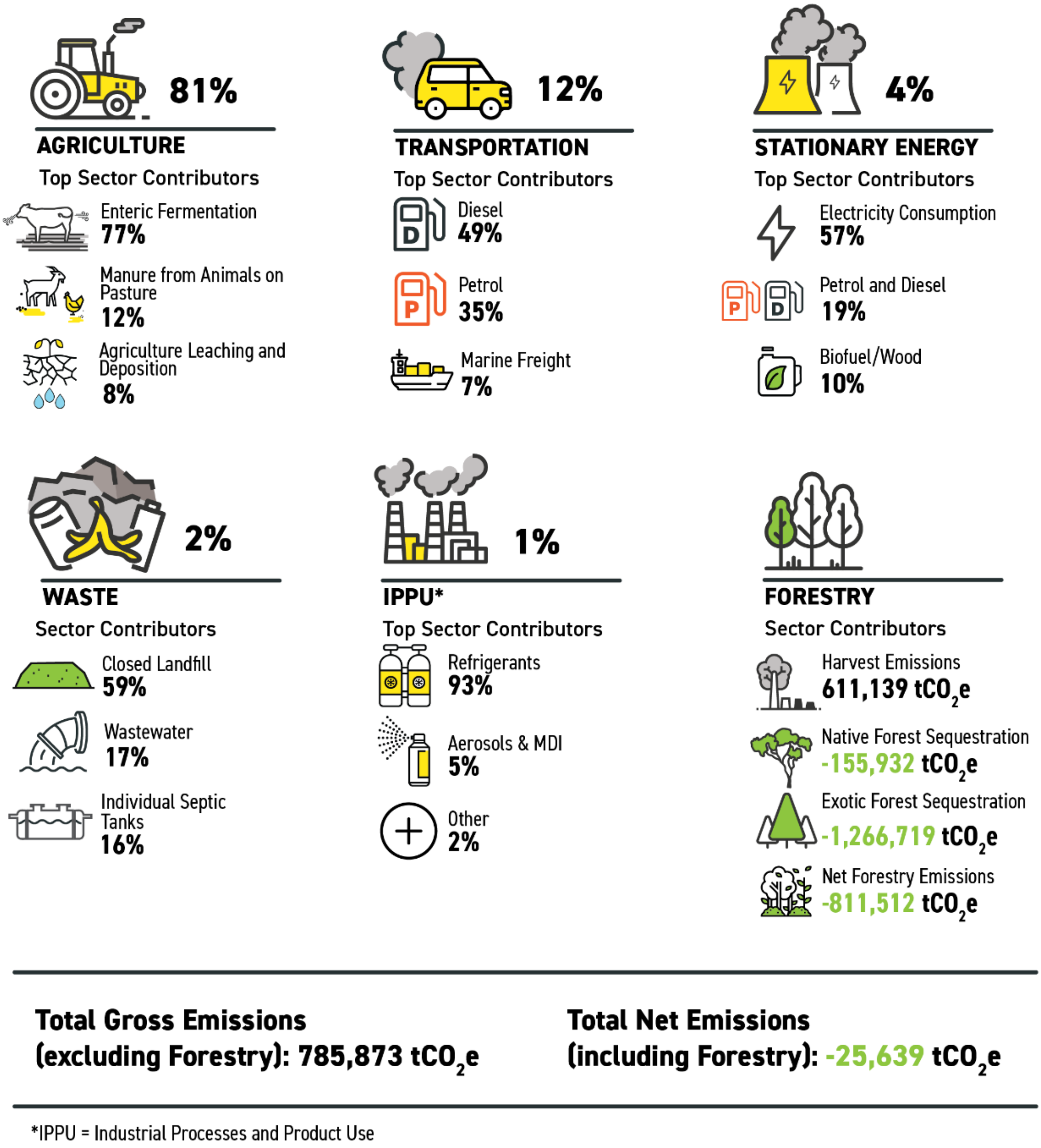

Figure 1: Masterton 2021/22 Emissions Inventory

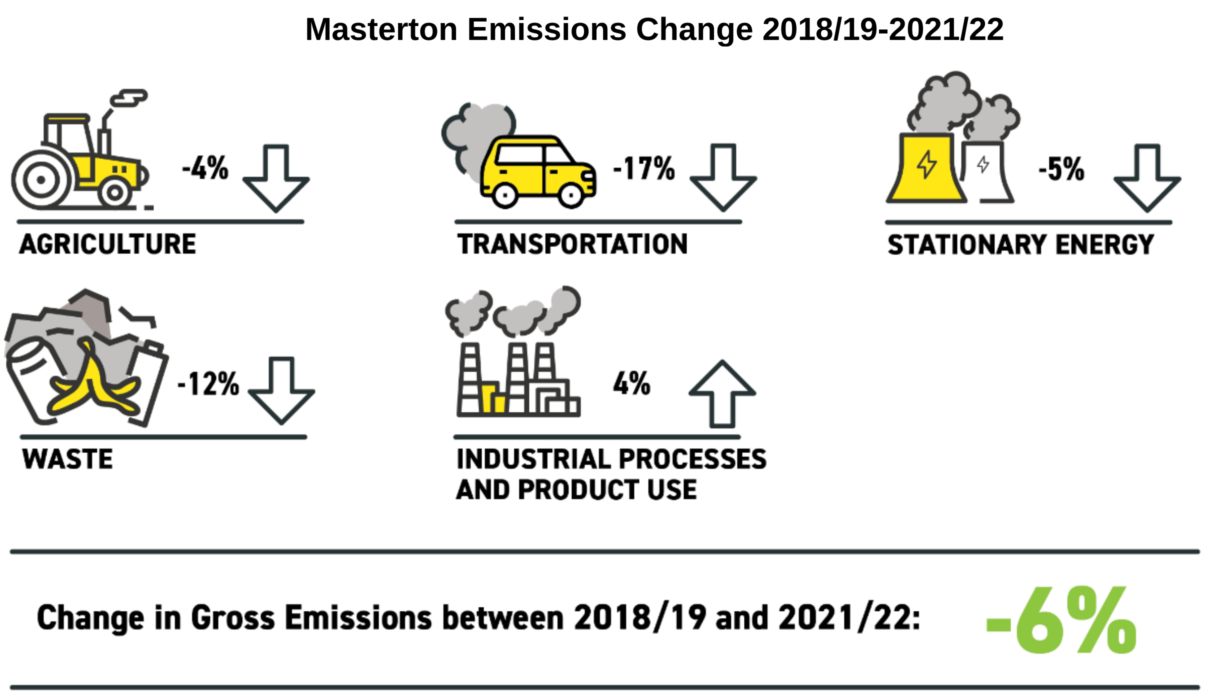

Figure 2: Change in Masterton Emissions Inventory between 2018/19 and 2021/22

1.0 Introduction

AECOM New Zealand Limited (AECOM) was commissioned by the Greater Wellington Regional Council to assist in the development of community-scale greenhouse gas (GHG) footprints for the Masterton District Territorial Area for the 2018/19 to 2021/22 financial years. As part of this work, AECOM recalculated emissions for the 2018/19 financial year, previously calculated by AECOM, using current best-practice methods, updated data, and additional emission sources to enable direct comparison to the other reported years.

This is part of a wider study to develop emissions inventories for each district within the Greater Wellington region. Emissions are reported for the financial year period from 1 July to 30 June for the respective years. The study boundary reported in the following pages incorporates the jurisdiction of the Masterton District Council.

The Masterton District Territorial Area is referred to hereafter as Masterton for ease. Greenhouse gas emissions are generally reported in this document in units of carbon dioxide equivalents (CO_2e) and are referred to as 'emissions'.

2.0 Approach and Limitations

The methodological approach used to calculate emissions follows the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory v1.1 (GPC) published by the World Resources Institute (WRI) 2021. The GPC includes emissions from Stationary Energy, Transport, Waste, Industrial Processes and Product Use (IPPU), Agriculture, and Forestry activities within the district's boundary. The sector calculations for Agriculture, Forestry and Waste are based on Intergovernmental Panel on Climate Change (IPCC) workbooks and guidance for emissions measurement. The sector calculators also use methods consistent with GHG Protocol standards published by the WRI for emissions measurement when needed.

The same methodology has been used for other community-scale GHG footprints around New Zealand, (e.g. the Bay of Plenty region, Hawke's Bay region, Auckland, Christchurch, Dunedin, and the Waikato region) and internationally. The GPC methodology[1] represents international best practice for city and regional level GHG emissions reporting and offers a robust, established method, which enables comparisons between different studies.

This emissions inventory assesses both direct and indirect emissions sources. Direct emissions are production-based and occur within the geographic area (Scope 1 in the GPC reporting framework). Indirect emissions are produced outside the geographic boundary (Scope 2 and 3) but are allocated to the location of consumption. An example of indirect emissions is those associated with the consumption of electricity, which is supplied by the national grid (these are classed as Scope 2). All other indirect emissions such as cross-boundary travel (e.g. flights) and energy transportation and distribution losses fit into Scope 3.

All major assumptions made during data collection and analysis have been detailed within **Appendix A – Assumptions**. The following aspects are worth noting in reviewing the emissions inventory:

- Emissions are calculated by collecting or estimating data for each emissions source and then converting that data into emissions (tCO_2e) using an emission factor. Emission factors enable an estimate of emissions from a unit of activity data (e.g. litres of fuel used)[2]. This inventory uses applicable emission factors predominantly from the New Zealand Ministry of the Environment (MfE).
- Emissions are expressed on a carbon dioxide-equivalent basis (CO_2e) including climate change feedback using the 100-year Global Warming Potential (GWP) values[3]. Climate change feedbacks are the climate change impacts from GHGs that are increased as the climate changes. For example, once the Earth begins to warm, it triggers other processes on the surface and in the

[1] http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities
[2] https://environment.govt.nz/publications/measuring-emissions-a-guide-for-organisations-2022-quick-guide/
[3] https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf (Table 8.7)

atmosphere. Current climate change feedback guidance is important to estimate the long-term impacts of GHGs.

- GPC reporting is predominately production-based (as opposed to consumption-based) and focused on emissions released within the geographic boundary but includes indirect emissions from energy consumption and cross boundary travel from sources such as air travel. Production-based approaches exclude globally produced emissions relating to consumption (e.g., embodied emissions relating to products produced elsewhere but consumed within the geographic area, such as imported food products, cars, phones, clothes etc.).
- Total emissions are reported as both gross emissions (excluding Forestry) and net emissions (including Forestry).
- Emissions for individual main greenhouse gases for each emissions source are provided in the supplementary spreadsheet information supplied with this report.
- Where location specific data were not accessible, information was calculated based on national or regional level data.
- Transport emissions:
    - Transport emissions associated with air travel, rail, and marine fuel were calculated by working out the emissions relating to each journey arriving or departing the area based on data provided by the relevant operators. Emissions for these sources are then split equally between the destination and origin. Emissions relating to a particular point source (e.g. an airport or port) are allocated to the expected users of that source, not just the area that it is located in. For example, in the Greater Wellington region, the Wellington Airport is treated as a regional airport where it is expected that all territorial authorities will use Wellington Airport for air travel. Therefore, emissions from this source have been allocated to all regional territorial authorities based on population. This is also applicable to marine freight and inter-island marine journeys.
    - All other transport emissions are calculated using the fuel sold in the area (e.g. petrol, diesel, LPG). Fuel sold in an area does not always mean that the fuel is used in that area, however this approach is considered to be a robust and comparable estimate of fuel consumption in a geographic area.
- Solid waste emissions:
    - Solid waste emissions from landfill are measured using the IPCC First Order Decay method that covers landfill activity between 1950 and the present day, as per the GPC reporting requirements. This method accounts for the gradual release of emissions from waste over a long period of time, and so calculates the emissions produced per year from waste in landfill (including emissions from closed landfill sites).
    - Emissions are calculated for waste produced within the geographic boundary, even if they are transported outside the boundary to be entered into landfill. Landfill waste for Masterton is understood to have been disposed at Bonny Glenn Landfill since 2015.
- Wastewater emissions:
    - Wastewater treatment plant emissions have been calculated following WaterNZ (2021) guidance. Wastewater emissions include those released directly from wastewater treatment, flaring of captured gas, and discharge onto land/water. Emissions relating to biosolid waste from wastewater treatment sent to landfill have been included in the solid waste emissions source category.
    - Wastewater emissions from populations not connected to centralised wastewater treatment plants have been estimated by assuming that these populations use septic tank systems.
- Industrial Processes and Product Use (IPPU) emissions:
    - IPPU emissions are estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2020 report (MfE 2022). Emissions are estimated on a per capita basis applying a national average per person.

- Forestry emissions:
  - This emissions inventory accounts for forest carbon stock changes from afforestation, reforestation, deforestation, and forest management (i.e. it applies land-use accounting conventions under the United Nations Framework Convention on Climate Change rather than the Kyoto Protocol). It treats emissions from harvesting and deforestation as instantaneous rather than accounting for the longer-term emission flows associated with harvested wood products.
  - The emissions inventory considers regenerating (growing) forest areas only. Capture of carbon from the atmosphere is negligible for mature forests that have reached a steady state.

Overall sector data and results for the emissions inventory have been provided to Masterton District Council in calculation table spreadsheets. All assumptions made during data collection and analysis have been detailed within **Appendix A – Assumptions**.

Uncertainty

It is important to consider the level of uncertainty associated with the results, particularly given the different datasets used. Depending on data availability, national, regional, and local datasets are used across the different calculators. At the national level, New Zealand's Greenhouse Gas Inventory shows that for 2020 (the most recent nationwide inventory) an estimate of gross emissions uncertainty was ±8.8%, whereas a net emissions uncertainty estimate was ±26.9% and uncertainty in the gross trend was ±6.4%. These levels of uncertainty should be considered when interpreting the results of this emissions inventory (MfE, 2022[4]).

StatsNZ Regional Inventory

Emissions reported using the GPC method (as reported here) differ from the regional emissions estimates produced by StatsNZ. The differences are due to differences in scope, coverage, data sources, emission factors, and methods[5].

Main differences:

- The StatsNZ approach is entirely based on production, while the GPC approach includes elements of consumption (e.g. where emissions from electricity are allocated to where the electricity is consumed, not where it is generated).
- The StatsNZ method uses a residence approach, while GPC is based on the territory approach.
- This report uses global warming potentials from the IPCC Fifth Assessment Report with climate change feedbacks, while the StatsNZ estimates use those from the Fourth Assessment Report, without climate change feedbacks.
- The StatsNZ estimates also don't include the scope 3 emissions reported here, such as cross boundary air travel and marine freight, or sequestration from forestry.

[4] https://environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf
[5] https://www.stats.govt.nz/methods/about-regional-greenhouse-gas-emissions-statistics/

3.0 Emissions Inventory for 2021/22

The paragraphs, figures and tables below outline Masterton's greenhouse gas emissions, referred to as 'emissions' in this assessment. This includes Masterton's total emissions, emissions from each sector, and major emissions sources within each sector. The focus of emissions reporting is on gross emissions.

During the 2021/22 reporting period, Masterton emitted **Total Gross Emissions** of 785,873 tCO_2e. Transport emissions are by far the city's most significant contributors to total gross emissions. Note that gross emissions do not account for Forestry sequestration and harvesting emissions. A breakdown of net emissions (i.e. including results from Forestry resources) is reported separately in section 3.7.

The population of Masterton in 2021/22 was approximately 28,700 people, resulting in per capita gross emissions of 27.4 tCO_2e/person. Discussion of per capita emissions is limited to when it is useful for comparing emission figures against other territorial authorities.

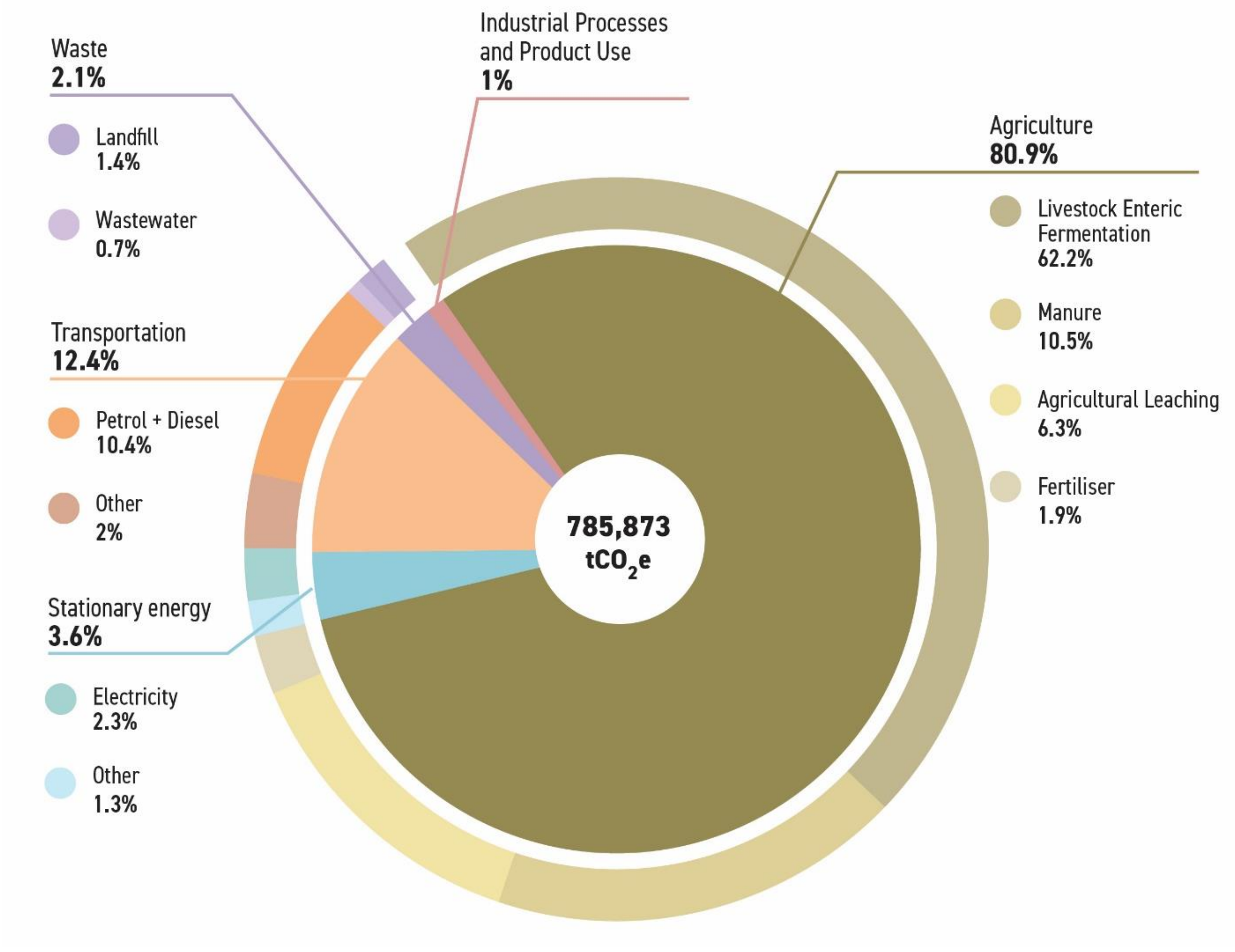

Figure 3: Masterton's total gross GHG emissions split by sector (tCO_2e).

The emissions inventory comprises emissions from six different sectors, summarised below. Due to rounding, there may be discrepancies between the sum of reported figures and reported totals.

The change in emissions from each emission source between 2018/19 and 2021/22 is presented in section 4.0. This includes analysis of notable changes in emissions.

3.1 Agriculture

The highest emitting sector in Masterton, Agriculture emitted 635,774 tCO_2e in 2021/22 (81% of Masterton's gross emissions).

Agricultural emissions are the result of both livestock and crop farming within the geographic area. Enteric fermentation from livestock produced 77% of Masterton's agricultural emissions (488,422 tCO_2e). Enteric fermentation GHG emissions are produced by methane (CH_4) released from the digestive process of ruminant animals (e.g., cattle and sheep). The second highest source of Agricultural emissions was produced by unmanaged manure from grazing animals on pasture (73,102 tCO_2e).

Table 1 Agriculture emissions by emission source

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Enteric Fermentation	488,422	62.2%	76.8%
Unmanaged Manure on Pasture	73,102	9.3%	11.5%
Agricultural Leaching and Deposition (manure, urine, and fertiliser)	49,543	6.3%	7.8%
Fertilisers on Land	14,665	1.9%	2.3%
Managed Manure	10,042	1.3%	1.6%
Total	**635,774**	**80.9%**	**100%**

Livestock was responsible for the majority of the Agriculture sector's GHG emissions. Sheep account for 61% of agricultural emissions in Masterton, with non-dairy cattle accounting for 26%. In 2021/22, there were an estimated 702,239 sheep in Masterton and 64,639 non-dairy cattle.

Table 2 Agriculture emissions by emission source

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Sheep	384,921	49.0%	60.5%
Non-Dairy Cattle	165,784	21.1%	26.1%
Dairy Cattle	63,852	8.1%	10.0%
Fertiliser	19,317	2.5%	3.0%
Other Livestock	1,900	0.2%	0.3%
Total	**635,774**	**80.9%**	**100%**

3.2 Transport

Transport is the second highest emitting sector in Masterton, producing 97,102 tCO_2e in 2021/22 (12.4% of Masterton's gross total emissions). Air travel and marine travel emissions relating to the Wellington Airport and CentrePort have been split between all territorial authority areas in the region (see below).

Table 3 Transport energy emissions by emission source

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Diesel	47,902	6.1%	49.3%
Petrol	33,463	4.3%	34.5%
Marine Freight	6,991	0.9%	7.2%
Jet Kerosene (Air Travel)	5,793	0.7%	6.0%
Marine (Inter-Island Ferries)	2,601	0.3%	2.7%
LPG	243	<0.1%	0.3%
Rail (Diesel)	79	<0.1%	0.1%
Aviation Gas (Air Travel)	31	<0.1%	<0.1%
Total	**97,102**	**12.4%**	**100%**

Most of the Transport emissions in 2021/22 can be attributed to diesel and petrol, which produced 47,902 tCO_2e and 33,463 tCO_2e respectively (collectively 84% of the sector's emissions and 10% of total gross emissions). Diesel and petrol transport emissions are broken down into on-road and off-road use. On-road transport consists of all standard road vehicles used on public roads (cars, trucks, buses, etc.). Off-road transport consists of all fuel used for vehicle movement off roads (agricultural tractors and vehicles, forklifts, etc.). On-road transport produced 71,892 tCO_2e in 2021/22 (74% of Transport emissions and 9% of total gross emissions) and off-road transport produced 9,716 tCO_2e (10% of Transport emissions).

Table 4 Petrol and diesel emissions – on-road and off-road

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Diesel - On-Road	38,736	4.9%	39.9%
Petrol - On-Road	33,156	4.2%	34.1%
Diesel - Off-Road	9,166	1.2%	9.4%
Petrol - Off-Road	307	0.0%	0.3%
Petrol and Diesel Total	**81,365**	**10.4%**	**83.8%**

The next largest emission source for Masterton in 2021/22 is marine freight, contributing 7% of the sectors emissions and 1% of total gross emissions (6,991 tCO_2e). Emissions from marine freight have been divided between all territorial authorities in the Greater Wellington region based on relative population sizes. It is understood that imports and exports through this port are not exclusively related on activities in the Greater Wellington region, however, to ensure that these emissions are reflected in community carbon footprints as per the GPC requirements, this approach is appropriate. A similar consideration has been applied to aircraft emissions relating to Wellington Airport and inter-island ferry journeys. All assumptions have been detailed in the appendix.

The remaining transport emissions are attributed to air travel (jet kerosene), inter-island ferries, LPG use for transport (e.g., forklifts), rail and aviation gas (used by small aircraft). Jet kerosene emissions are based on the fuel consumed by aircraft journeys to and from Wellington, with emissions split equally between the origin and destination location. It is important to note that jet kerosene emissions for Masterton in 2021/22 were 57% lower than in 2018/19, largely due to the restriction on international travel through Wellington Airport due to the COVID-19 pandemic (see section 7.0), it is likely that this will increase in 2022/23.

3.3 Stationary Energy

Stationary Energy produced 28,289 tCO_2e in 2021/22 in Masterton (3.6% of total gross emissions).

Table 5 Stationary Energy emissions by emission source

Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Electricity Consumption	16,119	2.1%	57.0%
Stationary Petrol & Diesel Use	5,333	0.7%	18.9%
Biofuel / Wood	2,944	0.4%	10.4%
LPG	1,927	0.2%	6.8%
Electricity Transmission & Distribution Losses	1,710	0.2%	6.0%
Coal	256	<0.1%	0.9%
Total:	**28,289**	**3.6%**	**100%**

Electricity consumption was the cause of 57% of Stationary Energy emissions in 2021/22 (16,119 tCO_2e) and 2% of Masterton's total gross emissions (17,829 tCO_2e when including transmission and distribution losses related to the consumption).

Stationary petrol and diesel use accounted for 19% of Stationary Energy emissions in 2021/22 (5,333 tCO_2e). The burning of biofuels/wood and use of LPG generated 10% and 7% respectively of Stationary Energy emissions in 2021/22. The burning of coal produced the remaining Stationary Energy emissions.

Biogenic CO_2 emissions from biofuels have not been included in these totals and are reported separately in section 3.10.

3.4 Waste

Waste originating in Masterton (solid waste and wastewater) produced 16,762 tCO_2e in 2021/22.

Table 6 Waste emissions by emission source

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Closed Landfill Sites	9,945	1.3%	59.3%
Wastewater Treatment Plants	2,805	0.4%	16.7%
Individual Septic Tanks	2,752	0.4%	16.4%
Open Landfill Sites	1,260	0.2%	7.5%
Total:	**16,762**	**2.1%**	**100%**

Landfill waste produced the bulk of waste emissions (11,205 tCO_2e in 2021/22), making up 67% of total waste emissions. Solid waste emissions include emissions from open (operating) landfill sites and closed landfill sites. Open landfill sites produced 1,260 tCO_2e in 2021/22, and closed landfill sites produced 9,945 tCO_2e in 2021/22. Both open and closed landfills emit landfill (methane) gas from the breakdown of organic materials disposed of in the landfill for many years after waste enters the landfill.

Landfill emissions are those that are the result of waste produced in Masterton and emitted in the reporting year, calculated based on all the waste sent to landfill over time. Open landfill emissions are low due to highly efficient landfill gas capture and the recent transition to this site. Closed landfill emissions are high due to the lack of landfill gas capture systems at closed landfill sites.

Wastewater treatment (treatment plants and individual septic tanks) accounted for 33% of total waste emissions in 2021/22 (5,557 tCO_2e). The majority of households in Masterton (54%) are connected to wastewater treatment plants, producing total emissions of 2,805 tCO_2e in wastewater emissions. Households not connected to centralised wastewater treatment plants (i.e., using individual septic tanks) produced 2,752 tCO_2e in wastewater emissions. Septic tanks have a higher emissions intensity per quantity of wastewater compared to the wastewater treatment plants in Masterton.

3.5 Industrial Processes and Product Use (IPPU)

IPPU in Masterton produced 7,947 tCO_2e in 2021/22, contributing 1% to Masterton's total gross emissions. This sector includes emissions associated with the consumption of industrial products and synthetic gases containing GHGs for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride for electrical insulation and equipment production. No known industrial processes (as defined in the GPC requirements) are present in Masterton (e.g., aluminium manufacture).

IPPU emissions do not include energy use for industrial manufacturing, which is included in the relevant Stationary Energy sub-category (e.g., coal, electricity and/or petrol and diesel). These emissions are based on nationally reported IPPU emissions and apportioned based on population due to the difficulty of allocating emissions to particular geographic locations. Addressing IPPU emissions is typically a national policy issue.

The most significant contributor to IPPU emissions is refrigerants, which produced 93% of IPPU emissions (7,393 tCO_2e).

Table 7 Industrial processes and product use emissions by emission source

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Refrigerants and Air Conditioning	7,393	0.9%	93.0%
Aerosols	412	0.1%	5.2%
SF6 - Electrical Equipment	81	<0.1%	1.0%
Foam Blowing	32	<0.1%	0.4%
SF6 - Other	16	<0.1%	0.2%
Fire Extinguishers	13	<0.1%	0.2%
Total	**7,947**	**1.0%**	**100%**

3.6 Forestry

Net Forestry emissions include:

- Sequestration of carbon from the atmosphere from native forests (e.g. mānuka and kānuka) and exotic forest (e.g. pine) sequesters (captures) while the trees are growing to maturity and,
- emissions released due to harvesting of forests via the release of carbon from organic matter and soils following harvesting.

When forest sequestration exceeds emissions from harvesting in a particular year, the extra carbon sequestered by forest results in net-negative Forestry emissions. Conversely, when emissions from harvesting exceed the amount of carbon sequestered by native and exotic forests, then Forestry emissions will be a net-positive source of emissions.

Total sequestration in 2021/22 was 1,422,651 tCO_2e (mostly from exotic forests), while harvesting emissions were 611,139 tCO_2e. This meant that Forestry in Masterton was a net negative source of emissions in 2021/22 (rather than a positive source of emissions, where harvesting emissions exceed sequestration). Total Forestry emissions in 2021/22 were therefore -811,512 tCO_2e. It is noted that the harvesting of exotic forests can be cyclical in nature. Some years will have higher sequestration, and some years will have higher harvesting emissions determined by the age of forests, commercial operators, and the global market.

Table 8 Forestry emissions by emission source (including sequestration)

Sector / Emissions Source	tCO_2e
Harvest Emissions	611,139
Native Forest Sequestration	-155,932
Exotic Forest Sequestration	-1,266,719
Total	**-811,512**

3.7 Net Emissions

Net emissions differ from gross emissions because they include emissions related to forestry activity (harvesting emissions and sequestration). The cyclical nature of harvesting and planting regimes influences the observed forestry emissions, which in 2021/22 were a net-negative source of emissions. During the 2021/22 reporting period, total net emissions for Masterton were -25,639 tCO_2e. Due to large-scale commercial (exotic) forestry in Masterton it is likely that the total net emissions figure will change significantly year to year dependent on planting and harvesting activity.

Figure 4 shows total gross emissions and total net emissions in 2021/22, and the impact of forestry sequestration and harvesting.

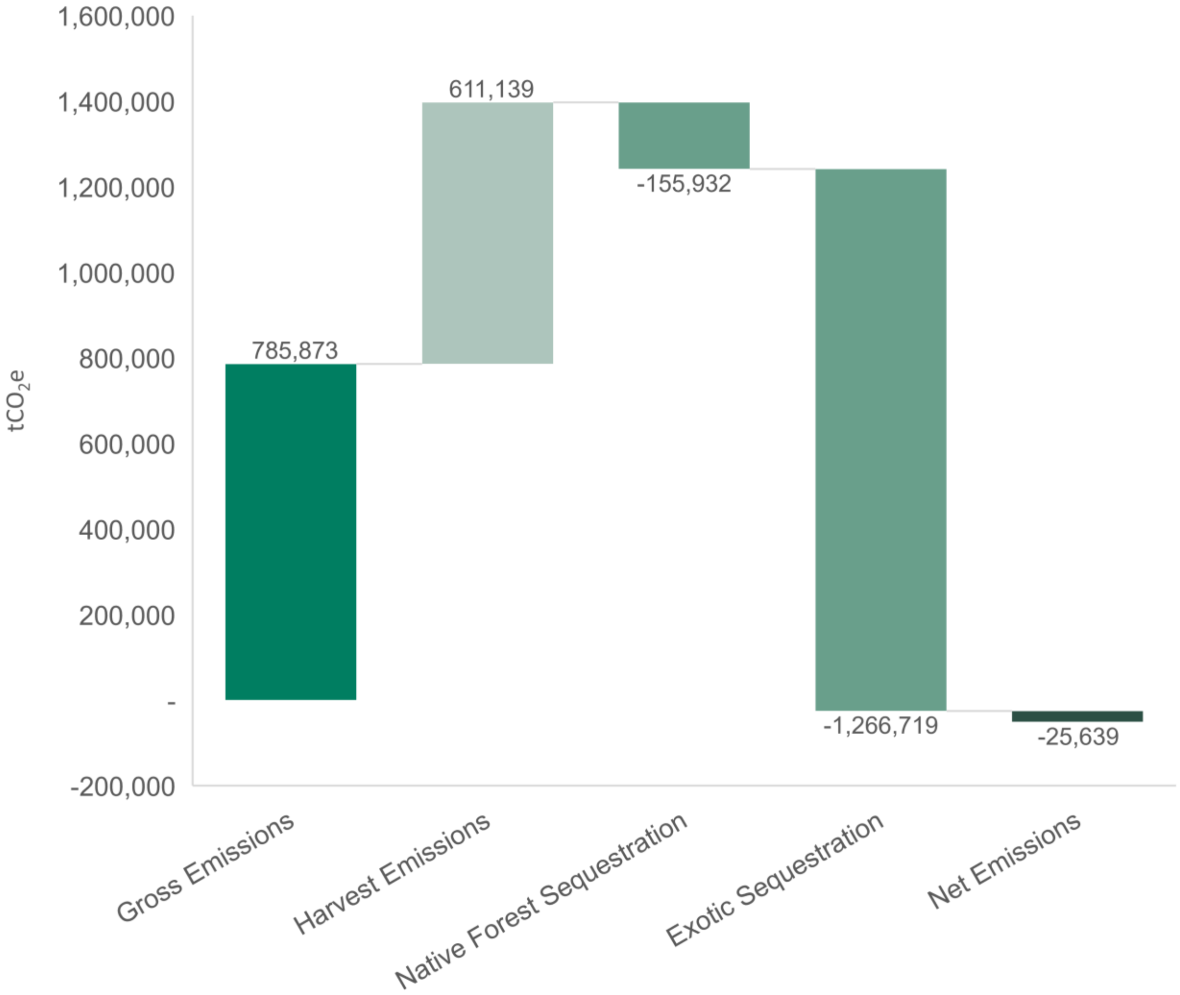

Figure 4 Total gross emissions and total net emissions in 2021/22, showing the impact of forestry sequestration and harvesting

3.8 Territorial Authorities in the Greater Wellington Region

The Greater Wellington regional area contains several territorial authorities including Wellington City Council, Porirua City Council, Kāpiti Coast District Council, Hutt City Council, Upper Hutt City Council, Masterton District Council, Carterton District Council, and South Wairarapa District Council.

Figure 5 shows the Greater Wellington Region total gross emissions divided by territorial authority. Figure 6 shows total gross emissions for the territorial authorities in the Greater Wellington Region, split by sector.

Wellington City is the highest emitting territorial authority in the region, representing 23% of Greater Wellington's total gross emissions. Wellington City's emissions inventory is predominantly transport-related emissions with the next largest emitting territorial authorities; Masterton and South Wairarapa containing significant agricultural emissions. Of the eight territorial authorities within the Greater Wellington region, Upper Hutt has the lowest total gross emissions, with emissions mostly from Transport and Stationary Energy.

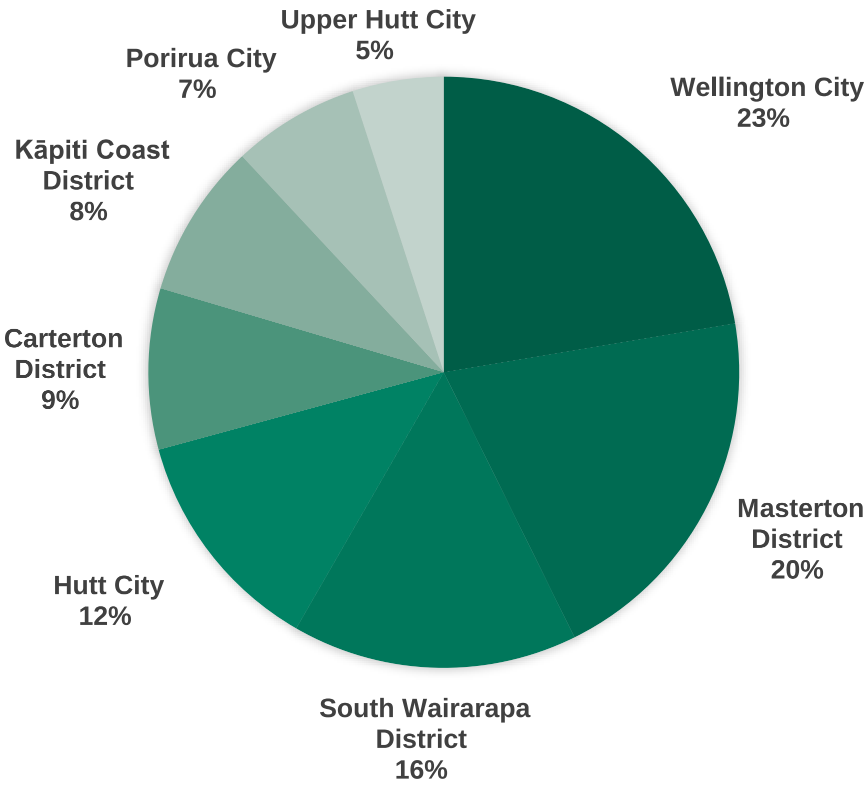

Figure 5 Greater Wellington's total gross emissions divided by territorial authority (tCO_2e).

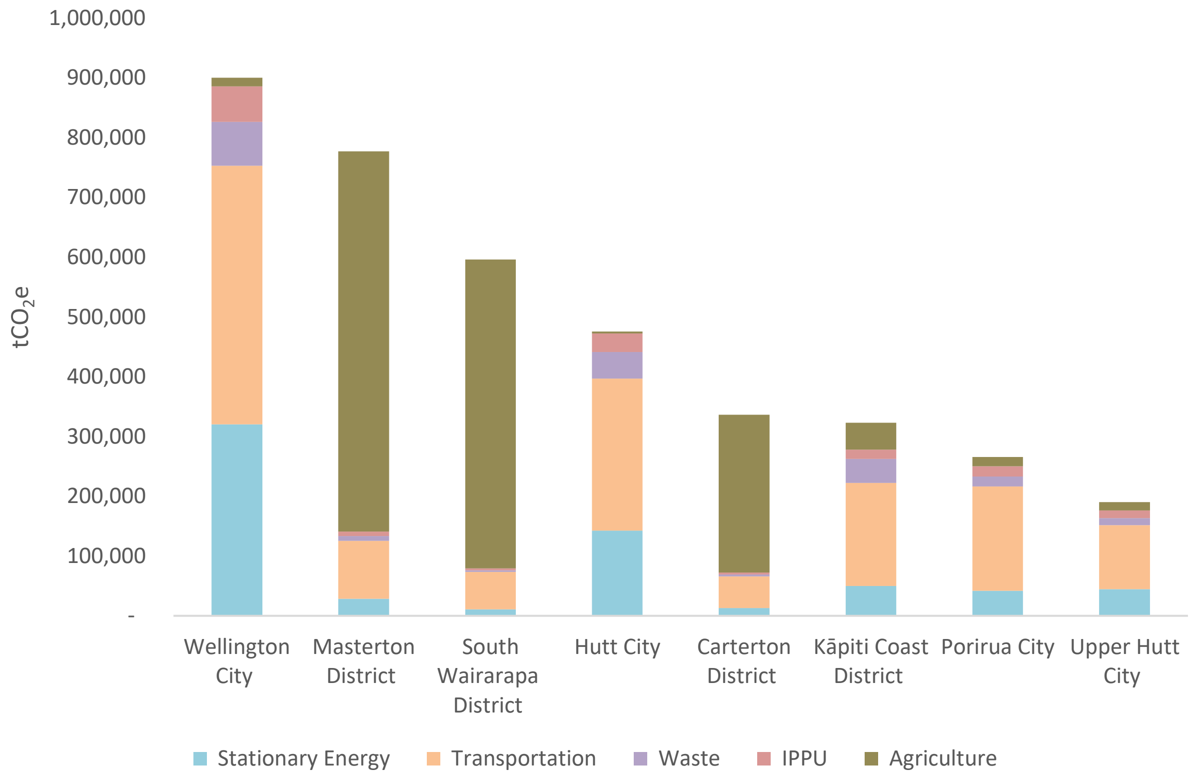

Figure 6 Total gross emissions by territorial authority in the Greater Wellington region (tCO_2e).

When comparing emissions inventories from different areas, a per capita figure can be useful because it provides a common reference point to understand the difference in emissions. Figure 7 shows emissions per capita for the territorial authorities within the Greater Wellington Region.

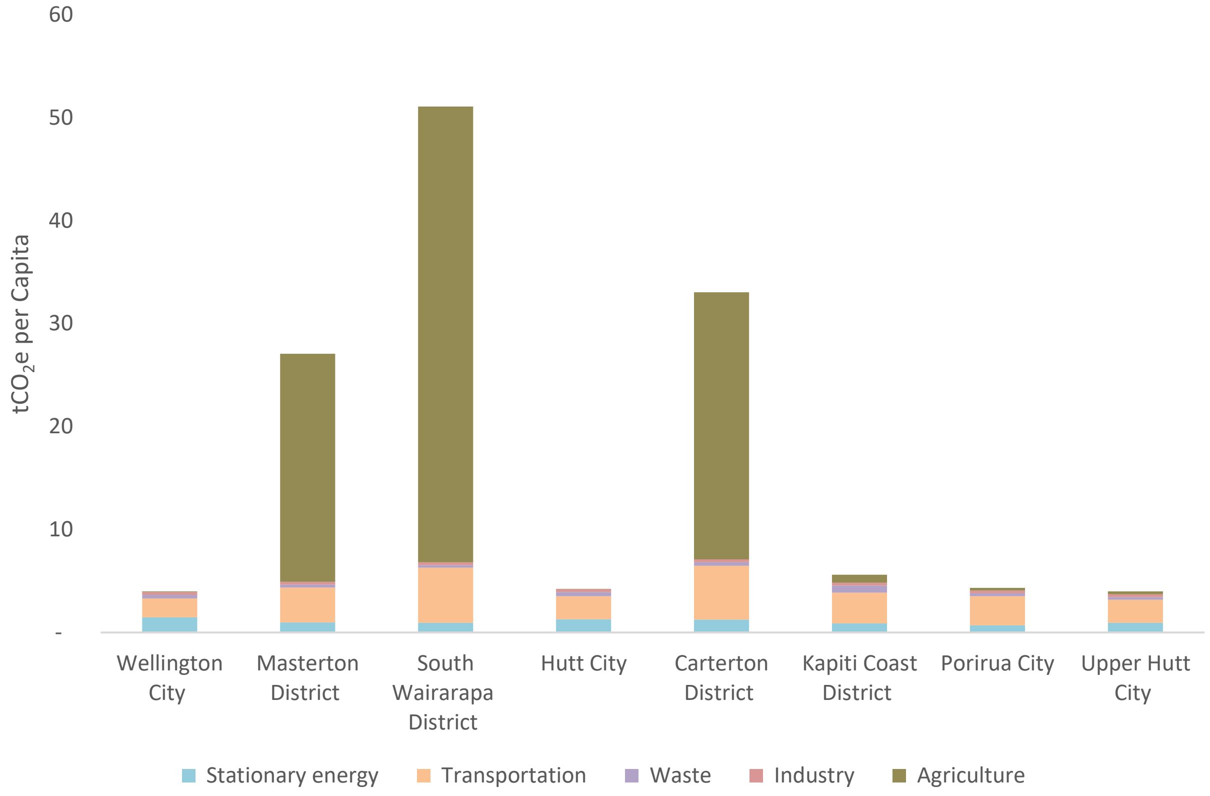

Figure 7 Total gross emissions per capita for the territorial authorities within the Greater Wellington Region (tCO_2e).

The Greater Wellington region has a 7.1 tCO_2e/per capita figure for total gross emissions which is lower than the national value of 15.7 tCO_2e/per capita. Upper Hutt has the lowest per capita total emissions at 4.0 tCO_2e/per capita. South Wairarapa and Carterton have the largest per capita total gross emissions at 51.4 tCO_2e/per capita and 33.3 tCO_2e/per capita respectively, both due to high Agriculture emissions in the district. Masterton has the third highest per capita emissions at 27.4 tCO_2e/per capita, again due to Agriculture emissions in the district. South Wairarapa, Carterton and Masterton also have the highest per capita transport emissions in the region (5.3 tCO_2e/per capita, 5.2 tCO_2e/per capita and 3.4 tCO_2e/per capita, respectively). Wellington City has the highest Stationary Energy emissions per capita in the region (1.5 tCO_2e/per capita).

3.9 Total Gross Emissions by Greenhouse Gas

Each greenhouse gas has a different level of impact on climate change, this is accounted for when converting quantities of each gas into units of carbon dioxide equivalent (CO_2e).

Table 9: Masterton total gross emissions, by greenhouse gas

Greenhouse Gas	Tonnes	Tonnes of CO_2e
Carbon Dioxide (CO_2)	123,896	123,896
Biogenic Methane (CH_4)	15,184	516,241
Non-biogenic Methane (CH_4)	52	1,770
Nitrous Oxide (N_2O)	458	136,406
Other / Unknown Gas (in CO_2e)	7,561	7,561
Total	**147,150**	**785,873**

By far the largest source of emissions in tonnes is carbon dioxide (CO_2) at 123,896 tonnes. Due to the greater global warming impact of methane per tonne, methane represents 10.3% of the total tonnage of GHG emissions from Masterton but represents 66% of CO_2e. Nitrous oxide represents 0.31% of the total tonnage of GHG emissions from Masterton but represents 17% of CO_2e.

3.10 Biogenic Emissions

Biogenic carbon dioxide and methane emissions are stated in Table 10 and Table 11, respectively.

Biogenic CO_2 emissions result from the combustion of biomass materials that store and sequester CO_2, including materials used to make biofuels (e.g., trees, crops, vegetable oils, or animal fats). Biogenic CO_2 emissions from plants and animals are excluded from gross and net emissions as they are considered to be part of the natural carbon cycle.

Table 10: Biogenic CO_2 in Masterton (Excluded from gross emissions)

Biogenic Carbon Dioxide (CO_2) (Excluded from gross emissions)		
Biofuel	29,009	t CO_2
Landfill Gas	1,463	t CO_2
Total Biogenic CO_2	**30,472**	**t CO_2**

Biogenic CH_4 emissions (e.g., produced by farmed cattle via enteric fermentation) are included in gross emissions due to their relatively large impact on global warming relative to biogenic CO_2. Biogenic methane represents 10.3% of the gross total tonnage of GHG emissions in Masterton but represents 66% of total gross GHG emissions when expressed in CO_2e. This is caused by the higher global warming impact of methane per tonne, compared to carbon dioxide. The total tonnage of each GHG and the contribution of each GHG to total gross emissions when expressed in CO_2e is shown in Table 9.

The importance of biogenic CH_4 is highlighted in NZ's Climate Change Response (Zero Carbon) Amendment Act. The Act includes specific targets to reduce biogenic CH_4 by between 24% and 47% below 2017 levels by 2050, and by 10% below 2017 levels by 2030. More information on the Act is available here: https://www.mfe.govt.nz/climate-change/zero-carbon-amendment-act.

Table 11: Biogenic Methane in Masterton (Included in gross emissions)

Biogenic Methane (CH_4) (Included in gross emissions)		
Enteric Fermentation (Livestock)	14,365	t CH_4
Landfill Gas	329	t CH_4
Manure Management (Livestock)	295	t CH_4
Wastewater Treatment	154	t CH_4
Biofuel	40	t CH_4
Total Biogenic CH_4	**15,184**	**t CH_4**

4.0 Annual Emissions Change from 2018/19 to 2021/22

Alongside calculating Masterton's emissions inventory for 2021/22, Masterton's emissions inventory for 2019/20 and 2020/21 has been calculated, and the previously published 2018/19 inventory has been recalculated. The 2018/19 inventory has been updated to account for updates in data and calculation best-practice and to align with the other reporting years. This section displays the results of the 2018/19, 2019/20, 2020/21, and 2021/22 emissions inventories with a focus on gross emissions and documents the change in emissions from 2018/19 to 2021/22.

This section is cautious in examining the interpretation of changes, due to the inventory only assessing one financial year (2018/19) prior to the COVID-19 pandemic disruptions. An analysis of the impact of the COVID-19 pandemic on Masterton's emissions is found in Section 7.0.

Table 12 Change in Masterton total gross and net emissions from 2018/19 to 2021/22

	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Total Net Emissions (including Forestry)	293,811	51,158	-6,994	-25,639	N/A[6]
Total Gross Emissions (excluding Forestry)	839,263	846,292	804,518	785,873	-6%

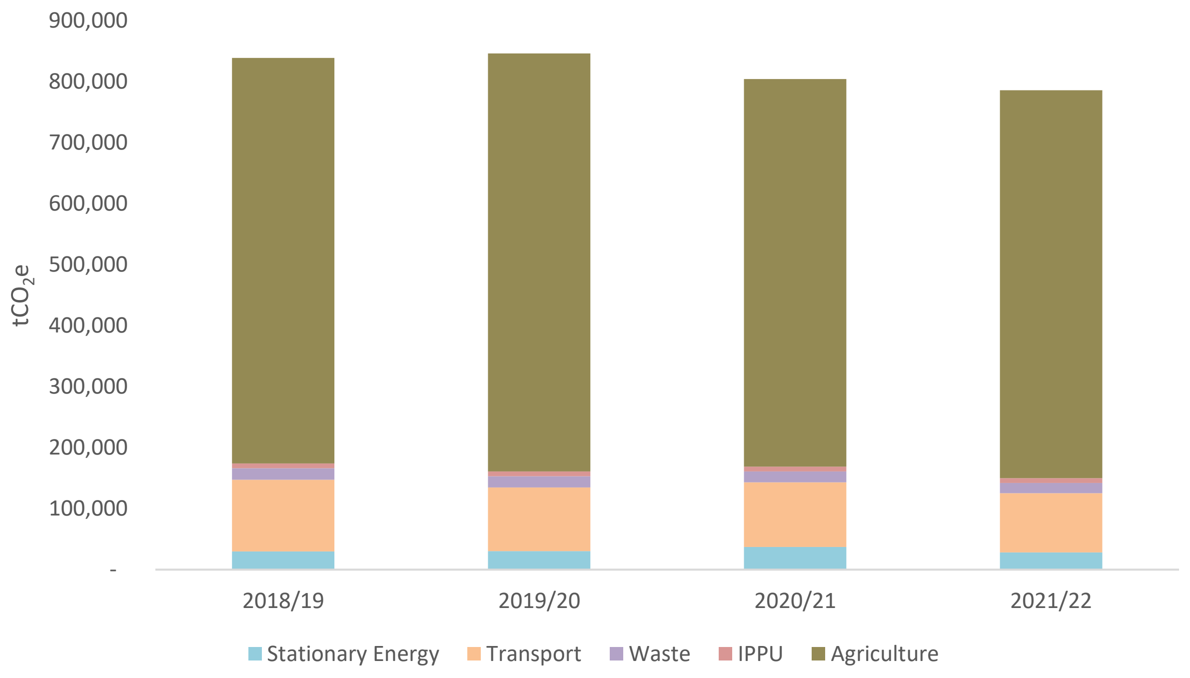

Figure 8 Change in Masterton total gross emissions from 2018/19 to 2021/22

Annual total gross emissions decreased by 6% from 839,263 tCO_2e in 2018/19 to 785,873 tCO_2e in 2021/22. Annual total net emissions in Masterton decreased from 299,811 in 2018/19 to -25,639 tCO_2e. The decrease in gross emissions was driven by a reduction in Agriculture emissions, related to a decrease in total sheep, and by a decrease in Transport emissions primarily related to air travel and on-

[6] A percentage change figure has been omitted as it can be misleading in this situation where total net emissions have gone from a positive to a negative figure due to changes in net forestry sequestration

road fuel use. The impact of COVID-19 pandemic restrictions can be especially seen in air travel emissions where emissions were 57% lower in 2021/22 compared to 2018/19. The reduction in net emissions was mainly due to a 7% increase in forest sequestration and a 23% decrease in harvest related emissions.

The population of Masterton increased by 7.7% between 2018/19 and 2021/22 (2,050 people). Owing to the decrease in total gross emissions, per capita emissions between 2018/19 and 2021/22 decreased from 31.5 to 27.4 tCO_2e per person per year. A discussion of the decoupling of gross emissions from population growth and GDP is found in Section 5.0.

The sections below outline the change in emissions between 2018/19 and 2021/22 for each sector and emissions source, highlighting the changes that have had the largest impact on total gross emissions. Due to rounding, there may be discrepancies between the sum of reported figures and reported totals.

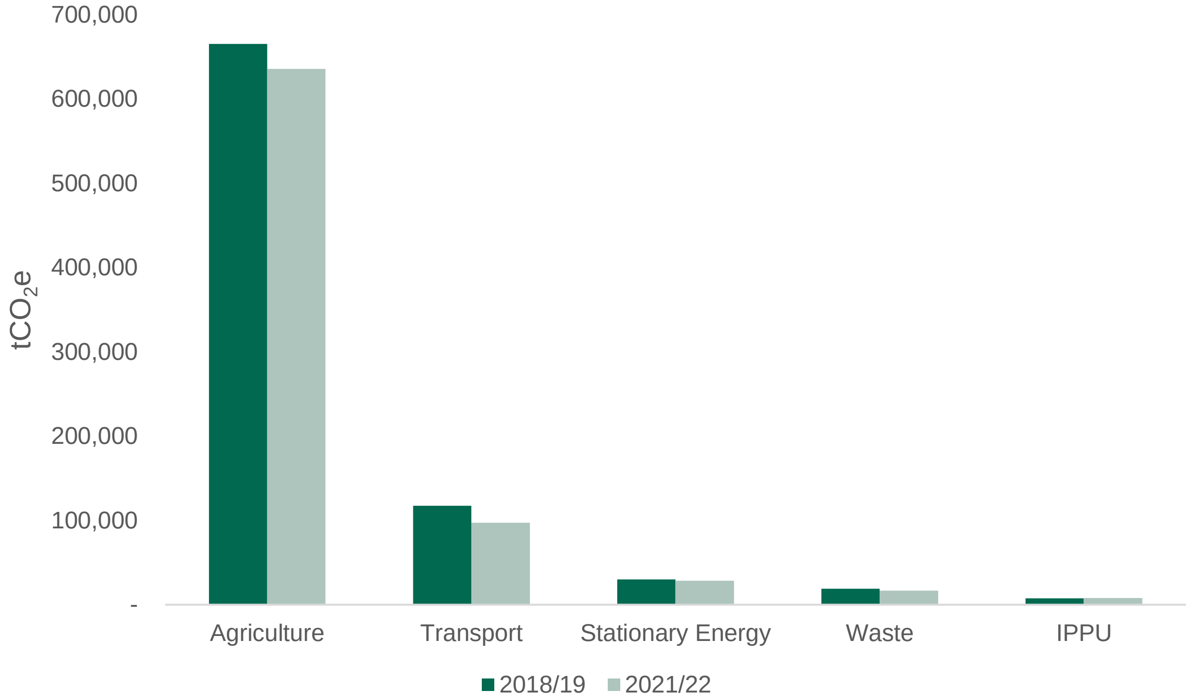

Figure 9 Emissions for each sector of Masterton gross emissions inventory for 2018/19 and 2021/22

4.1 Agriculture

Table 13 Change in Masterton's Agriculture emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Livestock Enteric Fermentation	511,260	526,760	488,422	488,422	-4%
Unmanaged Manure on Pasture	77,151	79,194	73,102	73,102	-5%
Agricultural Leaching and Deposition (Manure, Urine, and Fertiliser)	52,051	53,430	49,543	49,543	-5%
Fertilisers on Land	14,894	15,159	14,665	14,665	-2%
Managed Manure	9,868	10,817	10,042	10,042	2%
Total	**665,225**	**685,360**	**635,774**	**635,774**	**-4%**

The Agriculture sector's emissions decreased by 4% between 2018/19 and 2021/22 (29,451 tCO_2e). This decrease is driven by a reduction in total livestock numbers, especially sheep.

Sheep represent 90% of total livestock in Masterton in 2021/22 and 61% of agricultural emissions. Emissions related to sheep decreased by 10% (42,889 tCO_2e) due to an 10% reduction in the number of sheep (from 780,485 sheep to 702,239 sheep).

Non-dairy cattle represent 8% of total livestock in Masterton in 2021/22 and 26% of agricultural emissions, this is due to their greater emissions footprint compared to sheep. Emissions related to non-dairy cattle increased by 4% (6,493 tCO_2e) due to a 2% increase in the number of non-dairy cattle (from 63,091 cattle to 64,639 cattle).

4.2 Transport

Table 14 Change in Masterton Transport emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Diesel	49,514	47,228	50,526	47,902	-3%
Petrol	40,238	35,222	38,347	33,463	-17%
Jet Kerosene (Air Travel)	13,478	10,036	3,779	5,793	-57%
Marine Freight	10,699	8,151	9,557	6,991	-35%
Marine (Inter-Island Ferries)	3,284	3,354	3,482	2,601	-21%
LPG	224	228	240	243	8%
Rail (Diesel)	7	132	79	79	1004%
Aviation Gas (Air Travel)	29	29	30	31	5%
Total	**117,474**	**104,381**	**106,039**	**97,102**	**-17%**

Transport emissions decreased by 17% between 2018/19 and 2021/22 (20,372 tCO_2e). This was driven by an 8,016 tCO_2e reduction in on-road fuel use emissions and a 7,685 tCO_2e decrease in Jet Kerosene (aircraft fuel) emissions.

Jet Kerosene emissions decreased by 57% due to a reduction in flights, especially of international flights, with international passenger numbers down 91% and domestic passenger numbers down 39% between 2019/20 and 2021/22[7]. This is likely the impact of COVID-19-related restrictions on travel and the slow pace of recovery of the aviation industry. It is expected that emissions from this source will increase in 2022/23.

On-road fuel use emissions (petrol and diesel) decreased by 10%, with an 17% decrease in on-road petrol emissions (6,393 tCO_2e). This is partly due to the impacts of COVID-19 with restrictions on travel in both 2019/20 and 2021/22 in Greater Wellington. Improvements in the efficiency of private and commercial vehicles may have also contributed to this decrease.

Emissions related to the inter-island ferries decreased by 21% between 2018/19 and 2021/22 (684 tCO_2e), this is due to a change in fuel use for some journeys by one of the operators of this service, from heavy fuel oil to diesel, which has a lower emissions impact.

Marine freight emissions decreased by 35% between 2018/19 and 2021/22 (3708 tCO_2e). It is, however, important to note that maritime freight emissions for Wellington tend to fluctuate year-to-year based on distance travelled by vessels, size of vessels, and the number of visits in a particular year (for example, emissions from marine freight in 2021/22 are 14% lower than in 2019/20).

[7] https://www.wellingtonairport.co.nz/business/investor-services/traffic-reports/

4.3 Stationary Energy

Table 15 Change in Masterton's Stationary Energy emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Electricity Consumption	17,687	18,070	24,240	16,119	-9%
Stationary Petrol & Diesel Use	5,553	5,274	5,647	5,333	-4%
Biofuel / Wood	2,929	2,931	2,936	2,944	1%
LPG	1,776	1,803	1,904	1,927	8%
Electricity Transmission & Distribution Losses	1,545	1,580	2,254	1,710	11%
Coal	425	534	263	256	-40%
Total:	**29,915**	**30,192**	**37,244**	**28,289**	**-5%**

Emissions from Stationary Energy decreased by 5% between 2018/19 and 2021/22 (1,626 tCO_2e). This was driven by a decrease in electricity consumption related emissions. Electricity consumption in Masterton (in kWh) increased by 5% between 2018/19 and 2021/22. However, emissions from this source decreased by 9% due to a decrease in the emissions intensity of the national electricity grid (tCO_2e/kWh). The emissions intensity of the national grid decreased due to a reduction in coal and gas generation as renewable generation sources made up a greater proportion of national generation (especially hydropower). It is important to note that the emissions intensity of New Zealand's national grid fluctuates year on year, primarily driven by water levels in the hydropower system (as can be seen in the increase in emissions from 2019/20 to 2020/21 and subsequent decrease again in 2021/22).

Other notable changes can be seen in stationary petrol and diesel use which decreased by 4% (220 tCO_2e) between 2018/19 and 2021/22, and coal use, which reduced by 40% (168 tCO_2e). The decrease in coal use represents transitions away from coal use for energy to lower emission options.

4.4 Waste

Table 16 Change in Masterton Waste emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Closed Landfill	12,075	11,302	10,594	9,945	-18%
Wastewater Treatment Plants	2,605	2,668	2,742	2,805	8%
Individual Septic Tanks	2,555	2,618	2,690	2,752	8%
Open Landfill	1,771	2,080	1,644	1,260	-29%
Total	**19,007**	**18,668**	**17,669**	**16,762**	**-12%**

Total Waste emissions reduced by 12% between 2018/19 and 2021/22 (2,245 tCO_2e); this was driven by improvements in the landfill gas capture system at Bonny Glen Landfill, which has resulted in an emissions impact decrease of 29% for open landfill emissions. Closed landfill sites made up 59.3% of

Masterton's Waste emissions in 2021/22. Closed landfill sites continue to emit landfill gas long after they have closed, but, as no additional waste enters these sites, annual emissions from this source will fall over time. Annual emissions from closed landfill sites reduced by 18% (2,130 tCO_2e) between 2018/19 and 2021/22.

Waste originating in Masterton currently is deposited at Bonny Glen Landfill where landfill gas capture effectively captures the majority of the landfill gas produced in the landfill. As the closed landfill sites that Masterton has historically sent its landfill to do not have landfill gas capture systems, closed landfill sites will likely remain the largest source of Waste emissions in the area unless there are changes at those landfill sites.

Emissions from Individual Septic Tanks and Wastewater Treatment Plants increased by 8% between 2018/19 and 2021/22, in line with population growth. Better data for wastewater treatment plant emissions would improve the accuracy of results this source.

4.5 Industrial Processes and Product Use (IPPU)

Table 17 Change in Masterton IPPU emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Refrigerants and Air Conditioning	7,069	7,138	7,249	7,393	5%
Aerosols	445	417	404	412	-7%
SF6 - Electrical Equipment	70	76	79	81	15%
Foam Blowing	31	32	32	32	4%
SF6 - Other	15.2	15.3	15.5	15.8	4%
Fire Extinguishers	12	12	12	13	3%
Total	**7,642**	**7,690**	**7,791**	**7,947**	**4%**

IPPU emissions remained relatively unchanged between 2018/19 and 2021/22. The only notable change is a decrease in aerosols which may be due to a decrease in the quantity used or an increase in the use of lower emissions-impacting aerosols. Note that national-level data is used for this sector and is portioned out using a population approach; actual emissions for the district are unknown.

4.6 Forestry

Table 18 Change in Masterton Forestry emissions from 2018/19 to 2021/22

Sector / Emissions Source	2018/19 (tCO_2e)	2019/20 (tCO_2e)	2020/21 (tCO_2e)	2021/22 (tCO_2e)	% Change (2018/19 to 2021/22)
Total Harvest Emissions	797,073	625,093	611,139	611,139	-23%
Native Forest Sequestration	-155,932	-155,932	-155,932	-155,932	0%
Exotic Forest Sequestration	-1,186,592	-1,264,295	-1,266,719	-1,266,719	7%
Total	**-545,451**	**-795,134**	**-811,512**	**-811,512**	**49%**

Net Forestry sequestration (emissions released minus sequestration) increased by 266,061 tCO_2e between 2018/19 and 2021/22, from -545,451 tCO_2e to -811,512 tCO_2e. This is due to sequestration for exotic forestry emissions increasing by 7% (80,127 tCO_2e) and harvest emissions decreasing by 23% (185,933 tCO_2e).

Forestry harvesting emissions decreased due to a decrease in Masterton's proportion of Greater Wellington's land area covered by exotic trees of harvestable age (used to estimate Masterton's proportion of the Greater Wellington region's commercial harvesting) and a region-wide decrease in harvesting. Forestry emissions are influenced by the cyclical nature of harvesting and planting regimes, where some years will have higher sequestration and some years will have higher harvesting emission. This depends on the age of forests and the demand for lumber and timber. Improved and updated data sources may impact the estimation of emissions from this source in the future.

Sequestration by native forests remained unchanged during this time as the same data has been used for each year; however, it is unlikely that there have been significant changes.

5.0 Decoupling of GHG emissions from population growth and GDP

Decoupling of emissions is when emissions grow less rapidly than the growth of an economy (measured in Gross Domestic Product (GDP)). The term decoupling expresses the desire to mitigate emissions without harming economic well-being. The exact drivers for the decoupling of emissions from GDP are generally difficult to pinpoint. New policies, for restructuring the way to meet demand for energy, food, transportation, and housing will all contribute. Both direct local actions (e.g. landfill gas reductions) and indirect national trends (e.g. changes to emissions from electricity generation) can contribute to emissions decoupling. A complete discussion of the decoupling of emissions is beyond this project's scope.

Figure 10 shows the changes in gross emissions when compared to changes in other metrics of interest between 2018/19 and 2021/22. For example, total gross emissions have decreased by 6%, whilst the population in Masterton has increased by 8%, resulting in a 13% reduction in total gross emissions per capita. Similarly, Gross Domestic Product (GDP) in Masterton has increased by around 11%, resulting in an 15% decrease in the GHG emissions ratio to GDP. The data suggests that potentially a high-level, decoupling of the emissions covered by this assessment from economic growth has occurred between 2018/19 and 2021/22 in Masterton. However, it is noted that emissions calculated as part of this assessment are based on production-based emissions. Emissions calculated as part of a consumption-based assessment may present a different outcome.

Figure 10 Change in total gross emissions compared to other metrics of interest

6.0 Update to the 2018/19 Emissions Inventory

Improvements to the methodology, improvements in available data, and updates to emission factors since the 2018/19 Community Carbon Footprint (Emissions Inventory) was first published in 2020, have meant that the 2018/19 inventory results are required to be updated to allow direct comparison with the 2019/20, 2020/21, and 2021/22 inventories.

The previous 2018/19 inventory reported the three Wairarapa councils in one combined inventory. For the purposes of comparison to the previous inventory, all three emission inventories for the Wairarapa councils (Masterton, South Wairarapa and Carterton) for 2018/19 have been combined in Table 19.

Critical reasons for the change to results between these inventories are outlined below:

- Stationary Energy emissions have been adjusted due to improvements in data and methodology changes, notably the natural gas and electricity data and emission factors, and a difference in the allocation of diesel and petrol sales to stationary energy purposes.
- Transportation emissions have been adjusted due to data improvements and methodology changes, most notably in how the Wellington Region's petrol and diesel sales have been allocated to the territorial authorities within the Region (from a population approach to a vehicle kilometre travelled approach). The marine freight and inter-island ferry calculations have also been updated based on best-practice guidance for cross-boundary transport emissions.
- Waste emissions have been adjusted due to updates to the estimate of landfill gas capture system efficiency at the open landfill sites, the estimate of historical waste (1950-1999), and the population not connected to centralised wastewater treatment. Wastewater treatment plant emissions calculations have been updated to align with WaterNZ guidance (2021).
- IPPU emissions have been adjusted due to a change in data and emission factors provided by the Ministry for the Environment (MfE).
- Agriculture emissions have been adjusted due to improvements in data based on regional trends since the 2017 territorial authority-level census and changes in MfE emission factors.
- Forestry emissions have been adjusted due to improvements in published data and emission factors.

Table 19 Reported GHG emissions in Wairarapa for 2018/19, showing the change in emissions between those previously reported (2020) and the updated results (2023)

	2018/19 previous inventory (2020) – tCO_2e	2018/19 updated inventory (2023) – tCO_2e
Stationary Energy	59,293	54,486
Transportation	271,511	251,423
Waste	39,950	32,269
IPPU	14,219	13,546
Agriculture	1,349,348	1,439,551
Forestry	-1,380,860	-1,403,853
Total Net Emissions (incl. forestry)	**353,460**	**387,422**
Total Gross Emissions (excl. forestry)	**1,734,320**	**1,791,275**

Future emissions inventories for Masterton may also require adjustments to the emission results reported here due to improvements to the inventory process.

7.0 Impact of the COVID-19 pandemic on GHG Emissions

COVID-19 impacted New Zealand and the entire world during 2020 and 2021; causing widespread government-imposed restrictions on businesses and individuals and huge shifts in behaviours and economic markets. Restrictions in New Zealand relating to COVID-19 began in mid-March 2020 with many personal and business restrictions continuing past the end of 2019/20 and throughout 2021/22.[8]

Globally, carbon dioxide emissions from fossil fuels (the largest contributor to greenhouse gas emissions) in 2020 decreased by 7% compared to 2019[9]. Emissions from the transportation sector account for the largest share of this decrease. Surface transport, e.g. car journeys, fell by approximately half at the peak of COVID-19 restrictions in April 2020 (when restrictions were at their maximum, particularly across Europe and the U.S. Globally, emissions recovered to near 2019 levels and are expected to continue to increase.

In New Zealand, national daily carbon dioxide emissions are estimated to have fallen by up to 41% during the level 4 lockdown in April 2020[10]. National gross emissions decreased by 3% from 2018/19 to 2019/20, which was largely driven by a decrease in fuel use in road transport due to COVID-19 pandemic restrictions, a decrease in fuel use in manufacturing industries and construction due to COVID-19 restrictions, and a decrease in fuel use from domestic aviation also due to COVID-19 restrictions.

Total gross emissions in Masterton decreased by 53,389 tCO_2e (6%) between 2018/19 (pre-COVID-19) and 2021/22. A 4% decrease in Agriculture emissions (29,451 tCO_2e) and a 17% decrease in Transport emissions (20,372 tCO_2e) accounts for the vast majority of this change. Notably, Transport emissions were driven by reduced road and air transport fuel use (see Figure 10). Air travel emissions in particular have been impacted by COVID-19 with emissions 72% lower in 2020/21 than in 2018/19 especially due to a reduction in international flights. It is expected that air travel emissions will rise to near pre-COVID-19 levels in 2022/23 in the Wellington Region. On-road transport emissions were also impacted by COVID-19, especially through restrictions on travel for periods of time in 2019/20 and 2021/22.

Despite changes in Agriculture, Stationary Energy, Waste, and IPPU emissions, these sectors are not judged to have been significantly affected by COVID-19. Of note, electricity consumption (kWh) has increased during this time with annual emissions affected by the sources of national generation of electricity in each year. We cannot say with confidence whether energy consumption, or other changes have been significantly affected by COVID-19.

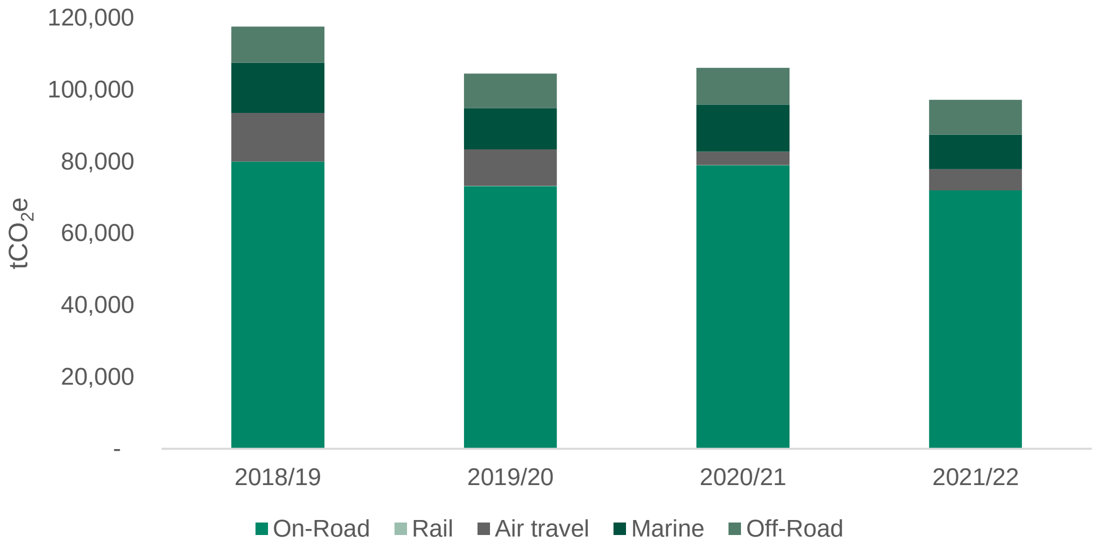

Figure 11 Masterton Transport emissions for 2018/19, 2019/20, 2020/21 and 2021/22 (tCO_2e)

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[8] https://covid19.govt.nz/alert-system/history-of-the-covid-19-alert-system/
[9] Pierre Friedlingstein et al. - Global Carbon Budget 2020 (2020)
[10] Corinne Le Quere et al. – Temporary Reduction in Daily Global CO_2 Emissions During the COVID-19 Forced Confinement

8.0 Closing Statement

Masterton GHG emissions inventory provides information for decision-making and action by the council, Masterton stakeholders, and the wider community. We encourage the council to use the results of this study to update current climate actions plans and set emission reduction targets.

The emissions inventory developed for Masterton covers emissions produced in the Stationary Energy, Transport, Waste, IPPU, Agriculture, and Forestry sectors using the GPC reporting framework. Sector-level data allows Masterton to target and work with the sectors that contribute the most emissions to the inventory.

Understanding of the extensive and long-lasting effects of climate change is improving all the time. It is recommended that this full emissions inventory be updated regularly (every two or three years) to inform ongoing positive decision making to address climate change issues. Use of real-time data for major emissions sources and consideration of consumption-based emissions, can also add to understanding of emissions across the region.

The accuracy of any emissions inventory is limited by the availability, quality, and applicability of data. Areas where data could be improved for future inventories include forestry (forest cover and harvesting), agriculture (especially livestock numbers), wastewater, and on and off-road transport fuel use.

9.0 Limitations

Where this Report indicates that information has been provided to AECOM by third parties, AECOM has made no independent verification of this information except as expressly stated in the Report. AECOM assumes no liability for any inaccuracies in or omissions to that information. This Report was prepared between January 2023 and June 2023 and is based on the information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time. This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice.

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Appendix A

Assumptions and Data Sources

Sector / Category	Assumption and Data Sources
General	
Geographical Boundary	LGNZ local council mapping boundaries have been applied. The emissions inventory for each territorial authority covers the entirety of the territorial authority area.
Population	Population figures are provided by StatsNZ. Financial year populations have been used, these are based on the average population from the two calendar years (e.g. the average of 2020 and 2021 calendar year populations for 2020/21).
Climate Change Feedback	Emissions are expressed on a carbon dioxide-equivalent basis (CO_2e) including climate change feedback using the 100-year Global Warming Potential (GWP) values. Climate change feedbacks are the climate change impacts from GHGs that are increased as the climate changes. For example, once the Earth begins to warm, it triggers other processes on the surface and in the atmosphere. Current climate change feedback guidance is important to estimate the long-term impacts of GHGs. Emissions for individual main greenhouse gases for each emissions source are provided in the supplementary spreadsheet information supplied with this report.
GPC Production Approach	GPC reporting is predominately production-based (as opposed to consumption-based) but includes indirect emissions from energy consumption. Production-based emissions reporting is generally preferred by policy-makers due to robust established methodologies such as the GPC, which enables comparisons between different studies. Production-based approaches exclude globally produced emissions relating to consumption (e.g., embodied emissions relating to products produced elsewhere but consumed within the geographic area such as imported food products, cars, phones, clothes etc.). A breakdown of emissions by scope (1, 2 and 3) is included in the supplementary spreadsheet information supplied with this report.
Emission Factors	All emission factors have detailed source information in the calculation tables within which they are used. Where possible, the most up to date, NZ-specific emission factors have been applied. AR5 Global Warming Potential (GWP) figures for greenhouse gases have been used accounting for climate change feedbacks.
Transport Emissions	
Petrol and Diesel:	Total petrol and diesel sales data was provided by Wellington City Council for Wellington City Council, Porirua City Council, Kāpiti Coast District Council, Hutt City Council and Upper Hutt City Council. Total petrol and diesel sales data was provided by Masterton District Council for South Wairarapa District Council, Masterton District Council and Carterton District Council. Sales data have then been then apportioned out to the territorial authorities within the region based on the total distance travelled by vehicles in each territorial authority in the financial year (known as Vehicle Kilometres Travelled or VKT). Allocating fuel consumption across a region based on VKT does not account for the likely makeup of the vehicle fleet of a particular geographic area (e.g. where a more rural area

	may use more diesel, or a more urban area may have more hybrid or electric vehicles travelling). Fuel sold in an area does not always mean that the fuel is used in that area, however this approach is considered to be a robust and comparable estimate of fuel consumption in a geographic area. Total petrol and diesel fuel use was then divided by likely end use. The division into transport and stationary energy end use (and within transport, on-road and off-road) was calculated using fuel end use data provided by the Energy Efficiency and Conservation Authority (EECA) in April 2020. - On-road transport is defined as all standard transportation vehicles used on roads e.g. cars, bikes, buses. - Off-road transport is defined as machinery for agriculture, construction and other industry used off-roads. - Stationary energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for stationary energy has been reported in the Stationary Energy sector.
Rail Diesel	Consumption was calculated by KiwiRail using the Induced Activity method for system boundaries. The following assumptions were made: - Net Weight is product weight only and excludes container tare (the weight of an empty container) - The Net Tonne-Kilometres (NTK) measurement has been used. NTK is the sum of the tonnes carried, multiplied by the distance travelled. - National fuel consumption rates have been used to derive litres of fuel for distance. - Type of locomotive engine used, and jurisdiction topography, have not been incorporated in the calculations. Using the induced activity method, the trans-boundary routes were determined, and the number of stops taken along the way derived. The total litres of diesel consumed per route was then split between the departure territorial authority, arrival territorial authority and any territorial authority the freight stopped at along the way. If the freight travelled through but did not stop within a territorial authority, no emissions were allocated. Data was not available for 2021/22 therefore the 2020/21 value has been used for 2021/22. This data is subject to commercial confidentiality.
Jet Kerosene (Scheduled Flights)	Calculated using the Induced Activity method as per rail diesel. An estimate of fuel use was calculated for flights arriving and departing from Wellington Airport: - The schedule of flights arriving and departing from Wellington Airport containing details on the aircraft used for each flight was used to calculate fuel consumption. - Flight distances and aircraft fuel burn rates were used for these calculations. - As per the induced activity method, only 50% of emissions calculated per one-way arrival and departure were allocated to Wellington Airport. The remaining 50% of each leg was allocated to the originating or destination airport. An estimation of fuel use from military, freight, private, and other flights for 2020/21 and 2021/22 have been estimated based on data provided in 2020. Wellington Airport has been treated as a regional airport, so emissions have been split between the territorial authorities in the region on a population basis.

	Fuel use by aircraft using Kāpiti Coast Airport has also been accounted for using the same methodology, with all emissions allocated to Kapiti Coast District.
Aviation Gas (General Aviation)	Aviation gas is mostly used by small aircraft for relatively short flights. Data for Wellington Airport was not available at the time of writing, so an assumption has been made based on similar sized airports in New Zealand. This is the same assumption used in the previous 2019/20 inventory. Wellington Airport has been treated as a regional airport, so emissions have been split between the territorial authorities in the region on a population basis. Fuel use by aircraft using Kāpiti Coast Airport has also been accounted for using the same methodology, with all emissions allocated to Kapiti Coast District. There are a number of small aerodromes and runways across the region. Due to the difficulty of obtaining data, emissions related to flights from these locations have been excluded. It is likely that these emissions would have been very small in relation to other sources, and so would fit below the materiality threshold.
Marine Fuels - Freight	Calculated using the Induced Activity method as per rail diesel and jet kerosene. An estimate of fuel use was calculated for flights arriving and departing from CentrePort (Wellington Port): - The schedule of vessels arriving and departing from Wellington Port containing details on size of the vessel was used to calculate fuel consumption. - Shipping distances and vessel fuel burn rates were used for these calculations. - As per the induced activity method, only 50% of emissions calculated per one-way arrival and departure were allocated to Wellington Port. The remaining 50% of each leg was allocated to the originating or destination Port. International shipping passing through CentrePort was split by weight of cargo into 'Logs' and 'All other cargo'. Emissions generated by 'All other cargo' has been allocated on a per capita basis between all territorial authorities in the Wellington Region. Emissions generated by 'logs' was split between territorial authorities, proportionally, by the percentage share of district forest area of harvest age (>26 years old).
Marine Fuels (Local)	Port operational vessels: - Fuel use has been provided directly from Wellington Port (CPL) for 2020/21 - The 2020/21 figure has also been used for 2019/20 and 2021/22 - All emissions from this source have been allocated to Wellington City Local ferries: - Diesel fuel use has been provided directly by the ferry operator - Electricity use has been provided directly by the ferry operator (beginning in 2021/22) - All emissions from this source have been allocated to Wellington City Private use, other commercial operators, and commercial fishing: - Most small private boats use fuel purchased at vehicle gas stations so this consumption will be included in off-road transport petrol and diesel emissions. - No data was available to determine emissions from other commercial operators, and commercial fishing

Marine Fuels – Inter-island Ferries	Data has been provided by the ferry operators in commercial confidence. Assumptions of fuel use have been used where data was not provided.
Cruise Ships	No reliable data was available to determine the emissions from cruise ships (only relevant to 2019/20 as there were no cruise ship visits in 2020/21 and 2021/22).
LPG	Total North Island consumption data was used and then split on a per capita basis to determine the territorial authority's consumption. National LPG end use data has been used to breakdown consumption into stationary energy and transport usage, these are then reported separately in their respective categories.
Stationary Energy Emissions	
Consumer Energy End Use	Stationary energy demand (e.g. electricity use, natural gas, etc.) is broken down by the sector in which they are consumed. We report stationary energy demand in the following categories: industrial (which includes agriculture, forestry, and fishing); commercial; and residential. These sectors follow the Australia New Zealand Standard Industrial Classification 2006 definitions. In addition to agriculture, forestry and fishing, the industrial sector includes mining, food processing, textiles, chemicals, metals, mechanical/electrical equipment and building and construction activities. Emissions from petrol and diesel used for stationary energy are not broken down into these sectors. Energy demand used for transport is reported in the transport sector.
Electricity Consumption	Electricity demand has been calculated using grid demand trends from the EMI website (www.emi.ea.govt.nz) to obtain raw grid exit point data for each territorial authority area. Reconciled demand has been used as per EMI's confirmation. The breakdown into sectors is based on NZ average consumption per sector (residential, commercial, and industrial).
Public Transport Electricity	Electricity used in the public transport system is included in the Transport sector (where known).
Private Transport Electricity	Electricity used for private transport (e.g. electric cars, electric bikes, electric micro-mobility) has not been separated from other stationary energy electricity consumption due to a lack of reliable data.
Coal Consumption	National coal consumption data has been provided by MBIE for all years (2022). Regional industrial coal data has been provided by EECA. National residential and commercial coal consumption has been divided between territorial authorities on a per capita basis. Regional industrial coal consumption has been divided between territorial authorities on a per capita basis, where relevant.

Biofuel and Wood Consumption	National biofuel consumption data has been provided by the Ministry for Business, Innovation and Employment (MBIE 2021). Biofuel consumption has been divided between territorial authorities on a per capita basis. Biofuel emissions are broken down into Biogenic emissions (CO_2) and Non-Biogenic emissions (CH_4 and N_2O). The latest year's data available is for 2019. 2019/20, 2020/21, and 2021/22 use the 2019 figure, adjusted for population change.
LPG Consumption	North Island LPG sales data (tonnes) has been provided by the LPG Association for 2020 and 2021. Data interpolated between known data points or copied from the most recent data point where data is not available. 'Auto' and 'Forklift' sales represent transport uses of LPG. All other sales represent stationary energy uses of LPG. Sales have been divided between territorial authorities on a per capita basis. The breakdown into sectors (Residential, Commercial, and Industrial) is based on NZ average consumption per sector as per MfE data.
Petrol and Diesel (Stationary Energy End Use)	Total petrol and diesel sales data was provided by Wellington City Council for Wellington City Council, Porirua City Council, Kapiti Coast District Council, Hutt City Council and Upper Hutt City Council. Total petrol and diesel sales data was provided by Masterton District Council for South Wairarapa District Council, Masterton District Council and Carterton District Council. Sales data have then been then apportioned out to the territorial authorities within the region based on the total distance travelled by vehicles in each territorial authority in the financial year (known as Vehicle Kilometres Travelled or VKT). Allocating fuel consumption across a region based on VKT does not account for the likely makeup of the vehicle fleet of a particular geographic area (e.g. where a more rural area may use more diesel, or a more urban area may have more hybrid or electric vehicles travelling). Fuel sold in an area does not always mean that the fuel is used in that area, however this approach is considered to be a robust and comparable estimate of fuel consumption in a geographic area. Total petrol and diesel fuel use was then divided by likely end use. The division into transport and stationary energy end use (and within transport, on-road and off-road) was calculated using fuel end use data provided by the Energy Efficiency and Conservation Authority (EECA) in April 2020. - On-road transport is defined as all standard transportation vehicles used on roads e.g. cars, bikes, buses. - Off-road transport is defined as machinery for agriculture, construction and other industry used off-roads. - Stationary energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for stationary energy has been reported in the Stationary Energy sector.
Natural Gas Consumption	Natural gas consumption data has been provided by FirstGas. Territorial Authorities supplied by gas from each Point of Connection (POC) have been confirmed by FirstGas.

Biogenic Emissions (CO_2)	Some carbon dioxide (CO_2) emissions are considered to be biogenic. These are CO_2 emissions where the carbon has been recently derived from CO_2 present in the atmosphere (for example, some agricultural and waste emissions). These emissions are not included in calculating total CO_2e.
Agricultural Emissions	
Agriculture	Territorial authority livestock numbers and fertiliser data taken from the Agricultural Census (StatsNZ). The last territorial authority census was in 2017. Regional agricultural data from StatsNZ (2021) has been used to estimate the change in livestock and fertiliser use since 2017. Due to the gap in data for 2021/22, the 2020/21 figure has been used for 2021/22.
Solid Waste Emissions	
Landfill Emissions	Landfill waste volume and landfill gas capture system information has been provided by the respective council departments. Solid waste emissions from landfill are measured using the IPCC First Order Decay method that covers landfill activity between 1950 and the present day, as per the GPC reporting requirements. This method accounts for the gradual release of emissions from waste over a long period of time, and so calculates the emissions produced per year from waste in landfill (including emissions from closed landfill sites). Waste volume: - Where information is not available, waste volumes have been estimated based on historical national data on a per capita basis. Landfill gas capture system efficiency: - Efficiency and coverage of the system used in the emissions calculations has been provided by the respective councils based on recorded or estimated data. Landfill gas flaring / burning for energy generation: - There is biogas energy generation at Southern Landfill which is a site used by some councils in the Wellington Region. The percentage of landfill gas flared or burned for energy generation used in the calculations has been taken from data provided by WCC in relation to the calculation of Southern Landfill's Unique Emissions Factor (UEF) for 2019/20 and 2021/22. - Emissions relating to burning of landfill gas for energy generation have been included in the Stationary Energy sector. Emissions are allocated to territorial authorities based on where the waste was produced, even if the waste is disposed in landfill outside the territorial authority: - Information on the origin and destination of waste produced in each territorial area has been provided by the respective councils based on recorded or estimated data.
Wastewater Emissions	
Wastewater Treatment	All wastewater emissions have been calculated following the WaterNZ (2021) guidance. Wastewater Treatment Plants: - Calculation of emissions includes emissions released directly from wastewater treatment, flaring of captured gas and from discharge onto land/water. - Where data was not available assumed values have been used based on the WaterNZ (2021) guidance - Emissions relating to discharge of biosolids sent to landfill (if present) have been included in the Solid Waste emissions source.

	- Emissions are allocated to territorial authorities based on where the wastewater was produced, even if the wastewater is treated outside the territorial authority. Individual Septic Tanks: - Populations not connected to known centralised wastewater treatment plants are assumed to be using septic tanks.
Industrial Emissions	
Industrial Processes	It is assumed that there are no significant non-energy related emissions of greenhouse gasses from industrial processes in the Region (e.g. aluminium manufacture).
Industrial Product Use	National data covering industrial product use (e.g., fire extinguishers, refrigerants) have been estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2020 report (MfE 2022). Emissions are estimated on a per capita basis applying a national average per person.
Forestry Emissions	
Exotic Forestry Harvested and Exotic Forest coverage	Harvested forestry, and forest cover information for each territorial authority has been derived from Landcare Research data. This emissions inventory accounts for forest carbon stock changes from afforestation, reforestation, deforestation, and forest management (i.e., it applies land-use accounting conventions under the United Nations Framework Convention on Climate Change rather than the Kyoto Protocol). It treats emissions from harvesting and deforestation as instantaneous rather than accounting for the longer-term emission flows associated with harvested wood products. The emissions inventory considers regenerating (growing) forest areas only. Capture of carbon from the atmosphere is negligible for mature forests that have reached a steady state.
Native Forest	Native forest land area for each territorial authority has been provided by Landcare Research.